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European North Sea Energy Alliance ("ENSEA") FP7-2012-2013-1: 320024

(Duration: 01.10.2012-31.12.2015)

Final report

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European North Sea Energy Alliance (“ENSEA”)

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Speaker Scottish Cluster:	Mr David BUTLER	scottish renewables
Speaker Norwegian Cluster:	Prof. Dr. Mohsen ASSADI	Universitetet i Stavanger

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Ia Vorwort

Das Energie-Forschungszentrum Niedersachsen (EFZN) verfolgt eine gezielte Internationalisierung und damit auch eine Forschungsförderungs- und Netzwerkstrategie, die sowohl auf europäischer Ebene als auch weltweit vorangetrieben wird. Dies gilt insbesondere für die Integration von Energiesystemen. Das in dieser Schriftenreihe vorgestellte Projekt „Europäische Nordsee Energie Allianz“ (ENSEA) ist ein erstes europäische Verbundprojekt des EFZN zu diesem Thema.

Auch wenn die Nordsee als Teil des Atlantiks eine relativ kleine Fläche abdeckt, ist sie dennoch unter Energie-Gesichtspunkten einzigartig. Die Fördergebiete in der Nordsee wurden in den 1970er Jahren nach dem ersten Ölpreisschock als Alternative zum OPEC-Öl entwickelt. Mittlerweile sind die Abbaufelder für das qualitativ hochwertige Öl weitgehend erschöpft bzw. weniger rentabel. Gleichzeitig ist die Energiewirtschaft für regenerative Energien in und um die Nordsee zu einer der dynamischsten Branchen in Europa geworden: Dieser „hot spot“ umfasst Windparks auf hoher See vor der deutschen, niederländischen und britischen Küste, Wasserkraftwerke in Norwegen, Gezeitenmeiler an der belgischen und dänischen Küste, schwimmende Gezeitenkraftwerke und Wellenkraftanlagen in Schottland, Hochspannungs-Unterseekabel, die den Strom an Land bringen und mit Wind- und Solaranlagen auf dem europäischen Festland verbunden werden.

Hauptanliegen des Projektes ENSEA ist es, die internationale Zusammenarbeit zwischen Wissenschaft, Wirtschaft und öffentlicher Verwaltung in regionalen Energiesektoren (Triple-Helix-Ansatz) gezielt aufzubauen und die Entwicklung von Wissen über Energiesystemintegration innerhalb der internationalen Regionen zu fördern. Kern-Wissensregionen des ENSEA-Verbundes waren die nördlichen Niederlande, Niedersachsen in Nordwest-Deutschland, Südwest-Norwegen und Schottland. Im Verlauf des Projektes wurde das Konsortium um die Region Nordjütland in Dänemark erweitert und bildet somit einen umfassenden Verbundring um die Nordsee ab.

Die initiierte Zusammenarbeit der Partnerregionen, die Zusammenführung bestehenden Energie-Know-hows, die Abstimmung von regionalen, nationalen und europäischen Forschungsprogrammen und die Verstetigung der Zusammenarbeit sind die wichtigsten Ergebnisse der in dieser Schriftenreihe vorgestellten Aktivitäten.

ENSEA leistet damit einen signifikanten Beitrag zur Integration erneuerbarer Energien der Nordsee in das bestehende Onshore-Energiesystem.

Prof. Dr.-Ing. Beck, Vorstandsvorsitzender des EFZN und ENSEA-Projektleiter

Dr. Kappenberg, Referent Internationale Kooperationen des EFZN und ENSEA-Projektkoordinator

gez. Knut Kappenberg, Goslar, im Februar 2017

Ib Preface

The Energy Research Center of Lower Saxony (EFZN), Germany, focuses on a targeted internationalization and, thus, pursues a research and network strategy on both a European as well as global level. This applies in particular to the integration of energy systems. The project "European North Sea Energy Alliance" (ENSEA), presented in this series of publication, is a first European joint project of the EFZN on this topic.

Even though the North Sea, as part of the Atlantic Ocean, only covers a relatively small area, it is unique from an energy perspective. The production areas for oil and gas in the North Sea were developed as an alternative to the OPEC oil in the 1970s after the first oil price shock. Today, the exploration fields for this high-quality oil are largely exhausted or less profitable, due to a drop in oil and gas prices. Meanwhile, the industry for renewable energies in and around the North Sea area has become one of the most dynamic industries in Europe: This "hot spot" includes German, Dutch and British offshore wind farms, Norwegian hydroelectric power stations, Belgian and Danish tidal power stations along the coasts and Scottish floating tidal and wave power plants. All these different concepts are connected via high voltage subsea cables with wind and solar power plants on the European coasts and the mainland.

The main objective of the ENSEA project is to develop an international cooperation between the regional energy fields of science, business and public administration (triple-helix approach), and to promote the development of knowledge of energy system integration within international regions. The core participators in the ENSEA network are the Northern Netherlands, Lower Saxony in Northwest Germany, Southwest Norway and Scotland. In the course of the project, the consortium expanded to include the North Jutland region in Denmark, thus forming a comprehensive network around the North Sea.

Closer collaboration between the partner regions, pooling of existing energy know-how, the alignment of regional, national and European research programs and the consistency of co-operation are the most important results that are presented in this series.

Therefore, ENSEA makes a significant contribution to the integration of renewable energies of the North Sea into the existing onshore energy system.

Prof. Dr.-Ing. Beck, Chairman of the EFZN

Dr. Kappenberg, Manager International Cooperation of the EFZN and Project Coordinator of ENSEA

signed Knut Kappenberg, Goslar, February 2017

IIa Zusammenfassung

Das Projekt Europäische Nordsee Energie Allianz (‚ENSEA'), das von der Europäischen Kommission im Rahmen des FP7-Programms „Kapazitäten-Wissensregionen" mit einem Fördervolumen von drei Millionen Euro unterstützt wurde, begann am 1. Oktober 2012 und endete am 31. Dezember 2015. Hauptziel dieses Projektes war es, die internationale Zusammenarbeit zwischen Wissenschaft, Wirtschaft und öffentlicher Verwaltung in regionalen Energiesektoren (Triple-Helix-Ansatz) gezielt aufzubauen und die Entwicklung von Wissen über Energiesystemintegration innerhalb der internationalen Regionen zu fördern.

Kern-Wissensregionen und **Partner des ENSEA-Verbundes** sind die nördlichen Niederlande, der Nordwesten Deutschlands, Südwest-Norwegen und Schottland:

Niederlande: Energy Valley ist eine Netzwerkorganisation mit öffentlichen und privaten Partnern im nördlichen Teil der Niederlande, die zum Ziele hat, Wachstumschancen im Energiesektor zu erkunden. Der Fokus liegt dabei auf Energieinnovationen und dem Übergang hin zu einer nachhaltigen Energiewirtschaft.

Niedersachsen im Nordwesten Deutschlands: Wachstumsregion Ems-Achse e.V. ist ein Zusammenschluss von Unternehmen, Behörden, akademischen Einrichtungen und Handelskammern. Ziel ist es, die Ems-Achse als unabhängige Wirtschaftsregion weiter auszubauen. Dazu koordiniert der Zusammenschluss Projekte zur Erweiterung der wirtschaftlichen Infrastruktur, der Netzwerk-Entwicklung sowie der Förderung von F&E-Aktivitäten. Weiterer deutscher ENSEA-Partner ist das Energie-Forschungszentrum Niedersachsen (EFZN), ein gemeinsames wissenschaftliches Zentrum der fünf renommierten nordwestdeutschen Universitäten Braunschweig, Clausthal, Göttingen, Hannover und Oldenburg. Die Kernaufgabe des EFZN besteht darin, die Energieforschungskompetenzen der Partneruniversitäten aus den Bereichen Natur- und Ingenieurwissenschaften sowie Rechts-, Sozial- und Wirtschaftswissenschaften auf besonders bedeutsamen Gebieten der anwendungsorientierten Grundlagenforschung dauerhaft zu bündeln und strategisch abzustimmen.

Norwegen: Rogaland mit der Universität Stavanger und dem Zentrum für nachhaltige Energielösungen (CENSE), die F&E-Aktivitäten im Hinblick auf erneuerbare Energien und saubere fossile Energie abdecken; die Rogaland Bezirksratseinheit für wirtschaftliche Kompetenzen im Bereich Energie und F&E; das Energie- und Telekommunikationsunternehmen Lyse AS, das als Genossenschaftsbesitz von 16 Gemeinden im Verwaltungsbezirk Rogaland geführt wird.

Schottland (Vereinigtes Königreich): Die wichtigste Wirtschaftsförderungsagentur des Landes, Scottish Enterprise, hat zum Ziel, Investorenakquisition für Schottland zu betreiben und schottische Unternehmen dabei zu unterstützen, deren globale Wettbewerbsfähigkeit zu stärken; Energy Technology Partnership ist ein Zusammenschluss von 12 unabhängigen schottischen Universitäten und engagiert sich in der Energieforschung durch Entwicklungs- und Demonstrationsvorhaben; Scottish Renewables ist die Vertretung der Branche der erneuerbaren Energien in Schottland mit mehr als 330 Mitgliedsorganisationen.

Geographische Lage von Triple-Helix-Cluster der Europäischen Nordsee Energy Alliance (ENSEA)

Die wichtigsten Ziele des ENSEA Projekts:

- Bereitstellung von Informationen und Durchführung von (SWOT-) Analysen zu den Rollen, Fähigkeiten, Netzwerkanbindungen, Innovationskapazitäten und aktuellen Ansätzen für Forschung und Entwicklung im Zusammenhang mit Energiesystemintegration der ENSEA Regionen
- Entwicklung eines gemeinsamen Aktionsplans, abgeleitet aus den vorangegangenen Analysen, hin zu einer interregionalen Energiestrategie für die Nordsee. Fokus: Spezifische Themen der Energiesystemintegration bei denen eine grenzüberschreitende/ überregionale Zusammenarbeit erforderlich ist
- Maßnahmen zur gemeinsamen Umsetzung des Aktionsplans und Zusammenarbeit in Schlüsselbereichen der Energiesystemintegration
- Aufbau, Betrieb und Stärkung eines Netzwerkes von forschungsgetriebenen, interregionalen Energieclustern rund um die Nordsee, die das Modell der Energiesystemintegration als Management-Instrument für eine nachhaltige Energiewende voranbringen.

Beschreibung der durchgeführten Arbeiten und die wichtigsten Ergebnisse

Das Projekt gliederte sich – neben den Arbeitspaketen „Management“ und „Dissemination“ – inhaltlich in die drei aufeinander aufbauenden Arbeitspakete (AP) „Analyse der Innovationskapazitäten“ (AP2), „Entwicklung eines Gemeinsamen Aktionsplans“ (AP3) und „Umsetzung des Gemeinsamen Aktionsplans“ (AP4). Zusätzlich wurde im Rahmen der ENSEA-Abschlusskonferenz in Edinburgh ein Maßnahmenkatalog für die Politikentwicklung („Edinburgh-Empfehlungen“) vorgestellt.

Schwerpunkt der Arbeit im **Arbeitspaket 2**, geführt vom schottischen Cluster, war die Gesamtanalyse der Innovationskapazitäten in der ENSEA Region, die zum Ziele hatte, Chancen für die Zusammenarbeit zu identifizieren. Dazu wurde ein methodischer, grundlegender Rahmen für die Struktur der aufzunehmenden Daten definiert und unter den Partnern abgestimmt, damit die zu erhaltenen Informationen (u.a. über Forschungsstärken und -schwächen, F&E-Ausgaben, die Beschreibung der regionalen Energiesysteme, Förder- und Finanzierungsmöglichkeiten, bestehende Verknüpfungen und Kooperationen, regionale, nationale und internationale (Energie-) Politik, regionale Strategien zu intelligenter Spezialisierung sowie Metriken im Hinblick auf Innovationskapazitäten) vergleichbar wurden.

Mit den gesammelten Daten wurden die regionalen Energiesysteme beschrieben sowie SWOT-Analysen für jede Region durchgeführt. Die Ergebnisse aus den SWOT-Analysen wurden bei Workshops in den einzelnen Regionen vorgestellt. In diesen Workshops diskutierten die Stakeholder der Triple-Helix-Organisationen über die in ihren Regionen identifizierten Stärken, Schwächen, Chancen und Risiken. Dadurch war das aktive Engagement von Industrie, Wissenschaft und Behörden direkt von Anfang des Projekts gewährleistet. Wo anwendbar und erforderlich wurden die vorläufigen Ergebnisse der SWOT-Analysen auf der Grundlage dieser Diskussionen angepasst und in einem Regionalbericht festgehalten. Signifikante Ergebnisse aus den Regionalanalysen und der in den Regionen durchgeführten Workshops in Form von vier separaten Regionalberichten sind:

- Energy Valley Region: Die Energy Valley Region besitzt einen starken Fokus auf Gas, basierend auf Erdgasreserven und damit verbundener Produktion, Transport, Lagerung und Forschungsdienstleistungen. In jüngster Zeit wird zunehmend moderne gasbezogene Aktivität (z.B. basierend auf grünem Gas, kleinmaßstäblicher Anwendung von LNG, Power-to-Gas, Gas und Mobilität) ein Thema der Innovationstätigkeit
- Nordwestdeutschland: Niedersachsen im Nordwesten von Deutschland hat sich als besonders stark im Bereich der erneuerbaren Energien und der Technologieentwicklung erwiesen, insbesondere bei Windkraftanlagen, Offshore-Technik, Biogasproduktion und Energiespeicherung. Die Energy Valley und der Nordwesten Deutschland Regionen weisen beide sowohl eine starke Erhöhung der Produktionskapazitäten sowie schnell wachsende Offshore-Aktivitäten im Zusammenhang mit Nordsee-Offshore-Wind auf
- Rogaland: Die Region Rogaland hat erhebliche Offshore-Öl- und Gasaktivitäten und ist besonders stark in Wasserkraft (flexible Generation). Es ist wichtig festzuhalten, dass die Wasserkapazität von Norwegen durch Verbindungsleitungen mit den anderen Regionen des ENSEA Projektes verbunden ist und damit einen Energiebeitrag zum Netzausgleich leisten kann. Kohlenstoff-Abscheidung und -Speicherung (CCS) wurde als ein weiteres Gebiet von besonderem Fokus und Stärke identifiziert
- Schottland: Schottland hat wie auch Rogaland einen starken Öl- und Gascluster, der eine gute Zusammenarbeit zwischen Unternehmen und innovativen Forschergruppen aufzeigt. Von großer Bedeutung für die Energiesystemintegration sind Stromnetze und Smart-Grid-Entwicklung zusammen mit Systemintegrationsmethoden (wie Datenmanagement, Informations-/ Kommunikationstechnologien und Leistungselektronik). In Bezug auf die erneuerbaren Energien besonders wichtig für die Region sind die großen Ressourcen an Offshore-Wind und Meeresenergie. Onshore-Wind wurde als ein Bereich von besonders hoher industrieller Aktivität gesehen.

In einem weiteren Schritt flossen alle oben genannten Regional- und SWOT-Analysen ein in die Analyse über die Innovationskapazitäten der ENSEA Region als Ganzes. Dazu wurden die Innovationsmerkmale der vier Regionen unter Verwendung von Variablen des EU-Innovation Union Scoreboard (IUS) analysiert und mit denen aller anderen EU-Regionen verglichen. Zudem wurde eine RIS (Forschungs- und Innovationsstrategien für intelligente Spezialisierung) Analyse für jede ENSEA-Region durchgeführt.

Zusammenfassung der wichtigsten Ergebnisse des Gesamtanalyseberichtes aus AP2:

- Der institutionelle Rahmen für die Förderung der interregionalen Kooperationen und die Zusammenarbeit über Energiesystemintegration rund um die Nordsee wurde, um weitere Fortschritte zu erreichen, als unverzichtbar angesehen, gleichzeitig aber als immer noch recht schwach und zerstreut betrachtet. Triple-Helix-Organisationen existieren zwar in den Regionen und funktionieren relativ gut, sind aber immer noch zu wenig international ausgerichtet und müssen die Vernetzung von Industrie- und Forschungsaktivitäten verbessern, um diese in erfolgreiche Innovationsaktivitäten zu übersetzen

- Die große Zahl von kleinen und mittleren Unternehmen (KMU) in den Regionen spielen nicht nur eine wichtige Rolle beim Energieinnovationsprozess, sondern auch vor allem in ihrer Eigenschaft als Subunternehmer für größere Unternehmen. Dies ist insbesondere im Öl- und Gas-Explorations-Sektor der Fall, in dem fast ausschließlich multinationale Unternehmen eine führende Rolle spielen
- Die untersuchten Regionen haben deutlich unterschiedliche Schwerpunkte. Die wichtigsten Ergebnisse der verschiedenen regionalen Berichte wurden in einen Satz von Tabellen übersetzt, die die relativen Stärken und Schwächen der vier Regionen durch ein Scoring darstellten. Alle Regionen erzielten hohe Werte bei Erneuerbaren Energien. Nachfrageflexibilität erzielte relativ niedrige Werte; Netz-/ Infrastrukturinnovation ist ebenfalls gering außer für Schottland aufgrund der Ausrichtung auf intelligente Netze. Integrationsmethoden hatten einen besonderen Schwerpunkt in Schottland. CCS ist ein Schwerpunkt in Rogaland und Schottland
- Bezogen auf die Chancen und Risiken zeigten alle Regionen großen Optimismus auf die zukünftige Rolle der Erzeugung aus Erneuerbaren im Energiesystem. Fast alle Regionen sind stark im Bereich Onshore-Wind. Dies gilt insbesondere für Niedersachsen, das zwei der wichtigsten globalen Industrieakteure aufweist. Darüber hinaus sind alle Regionen (außer Schottland) mit Niedersachsen als Spitzenreiter relativ stark in Biomasse
- Offshore-Wind ist relativ stark in Schottland, Rogaland und in Niedersachsen; Wasserkraft in Rogaland und Schottland; Meeresenergie in Schottland und Energie aus Abfall in der Energy Valley Region
- Was die fossilen Energieträger betrifft, sticht die Energy Valley Region durch den starken Gassektor im Groningen-Feld heraus. Norwegen und Schottland haben ebenfalls einen beträchtlichen Öl- und Gasexplorationssektor
- Die Innovationsmerkmale der vier Regionen wurden unter Verwendung von Variablen des EU-Innovation Union Scoreboard (IUS) analysiert und mit denen aller EU-Regionen verglichen. Das Gesamtbild zeigt, dass die untersuchten vier Regionen im europäischen Vergleich überdurchschnittlich starke Werte für Innovation, F&E-Aktivitäten und Bildungsniveau aufzeigen. Gleichwohl zeigte eine tiefergehende Betrachtung in Bezug auf Innovation einige deutliche Unterschiede zwischen den vier Regionen. Die Analyse der RIS (Forschungs- und Innovationsstrategien für intelligente Spezialisierung) zeigte, dass sowohl Niedersachsen als auch die Region Energy Valley Innovationsführer sind, während Schottland und Rogaland als Innovationsfolger eingestuft wurden. Die RIS-Metriken zeigten auch, dass eine höhere Aktivität im privaten Sektor nötig ist, um Nutzen von Innovationen zu generieren.

Im darauffolgenden **Arbeitspaket 3** unter Federführung des niedersächsischen Clusters (Ems-Achse und EFZN) konzentrierten sich die Aufgaben auf die Entwicklung eines gemeinsamen Aktionsplans (Joint Action Plan, JAP). Dieser Plan bestand aus vier separaten Aktionsplänen für jede Region, sowie einem gemeinsamen Aktionsplan über alle Regionen hinweg. Jeder der vier regionalen JAPs enthielt eine Vision und Strategie sowie eine Vielzahl von Projektideen zur Energiesystemintegration, die mit regionalen Kompetenzprofilen und Potenzialanalysen sowie mit dem Strategieplan für Energietechnologie („SET-Plan") der EU abgestimmt wurden. So wurden für den Gemeinsamen Aktionsplan insgesamt 160 Projekte identifiziert, die sich auf fast alle Themen der europäischen Energietechnologiepolitik beziehen.

Das **Arbeitspaket 4** des ENSEA-Projekts, geführt vom norwegischen Cluster, baute auf den Aktivitäten und Ergebnissen der früheren Arbeitspakete auf. Hauptziel ist die Umsetzung des in AP3 entwickelten Gemeinsamen Aktionsplans (JAP) und der damit verbundenen Projekte. Fernziel ist es, ENSEA und damit die Forschungseinrichtungen, Regionen und Unternehmen als Kompetenzzentrum für die Energiesystemintegration für die Nordseeregion zu etablieren.

Das AP4 konzentrierte sich daher auf die Internationalisierungsstrategien, die Identifikation und Definition von Projekten und die Einrichtung eines gemeinsamen nachfrageorientierten Forschungsprogramms zur Systemintegration. Um den Schwerpunkt auf verschiedene priorisierte Forschungsbereiche zu legen, wurden mehrere Arbeitsgruppen eingerichtet, Wissenslücken und Finanzierungsquellen identifiziert, europäische Partner mit komplementären Kompetenzen kontaktiert und Planungen für Projektvorschläge erstellt.

Die enge Zusammenarbeit zwischen den Partnerregionen, die fokussierten Forschungs- und Entwicklungsaktivitäten zur Energiesystemintegration rund um die Nordsee und die Fortsetzung der Zusammenarbeit mit anderen Stakeholdern und Regionen sind das wichtigste Ergebnis der AP4-Aktivitäten, die im nachfolgenden Bericht detailliert dargestellt werden.

Zusätzlich wurde auf der ENSEA-Abschlusskonferenz in Edinburgh ein Empfehlungs- und Maßnahmenkatalog für die Politikentwicklung veröffentlicht. Dieser Katalog basiert auf den Ergebnissen von drei Jahren europäischen Stakeholder-Engagements in allen Energiesektoren, von Hochschulen und dem öffentlichen und privaten Sektor bis zur Zivilgesellschaft, von Bürgerinitiativen bis zur Generaldirektion Energie der Europäischen Kommission.

Hauptforderung aus den **Edinburgh-Empfehlungen** ist die Einrichtung eines Forums für Energiesystemintegration für die Nordseeregion. Dazu werden innerhalb der gesamten Themenbreite von Technologie, Politik und Regierungsführung, Infrastruktur bis hin zu gesellschaftlichem Engagement auf 24 konkreten Energie-Handlungsfeldern die bestehenden Barrieren und Schranken sowie die vorrangigen erforderlichen Maßnahmen zur Energiesystemintegration dargelegt.

IIb Summary

The project European North Sea Energy Alliance (‘ENSEA’), supported by the European Commission under the FP7 program ‘Capacities’ started on the 1st of October 2012 and ended on the 31st December 2015. The European Union supported the ENSEA project with a funding of three million Euros under the “Regions of Knowledge” program. The main strands within this project are to promote the cooperation between public, business and academic energy sectors (triple helix approach) and to facilitate the development of knowledge on energy system integration.

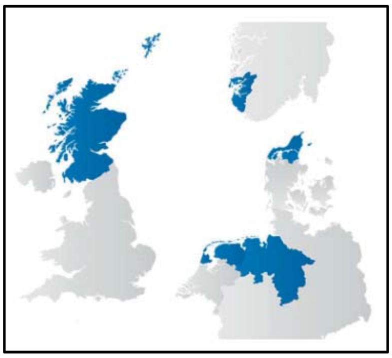
Core ENSEA knowledge regions are from the Northern Netherlands, Northwest Germany, Southwest Norway and Scotland:

The Netherlands: Energy Valley is a network organization working together with public and private partners in the Northern part of the Netherlands to explore growth opportunities in the energy sector. It focuses on energy innovations and the transition towards a sustainable energy economy which link up directly with national and international energy ambitions and regional strengths.

Lower Saxony in Germany: Wachstumsregion Ems-Achse e.V. is an association of companies, local authorities, academic institutions and chambers of commerce which aims to expand the Ems-Achse as an independent economic region, coordinating projects on economic infrastructure, network development and promotion of R&D activities; Energie-Forschungszentrum Niedersachsen (EFZN) – a joint scientific energy research centre contributing the expertise of five renowned Northwestern German universities to the project.

Norway: Rogaland with the University of Stavanger and the Centre for Sustainable Energy Solutions (cenSE) covering R&D activities on renewable energy and clean fossil-based energy; Rogaland County Council’s economic development unit with competencies within energy and R&D; the energy and telecommunications company Lyse AS owned by 16 municipalities in the Rogaland County.

Scotland (United Kingdom): Scotland’s main economic development agency Scottish Enterprise seeking to attract investors to Scotland and supporting Scottish companies to be more globally competitive; Energy Technology Partnership – an alliance of 12 independent Scottish universities engaged in world class energy research, development and demonstration; Scottish Renewables – the representative body of the renewable energy industry in Scotland with more than 330 member organizations.



Geographical location of triplehHelix-clusters of the European North Sea Energy Alliance (ENSEA)

Key objectives for the ENSEA project:

- Provide information and undertake (SWOT-) analyses on the roles, capabilities, connectivity, innovation capacities and current research approaches to R&D related to Energy Systems Integration of the ENSEA regions
- Develop a Joint Action Plan derived from the analyses implying an interregional energy strategy for the North Sea that focuses on specific themes related to Energy Systems Integration for which transnational/interregional cooperation is required
- Develop measures towards implementing the Joint Action Plan in order to contribute to enhanced cooperation in key areas of an integrated energy system
- Develop and strengthen a network of research-driven energy clusters around the North Sea that will promote the utilization of the Energy Systems Integration model as a management tool for a sustainable energy transition

Description of work performed and main results

In addition to the work packages "Management" and "Dissemination", the project is divided into the three successive work packages (WP) "Analysis of innovation capacities" (WP2), "Development of a Joint Action Plan" (WP3) and "Implementation of the Joint Action Plan" (WP4). Furthermore, an action catalog for policy development ("Edinburgh recommendations") was presented at the ENSEA final conference in Edinburgh.

The main focus of the work package 2, led by the Scottish Cluster, is the overall analysis of the innovation capacities in the ENSEA region, which aimed at identifying opportunities for cooperation. To this end, a methodological framework for the structure of the data to be collected was defined and coordinated among the partners for better comparability when providing information on research strengths and weaknesses, R&D expenditure, description of regional energy systems, funding and financing possibilities, existing cooperation, regional, national and international (energy) policies, regional strategies for intelligent specialization and metrics with regard to innovation capacities.

The collected data were used to describe the regional energy systems and SWOT analyses were carried out for each region. The results of the SWOT analyses were presented at workshops in the individual regions. In these workshops, the stakeholders of the triple helix organizations discussed the strengths, weaknesses, opportunities and threats identified in their regions. This ensured the active involvement of science, business and public administration right from the start of the project. Where applicable and necessary, the preliminary results of the SWOT analyses were adapted on the basis of these discussions and displayed in a regional report. Significant results from the regional analyses and the workshops carried out in the regions in the form of four separate regional reports are:

- The Energy Valley region: The Energy Valley region has a strong focus on gas, based on natural gas reserves and related production, transport, storage and research services. More recently, modern gas-related activity (e.g. based on green gas, small scale application of LNG, power-to-gas, gas and mobility) is increasingly a topic of innovative activity
- Northwest German Region: Lower Saxony in the Northwest of Germany turned out to be especially strong in renewables and technology development in, for instance: wind turbines, offshore technologies, biogas production, and energy storage. The Energy Valley and the North West Germany regions both share a rapid power production capacity increase as well as a rapidly growing offshore activity related to North Sea offshore wind

- Rogaland: The Rogaland region has substantial offshore oil and gas activities and is particularly strong in hydropower (flexible generation). It is interesting to note that the hydro capacity of Norway is, or will be, linked to the other regions of the ENSEA project by interconnectors in order to support grid balancing. Carbon capture and storage was identified as another area of particular focus and strength
- Scotland: Scotland, like Rogaland, also has a strong oil and gas cluster which shows a good collaboration between businesses and innovative researchers. Of significance to energy systems integration are power networks and smart grid development, along with systems integration methods (such as data management, information communication technologies and power electronics). In terms of renewables, the large potential resources of offshore wind and marine energy mark these areas particularly important for the region. Onshore wind was seen as an area of particularly high industrial activity.

In a further step, all the above regional and SWOT analyses were included in the analysis of the innovation capacities of the ENSEA region as a whole. To this end, the innovation characteristics of the four regions were analyzed using variables from the EU Innovation Union Scoreboard (IUS) and compared with those of all other EU regions. In addition, a RIS (Research and Innovation Strategies for Intelligent Specialization) analysis was carried out for each ENSEA region.

Summary of the most important results of the overall analysis report from WP2:

- The institutional framework for the promotion of interregional collaboration and cooperation on energy system integration around the North Sea has been regarded as indispensable in order to achieve further progress, but at the same time, is still rather weak and diffuse today. Triple helix organizations exist in the regions and function relatively well, but show a lack of international orientation which is needed to improve the networking of industrial and research activities and to translate these into successful innovation activities
- The large number of small and medium-sized enterprises (SMEs) in the regions do not only play an important role in the energy innovation process, but also in their capacity as subcontractors for larger enterprises. This is especially the case in the oil and gas exploration sector, where almost exclusively multinational companies play a leading role
- The examined regions clearly different emphases and focal points. The most important results of the various regional reports were translated into a set of tables that represented the relative strengths and weaknesses of the four regions through scoring. All regions achieved high levels for renewable energies. Demand flexibility achieved relatively low values; network- and infrastructure innovation was also low, except for Scotland due to its focus on smart grids. Integration methods had a special focus in Scotland. CCS was a focus in Rogaland and Scotland
- With regard to the opportunities and risks, all regions showed great optimism concerning the future role of renewable energy production in their energy system. Almost all regions are strong in the area of onshore wind. This is especially valid for Lower Saxony hosting two of the most important global industrial players. In addition, all regions (except Scotland) – with Lower Saxony as leading actor –are relatively strong in biomass. Offshore wind is relatively strong in Scotland, Rogaland and Lower Saxony; Hydroelectric power in Rogaland and Scotland; ocean energy in Scotland and energy from waste in the Energy Valley region

- As far as fossil fuels are concerned, the Energy Valley region stands out due to the strong gas sector in the Groningen field. Norway and Scotland also have a considerable oil and gas exploration sector
- The innovation characteristics of the four regions were analyzed using variables from the EU Innovation Union Scoreboard (IUS) and compared with those of all EU regions. The overall picture showed that the surveyed four regions showed well above-average values for both innovation, R&D activities and education. However, a deeper analysis of innovation showed some clear differences between the four regions. The analysis of the RIS (Research and Innovation Strategies for Intelligent Specialization) showed that both Lower Saxony and the Energy Valley region are innovation leaders, while Scotland and Rogaland have been classified as innovators followers. The RIS metrics also showed that stronger activity in the private sector is needed to generate benefits from innovation.

In the following **work package 3**, steered by the Lower Saxony cluster (Ems-Achse and EFZN), the tasks concentrated on the development of a Joint Action Plan (JAP). This plan consisted of four separate action plans for each region, as well as a JAP across all regions. Each of the four regional JAPs included a vision and strategy as well as a variety of energy system integration project ideas, which were matched with regional competence profiles and potential analyses, as well as with the EU's Strategic Plan for Energy Technology ("SET-Plan"). For the Joint Action Plan, a total of 160 projects have been identified that cover almost all the themes of European energy technology policy.

Work package 4 of the ENSEA project, led by the Norwegian Cluster, was based on the activities and results of the previous work packages. The main goal was to implement the Joint Action Plan and its related projects developed in WP3. The main objective is to establish ENSEA and thus the research facilities, regions and companies as a competence center for energy system integration for the North Sea region.

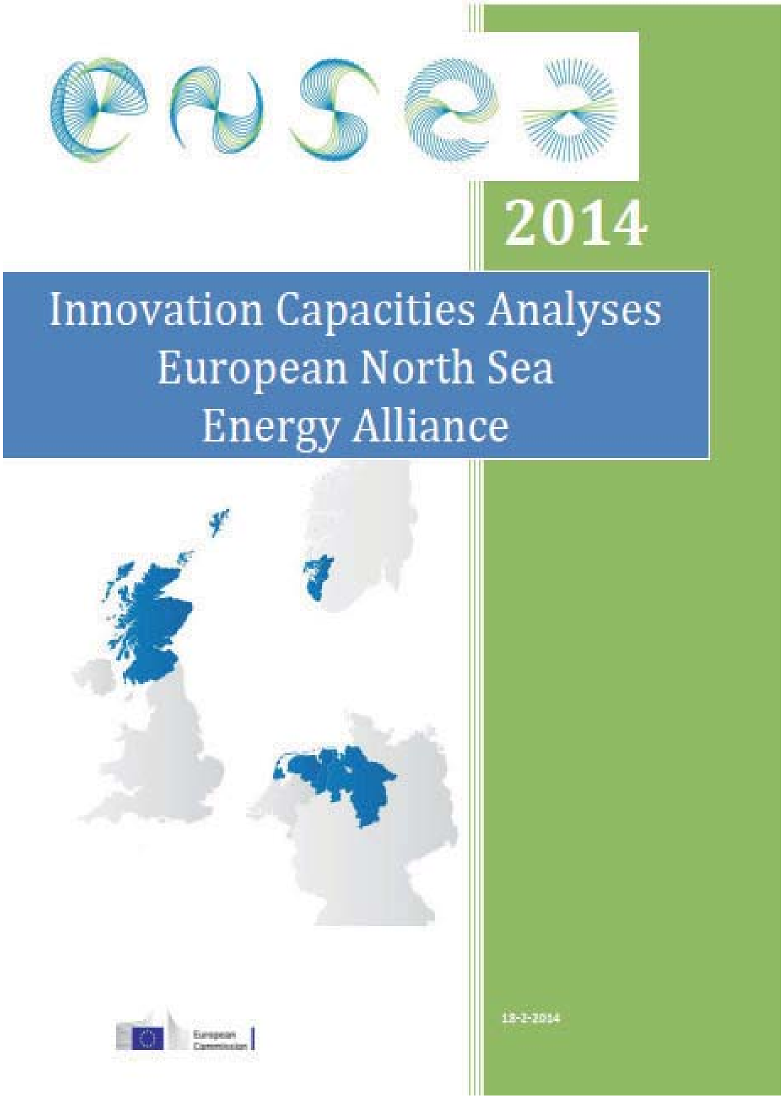
WP4 therefore focused on the internationalization strategies, the identification and definition of projects and the establishment of a joint demand-oriented research program for system integration. In order to focus on various prioritized research areas, a number of working groups have been set up, knowledge gaps and sources of funding have been identified, European partners with complementary competencies were contacted and plans for project proposals were prepared.

The close cooperation between the partner regions, the focused research and development activities for energy system integration around the North Sea and the continuation of cooperation with other stakeholders and regions were the most important result of the WP4 activities. They are described in further detail in this series.

In addition, a list of recommendations and measures for policy development was published at the ENSEA final conference in Edinburgh ("**Edinburgh recommendations**"). This catalog is based on the results of three years of European stakeholder engagement in all energy sectors, from universities and the public and private sectors to civil society, from citizens' initiatives to the European Commission's Directorate-General for Energy.

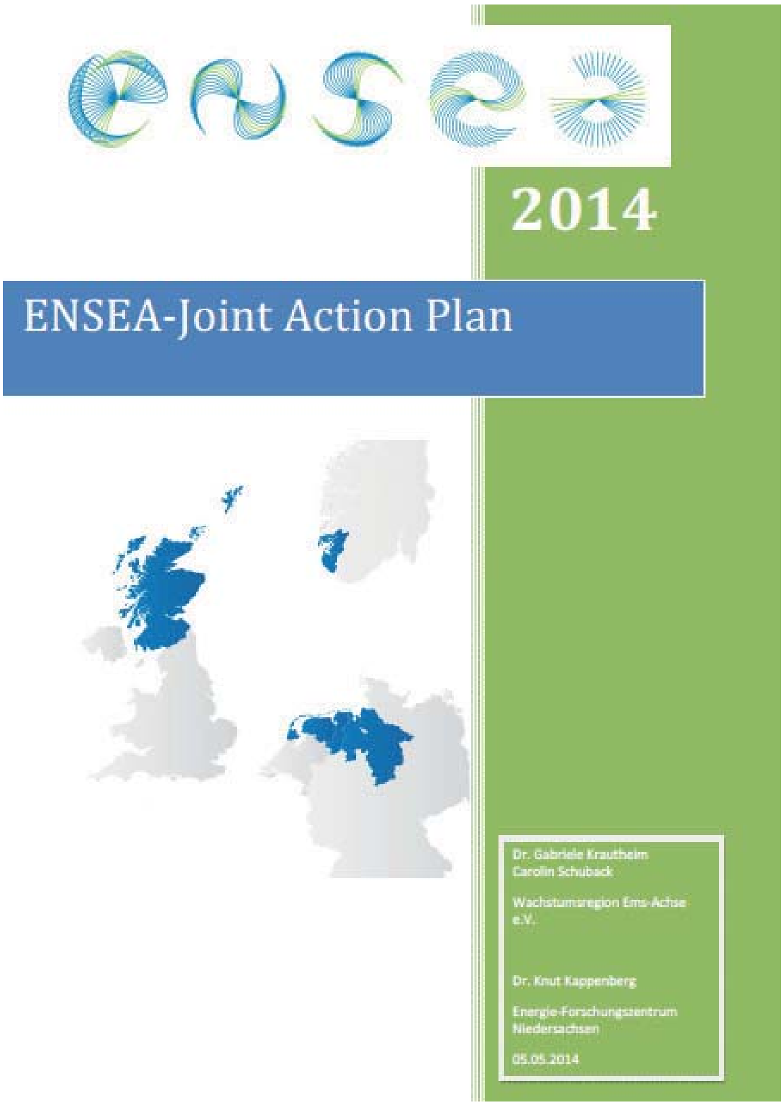
Main demand from the Edinburgh recommendations was the creation of a forum for energy system integration for the North Sea region. Therefore, the existing barriers as well as the priority measures necessary for the integration of energy systems were presented within 24 concrete energy fields of action that covered the entire range of topics of technology, politics and governance, infrastructure and social commitment.

III Innovation Capacities Analyses European North Sea Energy Alliance



s. pdf-Anhang (294 Seiten)

IV ENSEA 'Joint Action Plan'



s. pdf-Anhang (36 Seiten)

V Measures Towards Implementation of the Joint Action Plan

s. pdf-Anhang (65 Seiten)

VI Energy Systems Integration: The Agenda for the Future – Policy Brief

As the European energy landscape develops, the need to integrate our energy systems is increasingly recognized. Integration enables greater security of supply, higher levels of new and renewable low-carbon energy sources, reductions in the cost of energy, and requires increased deployment of low-carbon infrastructure. It compels us to create a system reflective of our changing energy use, and the changing energy landscape.

What is not as clearly understood, however, is how best to achieve the integration required. To be successful it must occur at all scales and in all sectors. It demands a holistic approach and coordinated, long-term policy commitment.

The European North Sea Energy Alliance (ENSEA), an EU-funded project looking at Energy Systems Integration (ESI) around the North Sea regions, has brought together experts in the field to discuss key issues and priority actions for enabling ESI across Europe. We present our priority actions below.

There are many organizations across Europe which could pursue these actions, however for the purposes of this report the actions are addressed primarily to the European Commission and the Directorate Generals for Energy, Climate Action, Enterprise and Growth, Digital Agenda and Consumers.

Definitions

Energy Systems Integration (ESI) describes the optimization of the design and performance of the supply of all forms of energy (electricity, heat, transport fuels and others) at all scales (consumer, community, regional and inter-regional).

Quadruple-helix approach refers to bringing together academia, industry, the public sector and civic society to work together.

The benefits of integrated energy systems

Integrating our energy systems brings multiple benefits to different players – from generators and consumers to system operators. We outline below how bringing our energy systems together can have positive effects on the three pillars of the energy trilemma.

Security of Supply: Bringing together different areas of our energy systems reduces our dependence on particular sources of energy. Variable generation is better managed in an integrated system and actively managed networks reduce the likelihood of outages and grid constraints. Energy systems integration creates resilient energy networks encompassing a wide range of technologies. Crucially, it reduces the need for imports from outside the EU and reduces the need to use finite energy sources.

Cost savings: Integrating our energy system drives efficiencies. Consumption can be reduced and smart systems mean less wasted energy. These energy efficiencies equate to cost savings for both businesses and consumers. By minimizing reliance on hydrocarbons, consumers are protected from their volatile costs.

Low-carbon generation: Energy systems integration enables better use of our low carbon generation capacity. For example, integrating wind power with energy storage, or converting excess renewable electricity to hydrogen for alternative uses, means that more of our generation can be low and zero-carbon. Energy systems integration supports energy efficiency measures, heat networks and decarbonized transport, helping to integrate renewable generation into the energy system.

The Vision

Our energy system is locked in a 'trilemma' as we try to balance the need for secure energy supplies, low-carbon sources, and affordable consumer costs. If we are to tackle the energy trilemma we need to see an integrated energy system where:

1. There is a holistic approach to energy systems policy-making and governance.
2. Integration is achieved through cooperation between the 'quadruple helix' of academia, industry, civic society and the public sector.
3. The public is educated and engaged, with 'pro-sumers' a key element of our demand and generation profile.
4. Policy aims to harmonize markets and frameworks for integration across Europe.
5. Infrastructure that facilitates integration between different energy sectors is prioritized.
6. Ambitious EU-wide R&D programs underpin continual technology development.
7. Data are shared and Active Network Management occurs at scale.

Key Barriers and Recommendations

Significant changes need to be made before our current energy system can resemble the holistic system we need to create. We outline below what we consider to be the key barriers to creating an integrated energy system across Europe within the four (overlapping) areas of *Technology; Infrastructure; Policy, Governance & Markets*; and *Consumers*. Through detailed stakeholder engagement across the 'quadruple helix', ENSEA has identified a series of priority actions to help overcome these barriers.

Principal Recommendation

Establish an Energy Systems Integration Forum to address in a holistic way the issues of Policy and Governance, Technology, Infrastructure, and Consumer Engagement.

The relevant Directorates of the European Commission should work together to seek new models of cooperation to encourage quadruple helix, cross-discipline and cross-sector collaboration.

Technology

We welcome the European Commission Communication "Towards an Integrated Strategic Energy Technology (SET) Plan" and the inclusion of energy demonstration projects in the Horizon 2020 program. However further action is necessary to fully and holistically address systems integration and to get genuine commitment. This includes the following action areas.

Action Areas:

1. Ensure continued R&D funding is made available for technology development and system integration research.
2. Encourage uptake of EU-level frameworks and guidelines which can support long-term stability and comparability of national support schemes.
3. Create a pan-European Energy Systems Integration demonstration roadmap, mapping existing demonstration projects as well as potential future projects.
4. This requires establishment of a cross-discipline, cross-sectorial technology grouping.

5. Create a pilot 'Energy Island' which is connected to a national energy network to test theoretical ideas in a location which isn't isolated. This would prove/disprove the feasibility of various technologies.
6. Involve SMEs working in the field through engagement programs to ensure coordinated approaches to technology development.

Infrastructure
Long lead times for energy infrastructure mean there is a need for strategic planning. Existing infrastructure needs to be better utilized, with priority infrastructure projects identified and network design improvements coordinated.

Action Areas:
7. Conduct gap analyses and determine top priority European infrastructure projects.
8. Launch a project turning selected existing assets into test-beds for new and smart systems.
9. Conduct a series of projects scaling-up the injection of hydrogen and bio methane into the grid.
10. Analyze the energy performance of cities using future cities technologies for integrated energy systems.
11. Develop auditing tools and frameworks for zero carbon zones and communities.
12. Develop a 'smart-neighborhoods' project focused on district heating, assessing roll-out potential from existing demonstration projects.
13. Coordinate an approach to develop all scales of storage solutions.
14. Develop a feasibility study and/or test cases for infrastructure synergies and Intelligent ICT pilot programs.
15. Create a pan-European network design roadmap, mapping existing infrastructure projects as well as potential future projects.
16. Conduct a SWOT analysis of discrete energy networks that have been designed latterly to identify strengths and weaknesses, and assess potential replicability.
17. Conduct an infrastructure ownership assessment and drive results into policy and regulations.

Policy, Governance and Markets
While we welcome the Energy Union strategy we recognize that further efforts are required to implement a holistic European approach to policy, governance and markets. Climate change considerations must be central to the European energy strategy: ambitious and binding targets need to underpin a multidisciplinary approach to projects, and regulatory landscapes and market mechanisms should be synergized.

Action Areas:
18. Establish binding targets and a strong governance framework for carbon reduction targets out to 2050 and energy efficiency incentives to create an appropriate investment climate into clean-technology development.
19. Assess the policy initiatives in the Energy Union strategy which can aid the facilitation of Energy Systems Integration.
20. Encourage uptake of EU-level frameworks and guidelines which can support long-term stability and comparability of national support schemes.
21. Develop frameworks for, and implement, zero-carbon zones in areas across member states, which are linked to technology demonstration zones and integration-enabling infrastructure projects.

22. Require all EU-funded energy projects to have a steering committee in place with a quadruple helix structure.
23. Develop an EU-wide position paper on principles for local governance of integrated, low-carbon, energy systems.

Consumers

The Commission's 'New Deal' for consumers initiative, and focus on consumer savings, choice and protection is welcome, particularly with regard to tackling fuel poverty. However, the role of the consumer within a more integrated energy system will change. Consumers will become 'pro-sumers', both generating and consuming energy. Appropriate structures to facilitate this transition for consumers (and communities, through the democratization of energy governance) need to be developed.

Action Areas:

24. Encourage national and/or regional governments to consider suitable local approaches for community-level engagement in energy projects

Conclusion

The energy system Europe needs looks very different from our system today. To tackle the energy trilemma – ensuring secure and cost-effective energy supplies while reducing carbon emissions – we need to integrate all parts of our energy system at all scales. This report has presented the barriers to reaching that vision and sets out what we believe to be the priority actions required to overcome those barriers.

Our findings are based on three years of stakeholder engagement with all energy sectors, academia, the public and private sectors, and community energy specialists across Europe and internationally – from grass-roots activity through to representatives from the European Commission and DG Energy. Our research is thus some of the most comprehensive on the topic and we would strongly encourage our recommendations be given full consideration in future policy development.

2014

Innovation Capacities Analyses European North Sea Energy Alliance

European Commission

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Table of Contents

Executive Summary

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1 Introduction

This study is the first substantive result of the collaboration of the partners in the European North Sea Energy Alliance (ENSEA) project. This project is supported by the European Commission through the Seventh Framework Program for Research and Technological Development (FP7) and started in October 2012.

ENSEA aims to increase the competitiveness of research-driven energy clusters through better coordination and exploitation of research to support innovation in Energy Systems Integration.

Energy Systems Integration (ESI) describes the optimisation of the design and performance of the supply of all forms of energy (electricity, heat, biofuels and other fuels) at all scales (end user, local community and regional levels). It incorporates consideration of the interactions and interdependencies between the energy system and other systems; such as economic, data, regulatory and social dimensions. Energy systems are currently undergoing considerable change as the European Union (and other regions and countries) seeks to transition away from fossil fuels and cut carbon emissions. ENSEA seeks to better understand, and make use of, potential co-benefits that increase reliability and performance, reduce cost, and minimise environmental impacts.

Energy activity in and around the North Sea is growing rapidly for a number of reasons and considerable innovation can be found in this region which is related to all kinds of technologies and energy carriers. However, a clear vision about how all this energy innovation hangs together, how it could be coordinated and what would be required in terms of organisation and collaboration, is simply absent. In order to get solid North Sea energy system integration machinery off the ground that is robust enough to provide the EU industrial heart with sustainable and renewable energy, formidable organisational effort and challenges still lie ahead, such as:

- Balancing the future grid, given the substantial increase of intermittent resources;
- Developing sufficient new storage technology and capacity;
- Organizing sufficient backup facilities;
- Managing demand;
- Lining up the various grid systems connecting the various sources of supply and demand of energy;
- Dealing with the decommissioning challenges and turning this into new opportunities for sustainable energy production and storage;
- Involving smaller companies in energy transition activity; and
- Organizing, not only supporting research and development, but also training activity.

None of these challenges can be tackled without good professional triple-helix support and international cooperation, collaboration and co-investment and design.

In the ENSEA project, the partner organisations are comprised from the leading energy triple helix (industry-government-academic research and development) organisations in each of the four partner regions; North Netherlands, Lower Saxony (North West Germany), Rogaland (South West Norway) and Scotland. Together, the ENSEA partners are estimated to cover and represent about half of the innovative energy research and development capacity around the North Sea.

In preparing this study a large group of experts from the four regions has worked intensively together in the last year. As well as regular teleconferences and use of other electronic means to exchange information, several joint workshops have taken place.

In order to be able to initiate new joint initiatives, a review was undertaken to identify regional strengths, weaknesses, opportunities and threats (SWOT Summary) in relation to Energy Systems Integration, and illustrate the capabilities of the partner regions. The results of the study are summarised in this Work Package 2 Report. The types of questions covered included:

- What distinguishes the regions in this regard?
- What have the regions in common?
- What are the particular strong points in one region or in the other?
- What can be said about existing networks, initiatives, triple-helix strengths?
- What are the key players in the area of energy system integration?

In the following sections, an overview is provided for each of the four regions of their activities in relation to Energy Systems Integration. It covers aspects such as; the main organisations involved in research and its exploitation, the drivers of innovation, key policies, and support mechanisms. The work illustrates, not only what is going on in the regions, but also assesses in which aspects are considered to be relatively strong or weak.

In comparing the four regional reports, it became clear that there are a number of clear similarities between the regions, such as: the general difficulties of involving small and medium sized enterprises in the triple-helix innovation process; the challenges of linking academic research to business activity; the lack of communication and coordination between the traditional fossil fuel based companies (and related stakeholders) and the newer, renewable ones; the lack of a sense of urgency to change thinking along the lines of energy system integration; or the generic lack of a collaborative vision on how to develop the North Sea area as an energy region.

On the other hand, the regional overviews revealed quite distinct differences between the regions, as described below:

The Energy Valley region, for instance, has a very strong focus on gas based on natural gas reserves and related production, transport, storage and research services. More recently, modern gas-related activity (e.g. based on green gas, small scale application of LNG, power-to-gas, gas and mobility)is increasingly a topic of innovative activity.

The North West of Germany turned out to be especially strong in renewables and technology development in, for instance; wind turbines, offshore technologies, biogas production, and energy storage. The Energy Valley and the North West Germany regions, both share a rapid power production capacity increase, as well as a rapidly growing offshore activity related to North Sea offshore wind.

The Rogaland region has substantial offshore oil and gas activity and is particularly strong in hydropower (flexible generation).It is interesting to note that the hydro capacity of Norway is, or will be, linked with the other regions in the ENSEA project through interconnectors in order to help with grid balancing. Carbon capture and storage was identified as another area of particular focus and strength.

Scotland, like Rogaland, also has a strong oil and gas cluster which shows good collaboration between business and innovative researchers. Of significance to energy systems integration, power networks and smart grid development along with systems integration methods (such as data management, information communication technologies and power electronics) are clear areas of focus. In terms of renewables, the large potential resources of offshore wind and marine energy mean these areas are of particular importance for the region. Onshore wind was seen as an area of particularly high industrial activity.

In very general terms, the ENSEA regions taken together show strong coverage of all of the key thematic areas identified as being important for Energy Systems Integration (with the exception of demand side flexibility – however even here there was activity). All of the regions were very focused on renewable energy technology development, with particular specialization being indicated for biomass and onshore wind. Almost every renewable technology was identified as an area of strength in at least one of the regions (with the exception of solar and geothermal technologies).

The various similarities and differences between the four regions cannot take away the overall impression that the scope for collaboration between these four important North Sea energy regions, so far has remained grossly underutilized. If the North Sea area further develops as planned, (i.e. offshore wind, marine power and other renewable capacities grow manifold during the next few decades) and if the North Sea energy system is to develop into an integrated energy system, fuelling a substantial part of EU industry and services, then there is still much to be done to make this happen.

This study provides a first step, by sketching the scope for collaboration between the four regions linked together in the ENSEA project. Clearly, the networks need to be strengthened, not only the physical ones, but also the organisational ones. Based on the inventory in this study, the next step in the ENSEA project is to define a number of concrete common initiatives that will serve to strengthen and expand these networks.

2 Main findings and conclusions

Before summarising the main conclusions drawn from the review of activities, capabilities and SWOT analysis related to Energy Systems Integration, some caveats should be highlighted:

Firstly, although the four regions in the ENSEA project cover a substantial part of North Sea area energy and energy research activity, they do not provide a complete picture of all activity in and around the North Sea. In other words, the ENSEA regions are representing the interests of the North Sea region, with a view to expanding the Alliance around other regions of the North Sea.

Secondly, although substantial quantitative and qualitative data and information was gathered in relation to ongoing innovation activity in the regions, not all the data was verifiable and/or available at appropriate regional scales from official statistics and sources. Consultation and contributions from expert energy sector stakeholders, and perspectives from literature and other qualitative information, were used to complete the overview and the SWOT analysis. The review of available data helped ENSEA identify the key data gaps crucial to supporting increased energy systems integration. Nonetheless, the ENSEA team are confident that the broad picture, as provided in the regional analyses, is a fair and proportionate representation of the ENSEA regions.

Thirdly, while available quantitative data was collated for comparative assessment, the overall scores provided by the regions are a reflection of individual region's areas of focus and strength. Each region used different data for this and as such, it provides a guide of relative strengths within regions rather than an absolute comparison between regions.

Fourthly, innovation processes are inherently difficult to predict. New policy regimes, new inventions, new industry players, or new coalitions, can fundamentally alter choices of technology for the future. Also, public acceptance issues can play an unexpected role, as for instance, has become clear with respect to Carbon Capture and Storage (CCS), but increasingly with onshore wind. Possible future public acceptance issues may arise with hydrogen production, transport and storage. Technological developments for which once had great potential, can therefore be slowed down or even ruled out. When assessing opportunities and threats for energy systems integration, one therefore, has to recognize the position that innovation processes and outcomes may well turn out to be quite different in the future, from those anticipated now.

Keeping the above caveats in mind, a number of general observations drawn from the regional data are summarised below (paragraphs A-M):

A: Energy Economy in North Sea Region.
The energy industry makes up a substantial part of the economy of all of the ENSEA regions. They are net energy exporters, often of both fossil and renewable energy. On the whole, the energy activity in the regions is a very high proportion of economic and research activity and is rapidly growing. In all regions, one clearly sees a shift of energy production and storage towards the coastal regions, which considerably enhances economic activity in those regions. In short, energy activity acts as an economic and innovation elixir for the regions bordering the North Sea.

B: Energy Transition Activity in the North Sea Region.
The shift of energy activity towards coastal regions is strongest, as far as energy transition activity (the shift from fossil to renewable energy) is concerned. What is striking in the ENSEA review, is that both traditional, fossil, and renewable energy activity, is rapidly growing in the

regions. On the one hand, various fossil power plants are situated in the regions, with significant natural gas production, transport and storage taking place, as well as oil exploration and production. On the other hand, there is a massive extension of wind capacity, bio-based activity, hydro-power production and, to a lesser extent, solar activity taking place in the same regions. In fact, renewable generation is considered to be a strong point in all four regions.

C: Energy System Integration in the North Sea Region.
Another general impression from most of the regional reviews is that fossil and renewable energy activities,, suffer from a lack of integration. Not only are most of the fossil and renewable investment and innovation activities in the hands of many different organisations, but also in research and innovation activities there appear to be some barriers between fossil and renewable energy activity. If, in the future development of energy system integration, both worlds will have to integrate, then there is likely to be a significant integration and coordination challenge. In Germany, the situation is somewhat different because of the "Erneuerbare Energien Gesetz" (German renewable energy law). There is no strict separation of fossil fuels and renewable energy. Usually energy providers operate both forms of energy generation and research investigations are issue-related, meaning researchers can be concerned with both areas.

D: Triple Helix Collaboration in the Energy Sector.
The triple helix concept is generally seen as a precondition for innovation success. All the regions do have a well-established triple helix partner collaboration dedicated to supporting industry, research and public energy perspectives and innovation. On the whole, collaboration between the various stakeholders within the regions is rapidly improving, but even so, still requires much improvement. Initiatives for new technological development often come from the research community rather than the industry, while local governments, on the whole, play a positive role in supporting such activity. Increasingly, public-private collaboration is used a precondition for public funding. However, linking industry and research activity, and translating it into successful innovation activity is often one of the greatest challenges.

E: SMEs and their Role in the Energy Sector.
On the whole, the large number of small and medium-sized enterprises (SMEs) in the regions, play an important role in the energy innovation process, but mostly in their capacity of sub-contractors to the larger companies. This is especially the case in the oil and gas exploration sector, where huge multinational firms tend to play the leading role, and sub-contract a wide range of activity to smaller enterprises (often but not always, located in the region). In the renewable energy sector, SMEs tend to play a larger role, but on average, collaboration between smaller enterprises and the research community are relatively weak.

F: Interregional Cooperation & Collaboration in the North Sea Region.
As a general impression the institutional setting for furthering interregional cooperation and collaboration on energy system integration, around the North Sea, was considered to be indispensable for further progress, but also as still being fairly weak. Triple helix organisations do exist in the regions, and function on average relatively well, but still have too little international focus. A triple helix organisation, or at least organisational framework, for energy covering the whole North Sea area is not in existence, but seems a logical next step in modernising the North West European energy system. One of the key challenges is not only to combine the various research resources in the regions, but also to make better links between official decision-making bodies. Above all, it would be most beneficial to unite the key players from the North Sea region's private sector, both from the fossil and renewable world. The latter challenge seems the most demanding of the three, and may therefore require prior research and public authorities' North Sea network- building.

G: Regional Innovation Bench-Marking against EU Member States

The innovation characteristics of the four regions, compared with those of all EU regions together, have been analysed using the variables covered by the EU's Innovation Union Scoreboard (IUS). This approach developed an approximate Regional Innovation Scoreboard (RIS) for the ENSEA regions which broadly enabled comparison of the regions (or wider regions where data was not available) considered against a benchmark of all the EU 27 member states. A few of the main findings in comparing the ENSEA regions' innovation potential, with that of the EU average are:

- a relatively highly educated population (except for Lower Saxony scoring about EU average);
- a relatively high level of public R&D expenditures (some 25-50% higher than EU regional average);
- a relatively high level of R&D expenditure in the business sector (especially in Lower Saxony and Rogaland); and
- SMEs with a strong focus on innovation and collaboration with others, in order to strengthen such innovation are clearly over-represented in the regions (except for Scotland, where commercialisation activity is around EU average).

All in all, the four regions, if compared to the EU average, show above average innovation and R&D activity and collaboration along with a population with a relatively high level of education.(More detailed information is provided in the following summaries).

H: Energy Activity Overview for the ENSEA Regions.

The various regions all have clearly different areas of focus. The main results from the various regional reports above have been translated into a simple set of tables in which the relative strengths and weaknesses of the four regions are represented through relative scoring (see tables below). If one takes the ways to try to deal with the balancing constraints as a starting point for differentiation, that is to say: supply flexibility, storage, demand flexibility, grid/infrastructure, integration methods, integration boundary conditions, some regions have a strong focus on one element and other regions on others. Together, however, the regions cover all of the thematic areas that are seen as important for delivering Energy Systems Integration.

All regions have significant innovation activity concentrated on renewable generation. This illustrates the strong focus on energy transition in the regions, and a high perception of the future potential for renewable energy. Less innovation was focused on demand flexibility, although there is activity in this area in Germany and Scotland. Grid/ infrastructure development was, on average, slightly less high on the innovation agenda, apart from in Scotland where there is a clear focus on Smart Grids. Clear differences in emphasis could be seen in integration methods (data management, ICT and modelling, etc.), which was considered one of the specialisations in Scotland, boundary conditions (economic, legal and social aspects), which were considered to have a strong focus in the Energy Valley region, and Carbon Capture and Storage, mainly in Rogaland with potential in Scotland.

Table A: Summary of Indicative analysis of ENSEA regional activity in relation to key energy systems integration themes.

Themes	Scotland	Energy Valley	Ems-Achse	Rogaland
Supply flexibility	+	+	++	++
Storage		++	++	+
Demand flexibility	+		+	+
Grid / Infrastructure	++		+	
Integration Methods	++	+		+
Boundary Conditions	+	++	+	
Renewable generation*	++	++	++	++
Carbon Capture & Storage	++	+	Moratorium	++

Table key:

++ Area of high activity or strong focus for a region

+ Area of medium activity or good focus for a region

Area of lower activity or less focus for a region

Important Note: *The table above provides an indicative synthesis of extensive information covering several dimensions for each theme (e.g. technical maturity, research capability and capacity, economic activity, etc.). It should not be interpreted in isolation from the more detailed information and summaries on regional characteristics or strengths in the main reports.*

I: Renewable Energy Activity in the ENSEA Regions.

As far as renewable energy activity is concerned, the summary table below provides a broad picture. Almost all the regions considered themselves strong in the areas of onshore wind - for example two global industrial players are situated in the Ems-Achse region. Furthermore, all regions, apart from Scotland, are relatively strong in biomass. Offshore wind is relatively strong in Scotland, Rogaland and Ems-Achse; hydropower in Rogaland and Scotland; marine power and offshore wind in Scotland; and energy-from-waste in the Energy Valley region.

Table B: Summary of Indicative analysis of ENSEA regional activity in relation to renewable energy themes.

Themes	Scotland	Energy Valley	Ems-Achse	Rogaland
Wind onshore	++	++	++	+
Wind offshore	++	+	++	++
Solar	+		+	+
Geothermal		+	+	+
Biomass	+	++	++	++
Hydropower	+			++
Marine power	++	+		
Energy from waste	+	++	+	

Table key:

++ Area of high activity or strong focus for a region

+Area of medium activity or good focus for a region
Area of lower activity or less focus for a region

Important Note: *The table above provides an indicative synthesis of extensive information covering several dimensions for each theme (e.g. technical maturity, research capability and capacity, economic activity, etc.). It should not be interpreted in isolation from the more detailed information and summaries on regional characteristics or strengths in the main reports.*

J: Fossil Energy Activity in the ENSEA Regions.

As far as fossil energy is concerned, the very strong gas sector, based in the Groningen field in the Energy Valley region, is outstanding. Norway and Scotland also have a very considerable oil and gas exploration sector, mainly onshore. Even so, innovation seems to be much more focused on renewable energy, system integration and the various boundary conditions. It is likely that a considerable part of the innovation activity in the fossil energy sector is covered by in-company research and innovation activity,(rather than the more public-private oriented innovation activity in the renewables sector) and is therefore, less easily quantifiable.

K: Regional Innovation in the ENSEA Regions.

In terms of innovation there are some clear differences between the four regions; on average the RIS results suggested that Energy Valley and the Lower Saxony region had characteristics of innovation leaders whereas, Scotland and Rogaland were classed as innovation followers. The RIS metrics also suggested that, on average, higher activity in the private sector is needed to generate tangible benefits from innovation. For example, Scotland has a relatively well educated workforce, good research base and public spending levels, but is not sufficiently benefiting from this (in the way that Lower Saxony is) because of its weaker private sector activities. In particular, Ems-Achse is characterized by intense cooperation of the 400 cluster members within the triple helix structure. Rogaland has above average EU metrics for human resources, research and private sector innovation but below average for SME innovation. Energy Valley, scores well on SME involvement, but the linkages between the research community and private activity could be improved.

L: Opportunities & Threats in the ENSEA Regions.

As far as the opportunities and threats are concerned (see the table below), all regions show a great optimism towards the further extension of the role of renewable generation in the energy system, and in these regions, playing a vital role in the ongoing energy transition. On average, innovative energy activity is seen as a promising and booming area of economic performance. At the same time, the regions clearly indicated that such levels of optimism would be lowered, if the national and European policy regimes towards renewables should alter or slow down. All regions see great benefits in further collaboration within the region between triple helix partners, but above all, increased collaboration is critical between the regions around the North Sea.

Table C: Summary of opportunities and threats in relation to ENSEA regions

	Opportunities	Threats
Political	• EU harmonisation creates opportunity to address shortfalls in ENSEA regions • EU and ENSEA regions' ambitious energy targets	• Continuing uncertainty about policy support for renewables and other green policy targets • Disruption caused by EU periphery problems could cause instability in the market and lack of confidence from investors.

Economic	• Skilled engineering companies in ENSEA regions • Strong demand for energy / energy services outside these energy / energy services exporting regions (World energy demand is set to double at least, by 2050) • Very large source of renewable resources available in region. • Energy Systems Integration has the potential to provide a solution, to not just high levels of renewables, but also to network congestion and ageing.	• Magnitude of capital outlay required to delivery policy targets on renewables and network upgrades may be difficult to achieve without subsidies or industrial support. • Rising energy prices may impact negatively on renewable policy. • Supply chain for new sectors might not develop, which may mean activity will not be by firms in the North Sea region. • Oil industry is likely to continue to dominate energy sector and this may stifle development of alternatives.
Societal	• Energy price spikes and shortages create a public awareness of the need for solutions to lack of integration of energy systems.	• Consents and planning issues - public resistance to new projects may grow, slowing energy developments. • Solutions to resolving energy systems integration issues require changes to consumer behaviour. This may take some time and encounter difficulties if consumers do not have informed choices or sufficient support.
Technological	• Diverse mix of energy resources, technologies and services in the North Sea region creates a good base for developing ESI solutions. • ESI is a flexible solution that can include a variety of local and regional solutions and developments (e.g. hydropower in Norway, wind power in Lower Saxony, etc.) • Data management is getting cheaper which may facilitate systems integration. • Developing cross-boundary markets and new business models to support ESI.	• 2020 targets rely on a very demanding new renewable capacity • Development of common standards may be required to support Energy Systems Integration (ESI) and this is likely to be complex and take time. • Decommissioning of existing conventional generating capacity could create challenges that may divert industry focus from ESI. • Access to, and ownership of, data for ESI could become problematic. • Some of the optimum renewable resources are in technically challenging areas.
Environmental	• Common and ambitious policies on Climate Change across EU/globe. • North Sea region's diverse geography presents a broad range of natural test beds for energy technologies to support energy system integration solutions.	• International and national policies on climate issues, renewables, energy system integration, and efficiency, develop slowly and in a stop-go fashion, such that incentives are often unpredictable and create market uncertainty. • Environmental concerns could impact the delivery of new renewable capacity, both on and offshore.

General Introduction, Scope and Methodology

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18th February 2014

European Commission
CAPACITIES

1 Introduction

To deliver its "20-20-20" climate and energy goals (and other policy objectives), the supply of energy in the European Union will have to be changed rapidly over the coming years to accommodate more renewable energy.

The European North Sea Energy Alliance (ENSEA) aims to increase the competitiveness of EU regional energy clusters, situated around the North Sea, through better coordination and exploitation of innovation focused on Energy Systems Integration (ESI). As well as assisting delivery of the EU’s policy goals, successful exploitation of innovation in Energy Systems Integration will boost the competitiveness of industry, regional clusters and the European economy in general.

Power output from renewables can be highly variable; therefore, successfully managing it to continue to supply affordable and reliable power to end-users will need a combination of more energy storage, flexible thermal generation, increased interconnection between neighbouring power networks and demand-side management. Energy System Integration describes the optimisation of the design and performance of the supply of all forms of energy (electricity, heat, Biofuels and other fuels) at all scales (from end user, local community, to regional or continental levels). The scope of Energy System Integration is covered in the ENSEA project by eight broad areas which in turn cover 42 sub-topics (shown below).

Target outcomes for the ENSEA project include:

- better coordination of research, exchange of knowledge and staff through the development of joint demand driven research;
- strengthening basic and applied RTD (Research and Technology Development) by facilitating collaborations and commercialisation of results between different institutions of the cluster to secure the right focus in research and to ensure implementation of results;
- strengthening connections and RTD collaboration by facility sharing measures that improve access to unique and cost-intensive RTD facilities both within and between the clusters, and so facilitate more cost-effective energy research;
- support technology transfer by bringing entrepreneurs and researchers together, facilitating financing opportunities and infrastructure for start-ups;
- capitalising on international links, including existing collaborations with the Sichuan Region in China, through the development of a joint internationalization strategy.

Energy Systems and Energy Systems Integration

Energy Systems Integration (ESI) describes the optimisation of the design and performance of the supply of all forms of energy (electricity, heat, biofuels and other fuels) at all scales (end user, local community and regional levels). It incorporates consideration of the interactions and interdependencies between the energy system and other systems; such as economic, data, regulatory and social dimensions. Energy systems are currently undergoing considerable change as the European Union (and other regions and countries) seeks to transition away from fossil fuels and cut carbon emissions. ENSEA seeks to better understand, and make use of, potential co-benefits that increase reliability and performance, reduce cost, and minimise environmental impacts. ENSEA is focused on innovation to support Energy Systems Integration for the North Sea region, both within the four current project partner regions, the neighbouring regions and as appropriate, at national levels.

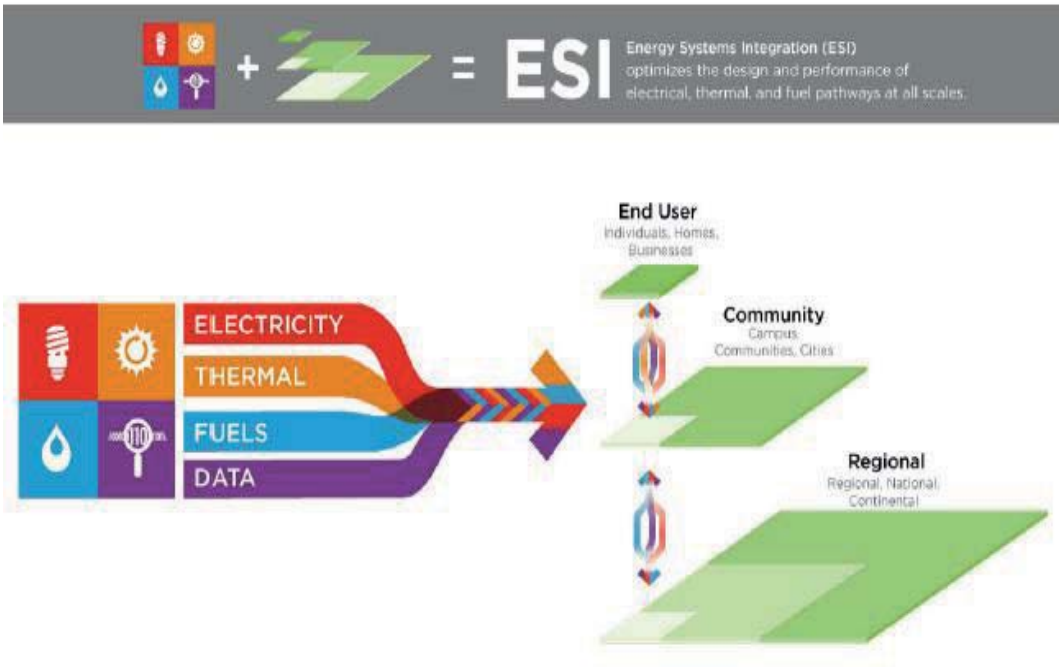

Figure 1: Illustration of Energy Systems Integration (ESI)

1.1 ENSEA Project Partner Organisations

The ENSEA regions will capitalise on the current successful collaboration between the Northern Netherlands and North Western Germany (the Hansa Energy Corridor) extending this approach to Scotland and South West Norway. Based on this FP7 project, further expansion of ENSEA to other regions around the North Sea is envisaged.

Lead partner – the Energy Valley (North Netherlands)

The Energy Valley has a national status and is supported by a wide range of large sized business and municipalities bringing all sort of specialized knowledge into the Energy Valley cluster. Examples are Groningen Seaports, Alliander, Enexis, Eneco, KEMA, TAQA, PWC and the municipalities of Assen, Emmen, Den Helder and Alkmaar. In addition the Energy Valley platform enjoys membership support from about 150 small and medium sized enterprises actively pursuing business opportunities in the national and international energy industry. This combination of support has proven to be a highly effective vehicle in bolstering businesses, facilitating investments and increased employment opportunity locally, regionally, nationally and in the future internationally by means of ENSEA.

Wachstumsregion Ems-Achse (North West Germany)

Ems-Achse partners represent a joint economic region in Lower Saxony aiming to advance economic growth and increase employment. This is achieved through development and implementation of different projects and the advancement of communication between the companies to gain and amplify knowledge. The economic region Ems-Achse, founded in 2006, profits from the close and faithful collaboration between companies, local authorities and academic institutions. Six working groups, chaired by the administrative districts, have been formed, addressing and advancing the main topics of the regional economy. Many renowned projects have been realised which are strengthening the transnational collaboration and the different industries. Within this structure, the Landkreis Aurich is responsible for the theme "Energy". That economy, science and politics are linked within the Wachstumsregion Ems-Achse, is demonstrated in the working groups, various networks, collaborations and Interreg-projects.

Rogaland (South West Norway)
Rogaland is a research intensive region in South West Norway with an internationally renowned university in the energy field and two research institutes specializing in energy research with strong industry collaboration. Rogaland is the centre for oil and gas exploration (oil and gas capital of Norway) and therefore many small and big companies specialized in the energy field. Many of these companies are also involved in renewable energy research. Natural gas is exported from Rogaland (Kårstø) to Europe (e.g. Emden) and is crucial for Europe's Energy security. Rogaland is known for its successful triple helix and is characterized as the most innovative region in Norway. This is due to a strong energy sector with many innovative companies creating spin- offs and start- ups. Rogaland is one of the biggest producers in Norway of hydropower, and has strong plans for utilizing biogas for district heating and in the transport sector.

Scotland (United Kingdom)
The Scottish cluster in ENSEA is represented by the triple helix of Scottish Enterprise, University of Strathclyde (representing the Energy Technology Partnership) and Scottish Renewables. Scottish Enterprise is Scotland's main enterprise, investment and innovation agency, delivering a wide range of services to support business development, research, innovation and investment, particularly focused on SMEs. The Energy Technology Partnership is the largest power and energy research and education partnership in Europe encompassing 12 Scottish Universities. Scottish Renewables is the trade organisation representing the full renewable energy industry in Scotland (including >150 SMEs).

In addition, on the basis of existing collaboration, the Sichuan region in China was included as an international partner region. Further international partners and more regions from around the North Sea are to become involved in the Alliance.

2 Overview of ENSEA project

2.1 ENSEA Objectives

The three key objectives of the project are -

1. Provide information on the capabilities, roles and connectivity of participating ENSEA research driven clusters

2. Analyse strengths and weaknesses of current approaches to research and innovation and identify opportunities for improving the overall effectiveness of the system

3. Identify opportunities for strengthening the relationships within and between the clusters, to optimise the impact on regional economic development and global competitiveness.

2.2 Description of project activities

The ENSEA project consists of five Work Packages.

- WP1: Management and coordination.
- WP2: Analysis and integration of research agendas of institutions in regional clusters (i.e. analysis of capabilities, roles and connectivity, SWOT of current approaches to R&D, identification of opportunities).
- WP3: Development of joint action plans.
- WP4: Measures towards implementation of the Joint Action Plans (i.e. formalisation of:
  - research and innovation collaboration, identification of funding sources, joint research; and innovation projects through securing of funding, initiation of an international joint Energy academy.
- WP5: Dissemination and Internationalisation.

This report summarises the outputs of Work Package 2 for the Scottish cluster.

2.3 Description of Work Package 2

Work Package 2 assembled an information base and includes SWOT analyses which will helps the ENSEA partners to identify opportunities to work together to address the challenges of Energy Systems Integration. It also provides a critical analysis of existing performance of the institutions involved in R&D, innovation and regional economic development work and identifies opportunities for best practice and synergies across regions. This creates the basis for the Joint Action Plan to be developed in WP 3. WP2 also includes an analysis of EU and international links and cooperation as part of ENSEA internationalisation strategy.

Work Package 2 comprised of five main tasks:
Task 2.1 Define methodological framework
Task 2.2 Definition and validation of methodological framework
Task 2.3 Collect regional & international data
Task 2.4 SWOT analyses per region
Task 2.5 Analysis & integration of findings

Task 2.1 Define methodological framework

The methodological framework is based on data and information collection and SWOT analysis, supported by bench-marking innovation capabilities by means of the Innovation Union Scoreboard (IUS). The IUS (a national level assessment) and also the Regional Innovation Scoreboard (RIS) have been developed by the EU to enable a comparison of the levels of innovativeness of EU countries and regions relative to each other. IUS and RIS are well established and have been used for a decade by the EU. Appendix B describes the Innovation Union and Regional Innovation Union Scoreboard methodologies in detail.

In practice, two of the ENSEA regional clusters (Ems-Achse and Rogaland) unfortunately do not match perfectly with the regions reported in the IUS and RIS. Also the IUS and RIS are not focussed specifically on energy or energy systems integration. Accordingly, additional material was collected in an attempt to provide more insight for the SWOT.

This report will use an innovation system model to analyse how the region develops and exploits innovation. This model, developed by the OECD and adapted by Aston University, can also be considered a representation of what is referred to as a Triple Helix or a Research Driven Cluster in other literature.

Task 2.2 Definition and validation of methodological framework

In the development of a sound methodological framework, ENSEA builds on prior efforts as executed in the Interreg IVB project: Energy Vision North Sea Vision. The Energy Valley Foundation is lead beneficiary of this project and is currently developing this research approach towards regional cluster analysis. Both approaches will be aligned to ensure quality and comprehensiveness of the framework.

Consensus on the chosen methodological approach, such as selection criteria and performance criteria, was sought through network events and meetings to consult with the relevant stakeholders in relation to the analysis by all ENSEA partners and invited stakeholders.

The table below shows the key thematic areas that were identified as being part of Energy Systems Integration for this project.

Table 1: Illustration of key themes within Energy Systems Integration (ESI)

Supply flexibility	Gas-fired Powerplant	
	Coal-fired Powerplant	
	Hydro Pumped Storage	
Storage	Hydropower	
	Power to Gas	
	Batteries (including chemical storage)	
	Gas Storage	
	Fuel cells	
	Other storage (hydrogen…)	
Demand flexibility	Industrial customers	
	Commercial customers	
	Domestic customers	
	Smart Meters	
Grid / Infrastructure	Balancing	Engineering
		Commercial planning
	Gas Grid	Distribution
		Transmission
	Power Grid	Distribution/Smart Grid
		Transmission
		Super Grid (HVDC)
Integration Methods	Data	
	Systems	
	ICT (information communication technologies.)	
	Modelling Simulation	
	Scenarios/Analysis	
	Power Electronics	
	Materials	
Boundary Conditions	Policy	
	Social Acceptance	
	Legal Aspects	
	Economics	
Renewable generation	Wind onshore	
	Wind offshore	
	Solar	
	Geothermal	
	Biomass	
	Hydro	
	Microgeneration	
	Marine Power	
	Energy from waste	
Carbon Capture & Storage	Carbon Capture & Storage	

Task 2.3 Collect regional & international data
The aim of WP2 was to research and compile data that provide insight into the following areas of interest for comparing the ENSEA research driven regional energy clusters (and their parent countries):

- Research strengths in the sector, public institutions
- Research strengths in the sector, private institutions
- Effectiveness of existing linkages and collaborations
- Skills availability
- Talent attraction
- Capacity for EU and international engagement

Additional information was also collected on -

- Background economic data including public and private spending on R&D, numbers of researchers, size of workforce for each of the ENSEA regions (or for the parent country if regional data were unavailable).
- Comparator metrics for a few leading and newly emerging countries (to include China and the Sichuan region).

Task 2.4 SWOT analyses per region
Information and data gathered throughout the project was used to conduct SWOT analyses for each partner region

Task 2.5 Analysis & integration of findings
An overall analysis of the different regional strengths and weaknesses as well as different regional opportunities and threats was under taken subsequent to an interregional workshop held on 16th October 2013, in Germany. Within this overall analysis, areas for improvement and opportunities for cooperation between the partner regions and with the identified international clusters were identified, including:

- R&D collaborations & Knowledge exchange
- Innovation support mechanisms
- Use of EU funding and support mechanisms
- Development of smart specialisation strategies
- Development of internationalisation strategies

The results were integrated to formulate recommendations which for the basis for the development of the strategic Joint Action Plan.

3 Methodology

3.1 Overview of Methodology

Work Package 2 (WP2) provides information source and structured SWOT and capabilities analysis which allows the ENSEA partners to identify opportunities to work together to address the challenges of integrated energy systems, with an approach that is central to strengthening regional economic growth.

WP2 also provides a critical analysis of existing performance of the actors in the regional clusters in R&D, innovation and regional economic development and internationalisation strategies, identifies opportunities for best practice, complementarities and synergies between regions. This creates the basis for the Joint Action Plan to be developed in WP 3.

3.2 Approach to Background Information Gathering

The collection methods for the ENSEA SWOT analysis were:

- Desk-based research to collect data for all the ENSEA regional clusters, using metrics defined in the European Innovation and Regional Innovation Scoreboard.
- Desk-based research to capture analyses of aspects of local energy innovation systems and gather relevant statistical material.
- Interviews with key institutions in energy research and innovation in the cluster to collect detailed information that is not available from the desk research. Examples included case studies on the ENSEA cross-cutting themes (grid, storage, etc.) and also forward-looking plans for activities over the Horizon 2020 time period.
- Regional workshops with local companies and Higher Education Institutes (HEIs) to identify any perceived barriers to increased energy innovation and to help evaluate the effectiveness of current research and policy support.
- Social Network Analysis to capture the linkages between stakeholders within and between the ENSEA clusters.

In addition to the Innovation Union Scoreboard data for all the ENSEA Regions, national innovation data profiles were also prepared for Germany, the Netherlands, the United Kingdom and Norway. These profiles include information about:

- Research strengths in the sector, both for public and private institutions (including human resources): all IUS indicators were tailored to the energy sector when possible as was as other key energy related data such as public and private R&D investments (overall and for the energy sector alone), Community Innovation Survey data for the energy sector, publications in the energy sector (for clearly identified keywords), patents in climate change mitigation technology, employment in high-tech energy sector (researchers and HRST), level of education of population (but not energy related: overall level of qualification and number of doctorate holders), etc.
- Effectiveness of existing linkages and collaborations: co-publications between private and public institutions, co-participation of ENSEA countries in FP7 energy research.
- Capacity for EU and international engagement: Framework Programme energy research funding of ENSEA countries and success rates, energy related high-tech exports.
- A profile was also created for China based on the indicators available, which might however not be comparable to the profiles of the European countries, because of different data sources.

A report and database has also been produced which outlines publicly-funded energy research and development being carried out by Scottish Universities, the names of Principal Investigators (senior academics, i.e. professors and doctors, involved in research) in specific fields of research covered by ENSEA and the levels of funding from Research Councils 2008-12.

Desk-based research
As part of the desk-based research in order to easily understand and compare the focus of activities in energy within the clusters a data summary matrix was designed to be filled in as much as possible by each region. The purpose of the matrix was to provide a summary to support the SWOT analysis activities by identifying levels of triple helix (academic, government and industrial) activity being carried out within each region.

Consultation
Consultation and interviews were undertaken to provide more detailed information on the roles, activities and intentions of key local stakeholders. Forward looking, towards Horizon 2020, of planned activities helped to identify opportunities for collaboration, and material for the Joint Action Plan.

Workshops / regional events
Regional workshops and events were undertaken to ensure engagement of academia, companies. These events provided feedback on the findings from work and also provide more opportunities to identify Joint Action Plan activities as part of WP3.

Social Network Analysis
Work Package 1 defines the use of "social network analysis" (SNA) to analyse the structural development of social connectivity within and between the regional clusters by means of social network surveying. An SNA is executed by means of surveys including particular types of questions strongly embedded in social and socio-economic science. The benefits of this (partially standardised) methodology, are the clear and strong metrics/ network measures that can be calculated based on the type of information social network surveys produce.

The first ENSEA SNA will be published in a separate report, and will be updated periodically.

Regional Report of the Scottish Region

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Date:
18th February 2014

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1 General Overview of Scottish Region

1.1 Geography

Scotland is a country occupying the northern third of the island of Great Britain; it shares a border with England to the south and is bounded by the North Sea to the east, the Atlantic Ocean to the north and west, and the Irish Sea to the south-west. In addition to the mainland, Scotland is made up of more than 790 islands including the Northern Isles and the Hebrides. It covers 78,387 km2 of land. The climate of Scotland is temperate and oceanic, and tends to be very changeable. It is warmed by the Gulf Stream from the Atlantic.

1.2 Governance structures

Scotland has self-government within the United Kingdom as well as representation in the UK Parliament. Executive and legislative powers have been devolved to, respectively, the Scottish Government and the Scottish Parliament at Holyrood in Edinburgh. The United Kingdom Parliament retains power over a set list of areas explicitly specified in the Scotland Act 1998 as reserved matters, including, for example, levels of UK taxes, social security, defence, energy and international relations.

1.3 Economy

As at March 2013, there were an estimated 343,105 private sector enterprises operating in Scotland - the highest figure since the time series began (in 2000).Per capita income is $44,378.
In 2011, Gross value Add (GVA) in the energy sector in Scotland amounted to £27 billion – this represents an increase of 12% on 2010, but GVA in the energy sector has not returned to the level generated in 2008 (£29 billion). These fluctuations in the energy sector GVA can be largely attributed to changes in oil prices('Metrics on the capabilities and connectivity of four research driven energy clusters', 2013, Technopolis).

Table 1: Number of businesses per 10,000 adults and typical size of businesses in Scotland

Size of business	No of businesses
Small (0-49 FTE*)	751
Medium (50-249 FTE*)	8
Large (250+)	5
Total	**764**

***FTE - Full time equivalent staff**
Source: Scottish Annual Business Statistics 2011
http://www.scotland.gov.uk/Topics/Statistics/Browse/Business/SABS

The Scottish energy sector is a priority industry for the Scottish Government and its Development Agencies with a value to the Scottish economy of some £18 billion, one of the highest of all industry sectors. The market value of the low carbon sector in Scotland is itself around £9 billion. The sector currently has around 4,000 companies employing 73,950 people. With the sector expected to grow to around £12 billion by 2016, low carbon employment in Scotland could increase to around 130,000 (ETP Business Plan, 2012, Energy Technology Partnership).

1.4 Employment

The population in the 2011 census was 5,313,600. The working age population is approximately 2.6 million('Metrics on the capabilities and connectivity of four research driven energy clusters', 2013, Technopolis).Given that the revenue from the energy sector is heavily influenced by fluctuating oil prices, it is helpful to consider changes in the energy sector employment series. Employment in the energy sector has increased in each year from 2008 to 2011 – the latest figures, from official statistics, show that employment increased from 65,500 in 2010 to 66,500 in 2011, representing an annual increase of 1.5%. Of this total, the number employed in the oil and gas industry was approximately 27,000 (2010 data).('A Compendium of Scottish Energy Statistics and Information', 2013, Scottish Government) It is important to note that energy economic statistics at the Scottish level are complicated by reporting arrangements, whereby employment and GVA associated with off-shore activity, under UK regional accounts procedures, is normally allocated to a separate 'Extra Region' category rather than allocated to a region within the UK.

The industry body, Oil and Gas UK, provides additional insight into the contribution of their particular sector by assessing the employment supported in the industry's supply chain and wider economy. The organisation's 2010 economic report estimates that from a total of 440,000 jobs UK-wide in 2010 being supported by the servicing of activity on the UK Continental Shelf (UKCS) and in the export of oil and gas related goods and services, 196,000 of these jobs were estimated to be based in Scotland. Of the Scottish jobs, 110,000 were employed directly by oil and gas companies or in the wider supply chain, with another 45,000 in the export of goods and services. Additionally, 41,000 jobs were supported by economic activity induced by employees' spending throughout Scotland('Oil & Gas UK Economic Survey 2011', 2012, Oil and Gas UK).

In 2014 Scottish Renewables produced its second annual comprehensive study of employment in the renewables (and power grid) sectors in Scotland, with the results showing that the industry is directly supporting more than 9984 Full Time Equivalent (FTE) posts in all parts of the sector including areas like project design, development, operation and its supply chain.

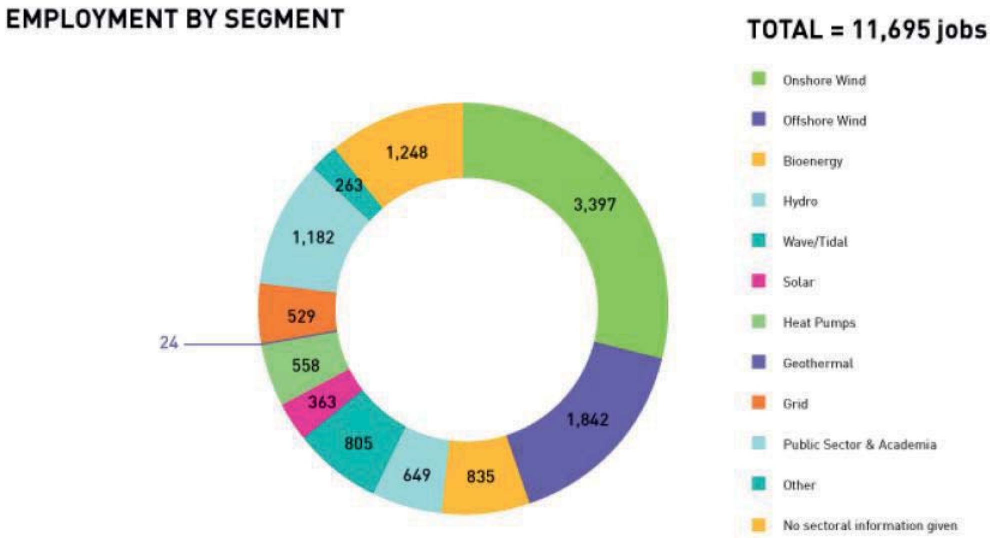


Figure 1: Renewable Employment

Source: Employment in renewable energy in Scotland in 2013, O'Herlihy & Co Ltd, commissioned by Scottish Renewables (2014)

Included in this figure there are around 1,182 posts associated with renewable energy development and research in our Further and Higher Education institutions (although subsequent research identified only 109 Principle Investigators) and the public sector, and some 529 employees involved in renewables and grid networks. This gives a total of 11,695 FTE posts in renewable energy in Scotland.

1.5 Scottish Academic Research in Energy

This section provides a general overview of academic energy research in Scotland. There are 12 universities in Scotland which collaborate in energy research through the Energy Technology Partnership (ETP). The way in which the ETP collaborates, and the range of research undertaken, is described in the following sections:

General Overview of ETP Collaboration in Energy Research

The Energy Technology Partnership (ETP) is an alliance of 12 Scottish Universities engaged in world-class energy-related Research, Development and Demonstration (RD&D).It is a part of the Scottish Funding Council (SFC) Research Pooling initiative that has invested over £350m in the Scottish research base in the past 5 years, with a specific focus on engineering and basic sciences underpinning the work of the ETP. Established in 2008, ETP aims to:

- promote greater levels of collaboration between its members, and
- develop new working relationships, with industry, academia and others both in the UK and internationally.

The cohesion displayed by the Energy Technology Partnership is exemplary and provides a strong basis for collaboration with a wide variety of business, public sector and other partners. With around 250 academics and 700 researchers, ETP is the largest, most broad-based power and energy research partnership in Europe with core research strengths across a spectrum of energy technologies. Coupled with research pooling, this provides an integrated energy technologies community demonstrating strong leadership in the UK, EU and international energy arenas. The pooling investments have advanced and improved the Scottish research scene to reach a position consistent with leading international research performance levels.

Scotland has both, an unparalleled partnership of energy RD&D capability and a large, world-renowned energy industry. A key focus of ETP is to further increase the extent of university-business collaboration, thereby promoting knowledge exchange for the benefit of the Scottish economy, including work on energy skills.

ETP member universities are active across:

- the full spectrum of energy sectors(oil & gas, power generation, renewables), and
- all aspects of the RD&D pipeline, from conceptual and feasibility studies through to applied research, testing, development, demonstration and supporting commercial deployment.

Core membership of ETP currently includes:3 Northern universities (Aberdeen, Dundee, Robert Gordon),

- 2 Edinburgh universities (Edinburgh, Heriot-Watt),
- 4 Glasgow universities (Glasgow, Glasgow Caledonian, Strathclyde, West of Scotland)

along with the;

- University of St Andrews,
- Edinburgh Napier University and
- University of the Highland and Islands.

Key ETP focus areas include:

- wind energy,
- marine energy,
- solar energy,
- bio-energy,
- grid, power systems and networks,
- energy conversion and storage,
- energy utilisation in buildings,
- oil & gas, and
- carbon capture and storage.

Research relevant to energy system integration within the ETP includes:

- Power Networks and Grid Infrastructure - distributed and renewable generation; asset management, monitoring and planning; power system modelling and simulation; power electronic systems; high voltage technologies; smart grid systems;
- Energy Conversion & Storage - fuel cell design and testing, alternative energy carriers, electrical storage, hydrogen production and storage, energy materials;
- Renewable generation technologies - including wind, wave and tidal, and solar energy;
- the capability to look at the implications of integration for the development of these technologies, and
- strong support from academic colleagues in the areas of energy economics, policy and law.

The table below provides an overview of the energy research expertise in the 12 Scottish universities which are part of the ETP:

Table 2: Overview of Energy Research Expertise in Scottish Universities

ENERGY TECHNOLOGY PARTNERSHIP UNIVERSITIES: EXPERTISE IN ENERGY RD&D	
SUMMARY OF EXPERTISE	**AREAS OF RESEARCH**
Carbon capture and storage expertise	
Scotland's offshore geology coupled with our existing oil and gas infrastructure provides it with an opportunity to store millions of tonnes of the greenhouse gas, carbon dioxide. A chain of technologies has the potential to capture high levels of CO_2 created by burning fossil fuels for power generation and industrial processes and store it deep below ground. SCCS (Scottish Carbon Capture & Storage Group) is the UK's largest CCS research and development group, comprising a network of universities and institutions with experience and expertise across the full CCS chain. SCCS is a single point of coordination between academia, industry and government. Its chief aim is to promote the global development and commercialisation of CCS as a climate change mitigation technology. Funded by ETP and the Scottish Funding Council, the partnership undertakes world-class strategic research, often with industry partners, in the UK, Europe and further afield.	• The full CCS chain of CO_2 capture, transportation and injection into geological formations for long-term storage. • Capture technologies • Transportation • Storage and monitoring • Enhanced oil recovery • Regulatory framework
Energy Conversion and Storage	
With the expansion of renewable energy capacity so comes the challenge of storing and converting intermittent energy sources. Scotland can claim both world leading research and commercial	• Electrolysis • Fuel Cells • Hydrogen Storage Materials

activities including the world's first Li-ion battery facility. ETP universities are working with industry to combine capabilities to deliver new and innovative energy conversion and storage technologies. ETP universities are engaged in a number of collaborative programs involving academics and industry from across the UK and beyond including: Supergen, ETP is engaged in the energy storage, delivery of sustainable hydrogen and fuel cell programs; FP7-SCOTAS, this is a European program investigating Sulphur, Carbon, and re-Oxidation Tolerant Anodes and Anode Supports for Solid Oxide Fuel Cells; and SHFCA, the Scottish Hydrogen and Fuel Cell Association, a body promoting Scottish capability in the hydrogen and fuel cell sector.	• Thermo electrics • Batteries • Expertise • Connectivity
Grid, Power Systems and Networks	
The challenge of integrating renewable energy sources like wind, tidal and wave into the electricity power system is at the core of ETP universities' work with industry. This integration presents a range of technical and economic issues about how to mesh traditional power engineering, advanced electronics, monitoring and control technologies, software as well as information and communications technology. ETP universities are well placed to support the development, demonstration and deployment of these next generation grid and related systems technologies.	• Distributed generation • Power systems • Power electronics • Digital communications • Electrical Machines
Solar energy	
The amount of solar radiation striking the earth over a 3 day period is equivalent to all the energy stored in all fossil fuels. To increase the harnessing of this versatile energy source ETP works with partner SISER – Scottish Institute for Solar Energy Research to develop technologies for the more diffuse light levels typical in northern climates as well as technologies for developing countries.	• Thin-Film PV • Excitonic and Hybrid PV • Next Generation PV • Solar Thermal • Concentrating PV • PV Systems • Building Integrated PV
Energy Utilisation in Buildings	
Through their construction and operational lifetime, buildings in the UK are responsible for 50% of all our carbon emissions. ETP universities are working with the construction industry to significantly reduce energy usage and carbon emissions by improving energy efficiency.	• Improving Energy efficiency • Modelling and real world performance software • Micro-renewables • Developing new materials and construction techniques
Bio-Energy	
With significant forest cover biomass is an important source of energy in Scotland. ETP universities are working with industry to contribute to the development of the Bioenergy industry in Scotland to reduce CO2 emissions, add to the carbon sequestration potential, enhance rural economies and help meet renewable energy targets. The scientists and engineers within ETP embrace many different disciplines to further their research and development of Bioenergy technologies: •Terrestrial and marine biomass production systems	• Biomass production systems • Supply Chain • Thermochemical Conversion • Physical-Chemical Conversion • Biological Conversion • Microbial fuel cells

•Plant breeding •Chemical and materials characterisation Resource economics and land use studies Carbon and lifecycle analysis Techno-economic analysis •Biochemical processing Bioengineering Thermo chemical processing Catalysis •System design •Process engineering	
Wind Energy	
With 25% of Europe's wind resource Scotland is a great location for wind power projects. ETP is forging links between Scotland's world leading universities and the wind power industry to optimise the capacity to produce huge amounts of sustainable, clean energy. Right now ETP is actively working on projects across all areas of wind energy.	• Operations & Maintenance • Control System design • Composite materials research • LIDAR and SODAR technologies • Power electronics and converters • Wind Modelling and Resource Assessment • Turbine Foundations • Scour and Geo-technics
Marine energy	
With some of the best and most exploitable marine renewable energy available, Scotland already has full-scale prototype wave and tidal energy generators at sea, connected and delivering energy to the UK. ETP is forging links between Scotland's world leading universities and the marine energy industry to help wave and tidal energy contribute to a diverse and secure energy mix in the future.	• Resource Assessment • Resource Modelling • Tank Testing • CFD modelling • Economic modelling and assessment • Machine design • Environmental Impact modelling

2 Description of the Regional Energy System

2.1 Overview

Some 160TWh of energy is consumed annually in Scotland. Approximately 35TWh of this is petroleum, 51 TWh is gas and 40TWh is electricity. Scotland is a significant exporter of power. Some 10Wh or 20% of what is generated locally is exported to England. Similarly, around 20% of the gas brought ashore at Aberdeen is piped south to England(Scottish Government online energy statistics, 2013).

2.2 Regional energy system

The term 'regional energy system' covers the provision of all forms of energy at all scales.

2.3 Investment in Energy in Scotland

Overall levels of Private Investment in Energy

Analysis by Scottish Renewables has revealed that investment in Scotland's renewable energy industry topped £900 million pounds in the first six months of 2012. The analysis, which was based on figures released by DECC, shows that onshore wind received the lion's share of investment, accounting for more than £800 million. PV received just under £60 million, while wave and tidal power received £3.6 million. No investment was made in offshore wind in Scotland in the first half of 2012('Renewable investment in Scotland 2012', 2013, Scottish Renewables website).

In comparison, Oil & Gas UK predicts that capital investment in Oil & Gas in UK waters will reach a record of £13billion in 2013. Over 2011 and 2012, 45 projects were approved by DECC which are likely to entail capital expenditure of the order of £22billion and will yield over 2 billion boe of production over time('Economic report 2012', 2013, Oil and Gas UK).

Overall levels of Public investment in energy

Audit Scotland estimated that in 2012 around £35 million of Scottish public money was invested in renewable energy (excluding investment by the Research Councils in Higher Education). Approximately 65% of this was funding was channelled by the Scottish Government through Scottish Enterprise, with the remainder coming via Highlands and Island Enterprise or directly from the Scottish Government ('Renewable Energy', 2013, Audit Scotland).

2.4 Scottish Demand for Energy

Overall energy consumption

Scotland has a target to reduce final energy consumption by 12% by 2020. The figure below shows a reduction in final energy consumption year-on-year from 2005. The data for 2009 shows a significant reduction in final energy consumption compared to 2008 (a fall of 7.4%) and an even greater reduction relative to the 2005-2007 baseline (a fall of 9.6%) - against which the 12% Energy Efficiency Target is measured.

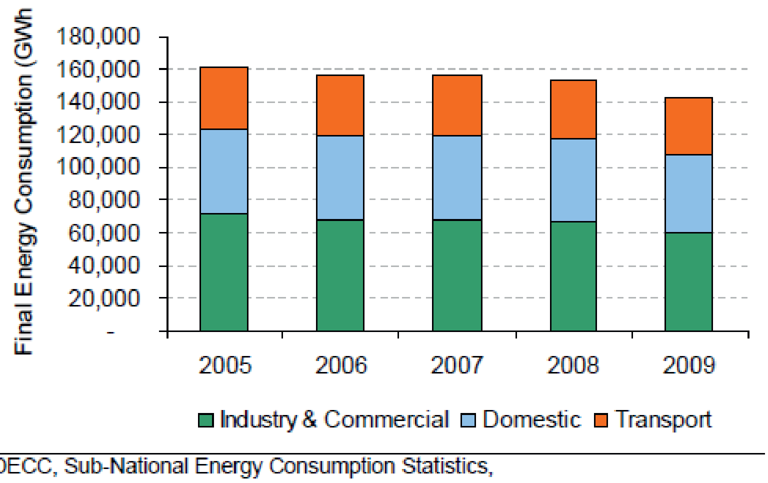


Figure 2: Total energy consumption in Scotland by sector

Electricity consumption

Gross electricity consumption measures total generation minus net exports and is used as the target for Scotland's 100% 2020 Renewable energy target. It is equivalent to total consumption plus generators' own use plus losses. Gross consumption was 39,515 GWh in 2010.

Electricity demand on power grids typically has two peaks a day and seasonal peaks as well. Electricity networks (and the generation that supplies them) have to be sized to meet this peak demand and as a result much of this capacity is under used. More constant, flatter, demand can be obtained by effectively managing customer electricity use. This is called Demand Side Management (DSM). DSM improves system efficiency and can defer, or even avoid, the need for grid investments. Scotland's Winter maximum demand is around 5500MW and the Summer minimum is 2500MW.

Consumption of Gas

In 2011 Domestic gas consumption in Scotland was 28,959 GWh and Commercial/ Industrial usage was 22,179GWh, total consumption was 51,137 GWh.

Comprehensive data is available in 'Energy in Scotland: A Compendium of Scottish Energy Statistics and Information' http://scotland.gov.uk/Resource/0038/00389297.pdf

Energy storage

The announcement of a new £800Million Coire Glas 600MW hydro pumped storage scheme underlines competitiveness of this mature technology. Three small-scale sub 1MW 'novel' storage schemes are also being tested in Scotland.

Electricity balancing

Cruachan hydro pump storage (400MW) and flexible thermal generation in combination with interconnectors to England and Ireland provide the primary mechanisms for load balancing on the Scottish electricity network at present.

In combination with Grid upgrades, more DSM and the new Coire Glas 600MW hydro pumped storage scheme, Scottish utilities plan to be able to load balance much larger levels of installed renewable capacity by 2020 and beyond.

2.5 The Gas Supply Industry

The gas network (transmission and distribution) across Scotland is wholly owned by Scotia Gas networks. Formed in June 2005, it has three shareholders, SSE (50% ownership) and two Canadian pension funds: Borealis Infrastructure Management Inc. (25%) and Ontario Teacher's Pension Plan Board (25%)

National Grid is the Great Britain System Operator for the gas network, responsible for managing the operations, planning of upgrades and connection to the gas grid across England, Scotland and Wales.

Natural Gas Grid (Transmission and Distribution)

The main gas transmission grid in Scotland mirrors the population centres in the country. Bulk transportation from the St Fergus gas terminal near Aberdeen runs down the East coast.

A gas distribution network provides extensive coverage for most of Scotland. The islands and parts of remote and rural Scotland are off the gas grid. Approximately 30% of consumers are off the gas grid in Scotland and use bottled gas or other forms of heating. The number of metered customers is 1,947,000 of which 1,922,000 are domestic customers and 25,000 are larger commercial or industrial users.

2.6 Electricity Supply Industry

Electricity Supply Industry

Scotland typically generates around 50,000 GWh of electricity. It is a net exporter of electricity and has been for a number of years. In 2010, net exports to England and Northern Ireland accounted for 21% of total generation.

There are two major power utilities in Scotland, Scottish and Southern Energy (SSE) headquartered in Perth and Scottish Power (SP) which is now owned by Iberdrola. A third large generator, Electricite de France (EdF), owns the two nuclear power stations of Hunterston and Torness. There are also a number of independent power producers.

The Scottish onshore transmission (and distribution) grid infrastructure is owned by Scottish Hydro Electric Transmission Limited (SHETL, in the northern part of Scotland) and Scottish Power Transmission (SPTL, in the southern part of Scotland). As network owners, these companies are responsible for building and maintaining the network, and are regulated by The Office of Gas and Electricity Markets (Ofgem). The investments in grid infrastructure these companies are allowed to make are strictly regulated through "price controls". The current price control is RIIOT1 and covers the period 2013-2021.

National Grid is the Great Britain System Operator, responsible for managing the operations, planning of upgrades and connection to the transmission lines across England, Scotland and Wales and the wholesale electricity and gas markets (via third parties). National Grid has also been designated as system operator for the new offshore electricity transmission regime.

There are six retail suppliers of electricity (and gas) supplying customers throughout the UK which are vertically integrated with generation companies. There are also some independent power suppliers. The Government imposes Supplier Obligation for renewable energy in order to create a market pull for renewables. Nearly all (99%) customers have access to grid electricity.

Conventional generation

Approximately 17TWh was produced by nuclear power and 9TWh came from gas or oil fired generators in 2011. Pumped storage generated 0.6TWh and run of river hydro produced 5.3TWh. The remaining 8TWh came from other renewables.

Renewables

Provisional 2012 data for renewable generation is shown in the table below.

Table 3: Provisional 2012 data for renewable generation

Renewable type	GWh
Hydropower	4,803
Wind, wave, tidal, solar	8,296
Landfill gas	560
other Biofuels	987
Total renewable	14,646
% of gross consumption	39%

Source: Scottish Government online (renewable) statistics 2013

Latest figures from the Department of Energy Climate Change (DECC) show that Scotland's renewable energy industry is now the second largest source of Scotland's electricity production, exceeding both coal and gas for the first time. While nuclear remains the largest source of electricity production, output from renewables was more than double that of gas-fired generation.

Table 4: Historic electricity generation

Electricity generated by renewables and as a percentage of gross consumption

Fuel Source	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hydro	4,665	3,738	4,455	2,902	4,475	4,612	4,225	4,693	4,709	4,864	3,313	5,332
Wind, wave, tidal and solar	217	245	406	449	848	1,281	2,023	2,644	3,330	4,558	4,862	6,992
Landfill Gas	69	109	157	228	339	395	424	487	502	534	534	507
Other biofuels	21	110	80	146	170	197	291	403	600	799	882	898
Total renewables	**4,972**	**4,202**	**5,099**	**3,724**	**5,832**	**6,486**	**6,963**	**8,226**	**9,141**	**10,755**	**9,591**	**13,728**
% of gross consumption	12.2%	10.4%	12.3%	9.0%	14.1%	15.5%	16.9%	20.2%	22.2%	27.6%	24.2%	36.3%

Source: Department of Energy and Climate Change (DECC)

(1) Hydro excludes electricity generated from hydro - pumped storage

(2) Other biofuels includes biofuels co-fired with fossil fuels and sewage gas.

(3) Prior to 2010, solar photovoltaics were only estimated on a UK-wide basis and could not be allocated to regions within the UK.

Source: Scottish Government online (electricity) statistics 2013

Installed renewable capacity is shown in the table below

Table 5: Installed renewable electricity generation capacity

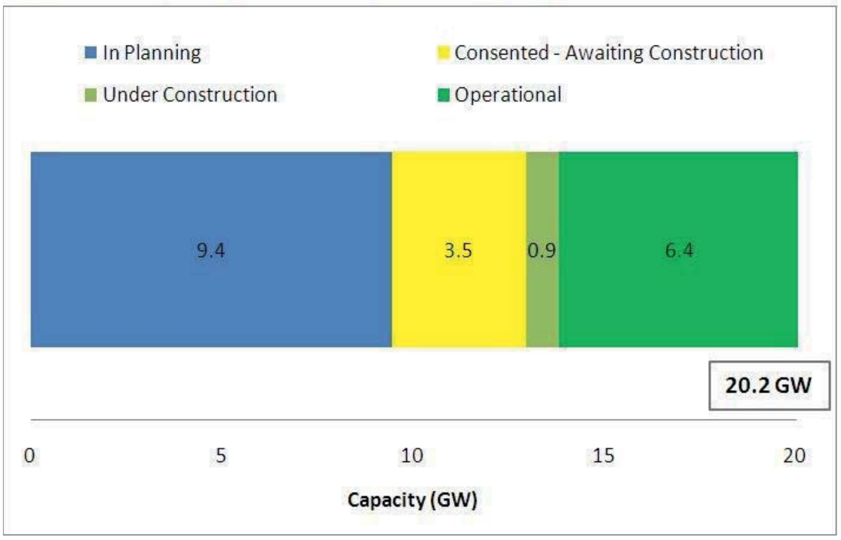
Annual Growth in Installed Renewable Capacity (MW) in Scotland Q2 2013

Technology	Installed Capacity (MW)	% Change (Annual)
Onshore Wind	4,279	27.4%
Large scale Hydro	1,339	0.0%
Offshore Wind	190	0.0%
Small scale Hydro	160	2.4%
Plant Biomass	124	9.4%
Landfill gas	115	0.0%
Solar photovoltaics	97	31.6%
Municipal solid waste combustion	18	0.0%
Animal Biomass (non-AD)	13	0.0%
Anaerobic Digestion	16	51.7%
Sewage sludge digestion	8	0.0%
Shoreline wave / tidal	5	0.0%
TOTAL	**6,363**	**17.9%**

Source: Scottish Government online (renewable) statistics 2013

The diagram below shows there is 20GW of renewable electricity capacity installed, consented, under construction, in planning or in scoping (and 6.4GW is installed). If all of the projects are developed this would take Scotland well beyond its 2020 target (which equates to around 14GW).

Renewable Capacity in Scotland by Planning Stage, June 2013



Source: Scottish Government online (renewable) statistics 2013

Figure 3: Gigawatts of proposed (electricity generation) renewable capacity in Scotland

It is expected that Offshore Wind projects will provide half of the new capacity required to meet the 2020 100% target.

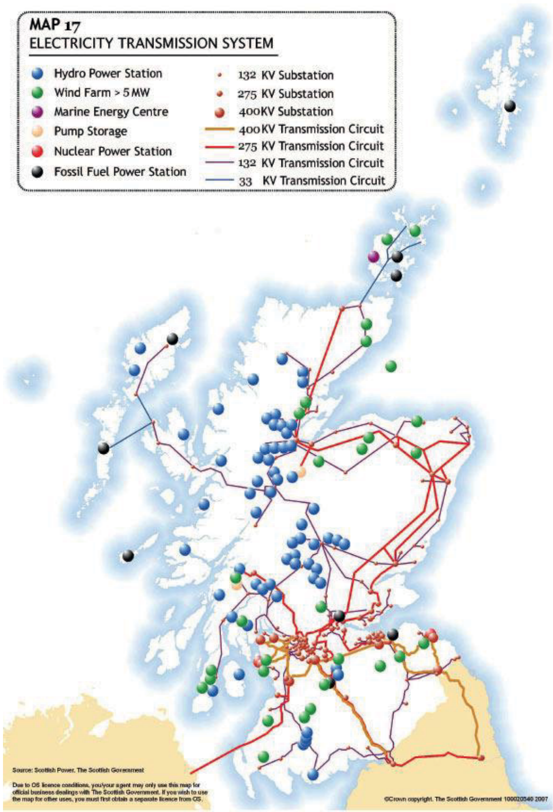
Scotland presently has two operational offshore wind sites, the Beatrice Demonstrator Project with two 5MW turbines and the Robin Rigg Array with a capacity of 180MW. There is at least a two year lag time between committing to a project by ordering the turbines and the project becoming operational but there have been no new orders in 2012 or to date in 2013.

Regional electricity transmission and distribution

National Grid is the Great Britain System Operator, responsible for managing operations, planning of upgrades and connection to the transmission lines across England, Scotland and Wales. National Grid has also been designated as system operator for the new offshore electricity transmission regime.

Scottish Hydro-Electric Transmission Ltd (SHETL) owns and operates the network in Northern Scotland, north of a line between Dundee and southern Argyll. Scottish Power Transmission Ltd (SPTL) owns and operates the network in the rest of Scotland.

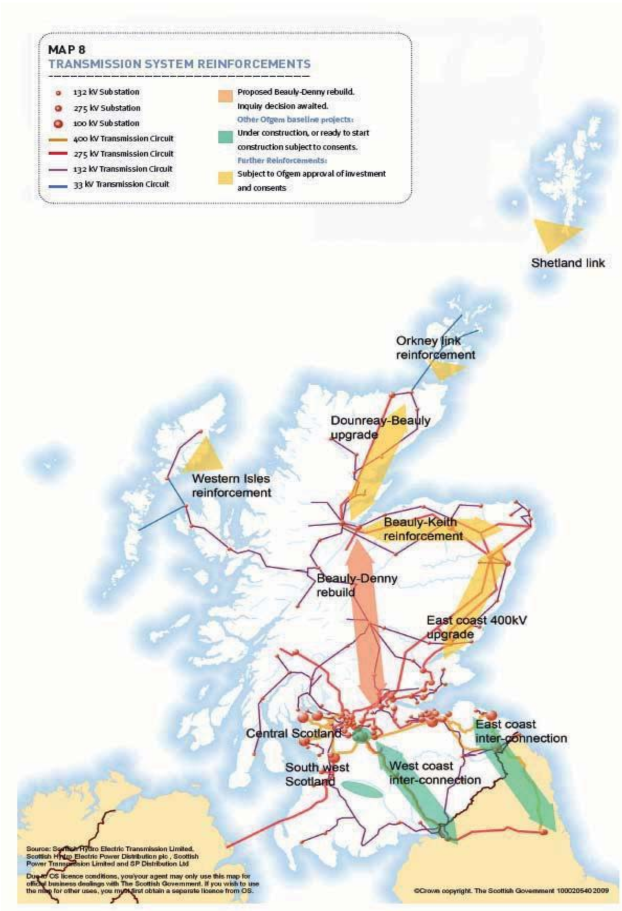
The current transmission infrastructure in Scotland is shown below. Beyond the transmission lines connecting Edinburgh and Glasgow with the English transmission network, there are currently no other 400 kV lines in Scotland.



Source: 'Integration of intermittent renewables', 2013 TNEI

Figure 4: Scottish Electricity Transmission System

The Scottish islands do not currently have transmission connections with the mainland. However, the Western Isles and Orkney are connected to the mainland distribution systems via 33kV (20MW) and two 33kV (20+30MW) connections respectively. There is no connection from Shetland to the mainland electricity systems. With this structure and network, the ability of the islands to host new renewable generation developments is very limited.



Source: 'Integration of intermittent renewables', 2013 TNEI

Figure 5: Planned Scottish Transmission System Reinforcements

Planned upgrades include –

Overhead line and substation works to increase north-south transfer capacity in Central Scotland;

- A new 275kV South-West Scotland transmission line;
- Strengthening the Scotland-England interconnectors to increase export capacity to 3.2GW;
- Upgrading the East Coast transmission route to 400kV;
- Upgrading the existing Beauly-Dounreay overhead transmission line;
- Reinforcing the Beauly-Keith overhead transmission line;
- Reinforcing the sub-sea cable link between Orkney and the Scottish mainland; and
- New sub-sea cable links for the Outer Hebrides and the Shetland Islands.

At present, very little electricity network infrastructure is installed offshore. Under a new regulatory regime for offshore transmission networks which has been active since June 2009, its development will be undertaken by Offshore Transmission Network Operators (OFTOs). This will be a licensed activity, awarded through a competitive tender process, regulated and run by Ofgem.

2.7 Heat Supply Industry

Heat plays an essential role both in domestic and industrial buildings. The growing significance that heat can play in the energy mix and delivery of low carbon targets has been recognised by EU, UK and Scottish Governments. Across the UK, some 50% of all energy consumed is to deliver heat.

There is no national heat network in Scotland but there are 103 District Heating Schemes in operation, delivering some 177GWh of heat per year. The majority (65%) is less than 500MWh per year biomass heat only plants but while 29% of the schemes are gas / CHP these deliver 62% of the total MWh per year (110GWh). Renewable district heating schemes deliver 66GWh of heat per year.

In addition, over 90 District Heating Schemes are in development (in 2013) which should deliver approximately 400GWh of heat per year. Of these, approximately 70 will use renewable heat sources. The majority of renewable heat supplied in Scotland comes from domestic wood burners supplied and serviced by relatively small SMEs. Sewage treatment plants provide another source of heat (as biogas).

The Scottish Government has made renewable heat a policy priority.

Renewable Heat

Scotland's renewable heat position in 2010 is shown below.

Table 6: Installed renewable electricity generation capacity

	2010 total capacity (MW)	2010 total output (GWh)
Biomass primary combustion	203	941
Biomass CHP	138	601
Waste treatment (energy from waste, landfill gas & anaerobic digestion)	23	74
Solar Thermal	17	9
GSHP	24	60
ASHP	5	11
WSHP	0.1	0.1
TOTAL	411	1,696

Source: Renewable Heat in Scotland, 2010 A report by the Energy Saving Trust for the Scottish Government, http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/Heat/RHiS

Key: Ground Source (GSHP), Air Source (ASHP), Water Source (WSHP) Heat Pumps

The Potential Role of Heat Energy

There is an important role for innovation and R&D in the heat technology sector. A Technology Innovation Needs Assessment (TINA) report noted that innovation in heat pumps and heat storage could significantly reduce UK energy system costs.

In order to meet Scotland's 11% 2020 Renewable heat target solid biomass will likely play a critical role. The use of bio energy, particularly wood fuel, has increased rapidly over the last five years mainly through use in domestic boilers and some Combined Heat and Power schemes. With about 400 MW of thermal capacity in Scotland, bioenergy is still at an early stage of development. It is considered that the optimum solution for Scotland will likely be a combination of different heating technologies, thermal storage and decarbonisation of the electric grid alongside potential for biogas injection into the gas network to deliver a low carbon heat solution.

3 Overview of Innovation and Collaboration

This section follows the Innovation System framework (see Appendix B for detail) to describe ESI innovation and collaboration in Scotland.

An Innovation System is a set of institutions which contribute to the development and commercialisation of new technologies and which provide the framework within which governments influence the innovation process. Current thinking emphasises the interactive nature of the innovation process (linkages) and the importance of absorptive capacity of firms as a complement for their own internal knowledge resources.

A series of functions make up the idealised Innovation System, based on the model of Higher Education Institutes (HEIs) creating knowledge which is then commercialised by the entrepreneurial activities of private companies with the public sector (at a regional, national and EU level) providing a facilitating role.

Scottish Renewables (SR) is a trade organisation for the renewable energy industry in Scotland. We work closely with government departments and agencies and other stakeholders to attract investment and funding into the Scottish sector, enhancing innovation and research and growing Scottish businesses to take advantage of the opportunities in the domestic, European and global renewable energy marketplace.

As a single voice for the industry, it represents over 300 member organisations to influence the legislative, regulatory and fiscal framework. A key focus is to work across industry, government and key stakeholders to develop policy solutions and encourage investment to integrate renewable energy generation into energy networks, including the electricity grid, demand management, storage technologies, smart grids and interconnection with continental Europe.

Membership spans public and private sector organisations academic and research institutions. Many of our members are actively involved in innovation, research and development in order to develop more efficient, cost-effective technologies to harness renewable energy resources to generate heat, power and transport fuel. Small and medium-sized enterprises (SMEs) make up a large part of our membership. SR regularly communicates, informs and gathers information from members working in renewable energy in Scotland. We manage 10 working groups, each comprising a selection of experts from within our membership, to represent each of the technology sectors and cross-cutting issues facing the industry. These groups are the prime driver for shaping our positions in each area of focus, e.g. offshore wind, wave & tidal, bioenergy, grid access & charging, economics & markets, planning & consents, etc.

In the ENSEA Scottish cluster, SR will maximise the engagement of industry along the whole value chain of the renewables sector, contributing to build the industrial critical mass around the project. The Scottish industry's most active businesses are our members and some of them are represented in the board. With nine major conferences as well as numerous seminars and workshops throughout the year, Scottish Renewables' engagement extends beyond its own membership base to the wider industry active in Scotland. Two of Scotland's largest companies, ScottishPower Renewables and SSE Renewables, deliver a large proportion of the renewables projects in the country and across the UK. SSE is developing Europe's biggest battery, 1MW sodium sulphur (NaS) unit which has been installed in a specially built large shed next to Lerwick Power Station in the Shetland Isles, allowing the storage of electricity generated on the island. We work closely with a wide range of research and innovation-based companies and research initiatives to cut costs and drive growth across the industry, including SMEs such as: NGenTec

Limited, a spinout company from the University of Edinburgh's School of Engineering developing wind energy magnet generators; and Smarter Grid Solutions, which creates smart grids, developed from research originating at the University of Strathclyde in Glasgow.

3.1 The Scottish Innovation System

Based on information provided by the Regional Innovation Scoreboard (RIS) and other information a summary of Scotland's Innovation System as it relates to Energy System Integration would be that overall it is (as with the other three ENSEA partners) above the European average for innovation but company activity and the economic benefits of innovation are less good. Linkages exist and there is broad alignment between the between the key stakeholders involved but these could be improved.

Knowledge creation and development
World class research and development and a well-educated workforce mean Scotland is well positioned to develop innovation in Energy Systems Integration, particularly in relation to electricity or Smart Grid related aspects.

Linkages with other HEIs outside Scotland and multinationals are good but need improving with the local SME base, however, a significant part of these have limited resources and capacity to innovate due to their small size.

Entrepreneurial activities
A dominance of smaller companies which are relatively lacking in resources means that levels of spend on innovation, levels of in-house innovation and local SME-University linkages are similar to benchmark levels for the whole of the enlarged EU (EU-27). As a result, the numbers of high growth SMEs and innovative SMEs are also very average and so are the economic effects of innovation as measured by exports and new to market products and services.

Public Sector (Scotland)
Scotland has a Smart Grid Sector strategy and action plan - under the management of the Energy Advisory board. If the scope of this could be widened from electricity to include all of Energy System Integration there would be excellent scope to enable public sector support for ESI.

Public Sector (UK)
As with Scotland there is no explicit policy support for ESI, however, the Technology Strategy Board is now in the process of setting up a new Technology Innovation Centre (or Catapult) focused on ESI.

Public Sector (EU)
Energy Systems Integration is now part of the latest European Strategic Energy Technology Plan (SET-Plan) which is one of the main drivers of Horizon 2020 work.

The overall innovation system for energy is illustrated in the following figure. Each level can be considered in turn and are further described in the following sections.

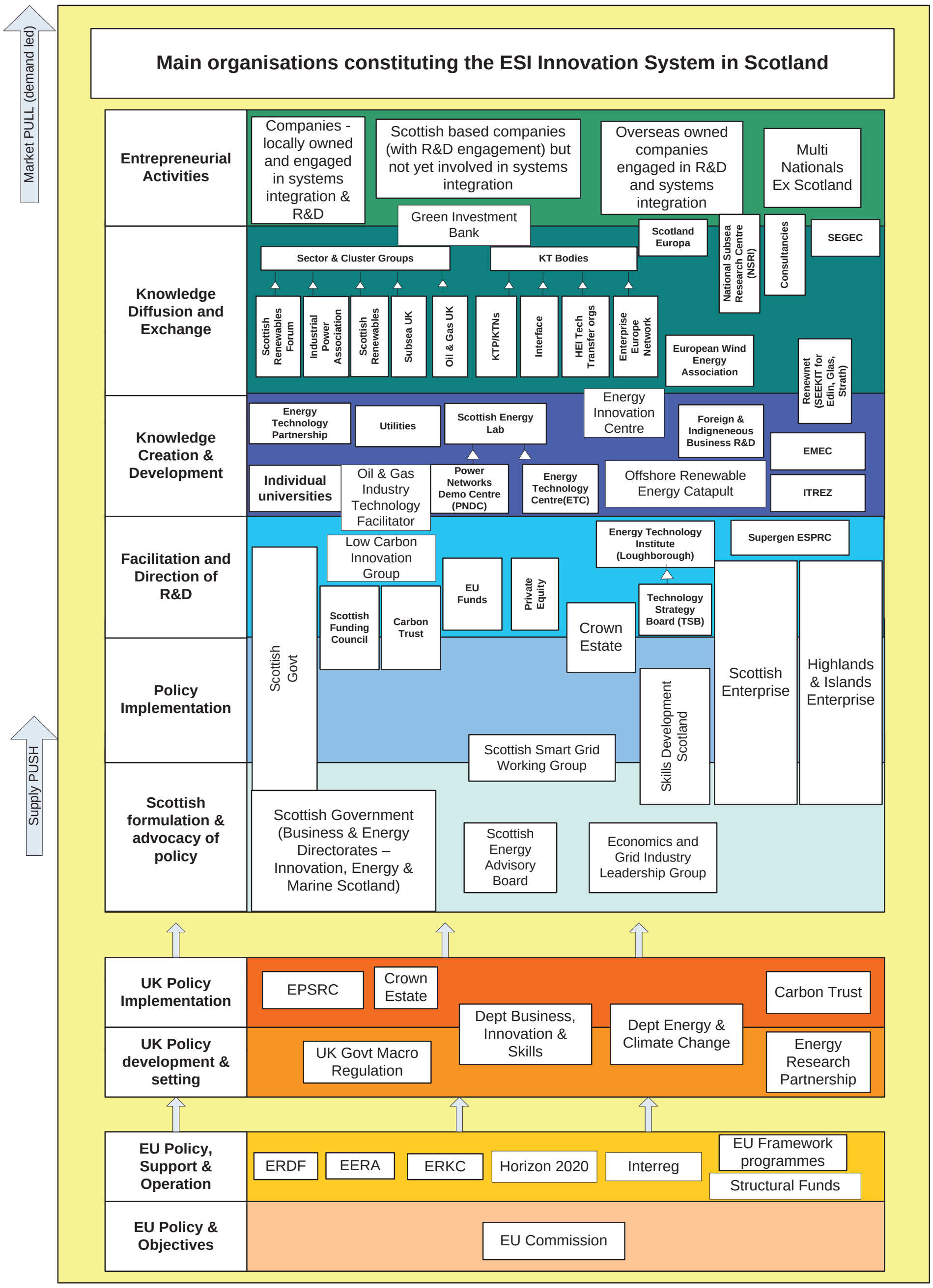


Figure 6: Scottish Innovation System in Relation to the Energy System

3.2 EU Policy & Objectives

The overall EU policy context is Europe 2020, the European Union's ten-year growth strategy, which aims to create the conditions for a different type of growth that is smarter, more sustainable and more inclusive. Five key targets have been set for the EU to achieve by the end of the decade. These cover employment; education; research and innovation; social inclusion and poverty reduction; and climate/energy.

The key objectives relevant to the ENSEA project are:

Smart Growth - Developing an economy based on knowledge and innovation
Sustainable Growth - Promoting a more efficient, greener and more competitive economy

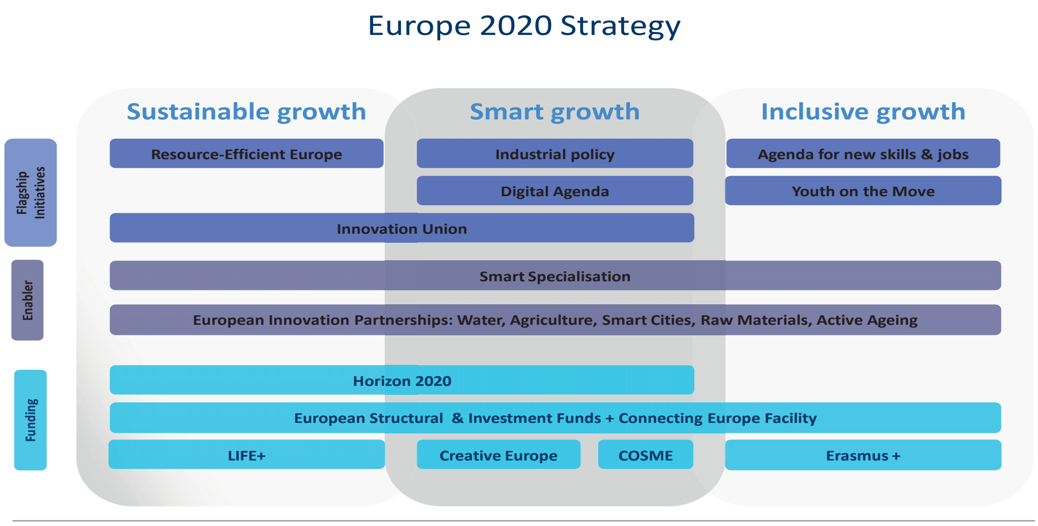
The key targets are:
R&D:

- 3% of the EU's GDP to be invested in R&D
- Climate change and energy sustainability:
- Greenhouse gas emissions 20% (or even 30% if the conditions are right) lower than 1990
- 20% of energy from renewable sources
- 20% increase in energy efficiency

The EU recognises that we need to do much better at turning our research into new and better services and products if we are to remain competitive in the global marketplace and improve the quality of life in Europe. Europe is spending 0.8% of GDP less than the US and 1.5% less than Japan every year on Research & Development (R&D) (Source: Europa website). The Innovation Union is the main response to this challenge.

The climate change and energy sustainability targets are supported by a range or EU policies, including the Renewable Energy Strategy and Low Carbon Economy & Resource Efficient Europe Roadmaps, and various directives on renewable energy, energy efficiency etc. Of specific relevance to the energy system integration are policies on the single European energy market and energy infrastructure.

The EU funding programmes are designed to help implement EU policy on research and innovation and address societal challenges, such as safe, clean and secure energy supply. Figure 8 illustrates the relationship between the Europe 2020 strategy, the flagship initiatives, enabling policies and initiatives, and the EU funding framework which will help drive delivery.



Source: Internal brief, 2013, Scotland Europa

Figure 7: European Commission's overarching Horizon 2020

The European Framework Programmes for Research, most recently FP7 (2007-13) are designed to foster research excellence and help address key sectorial policy challenges at a European level and through trans-national cooperation. To complement this, EU Cohesion and Regional Policy, through the Structural Funds, aim to develop regional capacity for growth and innovation.

The European Commission has published the sixth annual monitoring report on FP7, which provides statistics on participation from 2007 up to 2012. According to the report, more than 20,000 projects involving 105,000 participants have been awarded funding amounting to around €33bn in total. Higher education institutions are the main beneficiaries, both in terms of the number of participations (39%) and funding received (29%). With the continuous improvement of SME participation rates from FP6 onwards, SMEs now account for 18% of all FP7 participations and 14% of FP7 budget (19% and 16% respectively in the Cooperation programme). While around 20% of all participations and funding comes from the FP7 SMEs specific programme, the vast majority originates from the other FP7 priorities. Quantitative data from 3,220 projects have been analysed to show FP7 outputs of over 16 000 publications and 505 patent applications. However, it is generally acknowledged that the majority of FP7 results are not commercialised, and this is an issue which the new H2020 Programme will seek to address.

For 2014-20, the new Horizon 2020 Programme for Research and Innovation will bring together a number of previous programmes, including Intelligent Energy Europe, into a single, integrated and simplified programme, with an increased emphasis on innovation and commercialisation and deployment of research results.

3.3 EU Policy Support & Operations

There are a number of mechanisms at EU level to support delivery of the research and innovation policy, these are primarily designed to inform work programmes and calls for proposals, but also to an extent provide opportunities to facilitate collaboration and partnership building. These include the European Technology Platforms (ETPs). Building on the strategies for Europe 2020 and for an Innovation Union, the Commission's Horizon 2020 proposal for an integrated research and innovation framework programme recognises the role of ETPs as part of the external advice and societal engagement needed to implement Horizon 2020. ETPs will therefore be a key element in the European innovation ecosystem. A new landscape of recognised ETPs is also now in place following an assessment against the revised criteria for recognition defined in the Staff Working Document.

For more information see European technology Platforms website
http://cordis.europa.eu/technology-platforms/individual_en.html

The European Strategic Energy Technology Plan (SET-Plan) is a strategic plan to accelerate the development and deployment of cost-effective low carbon technologies, and is one of the main drivers of FP7 / Horizon 2020 work programmes. The plan comprises measures relating to planning, implementation, resources and international cooperation in the field of energy technology.

For more information see European Strategic Energy Technology Plan website
http://europa.eu/legislation_summaries/energy/european_energy_policy/l27069_en.htm

The SET-Plan Steering Committee is working on an integrated Roadmap bringing together the previous separate, technology-focused initiatives, to address the energy system as a whole. This should be more technology neutral and exploit synergies between areas and sectors, such as energy, ICT, transport and agriculture. The Group has until the end of 2013 to complete the Roadmap. National Governments will then be asked to agree a common Action Plan by mid-2014. It is noted that the Steering Group membership may have to be widened in light of its new task on the common Roadmap. In particular, it will be necessary to bring in more regional and local stakeholders to reflect the more market driven focus.

The Communication further stresses a need to concentrate on larger scale initiatives, where cooperation at EU level can create economies of scale and scarce finance can be pooled around fewer, but major priorities.

A new Energy Research Knowledge Centre (ERKC) was launched at the SET Plan conference as a means to facilitate better information sharing on the research and innovation programmes underway in each EU country. The ERKC is structured around nine priority areas; heat and power supply, alternative transport fuels, smart cities and communities, energy efficiency in industry, new knowledge and technologies, socio-economic analysis, policy studies and energy innovation and market uptake. The site is aimed principally at decision makers, but may also prove useful to private sector institutions interested in support available in different EU countries for low carbon energy projects.

The European Energy Research Alliance (EERA) is an alliance of leading organisations in the field of energy research. EERA aims to strengthen, expand and optimize EU energy research capabilities through the sharing of world-class national facilities in Europe and the joint realization of pan-European research programmes (EERA Joint Programmes). The primary focus of EERA is to accelerate the development of energy technologies to the point where they can be embedded in industry-driven research. In order to achieve this goal, EERA streamlines and coordinates national and European energy R&D programmes http://www.eera-set.eu/.

FP7 / Horizon 2020 require trans-national cooperation. That is, projects must involve partners from at least three different EU member states or associate countries, working together on a joint research programme to address topics of European significance.

This is similar to other EU programmes, such as European Territorial Cooperation (INTERREG) which is based on cooperation on cross border and common issues across regional programmes. Most relevant for the ENSEA partners is the North Sea Programme, for which the current ENSEA regions are eligible, and which has supported a number of projects from 2007-13 in the energy field. Recently the learning from these projects has been brought together in a number of Cluster or capitalisation projects, including North Sea Energy Vision, to help ensure that the results have an ongoing impact and prepare for cooperation in the new programming period.

There is a strong history of joint working between partners in the ENSEA regions, particularly in the energy sector. This has been facilitated by good ongoing relationships between partners and in particular the partnership structure offered by the North Sea INTERREG programme.

For FP7, structures for identifying and working with partners from across Europe are less developed, although there are various mechanisms which can be used e.g. the network of National Contact Points, the Enterprise Europe Network, European Technology Platforms and Industrial Associations, various other networks of interest groups, such as ERRIN, and the EERA. For example, ERRIN, the European Regions Research and Innovation Network, have a number of thematic groups, including Energy, and organises brokerage events to assist partnership and project development.

New opportunities are likely to evolve with the implementation of Horizon 2020, but there is a gap in formal and informal clustering arrangements around specific challenges, research areas or geographical regions. Further, many of the existing networks and structures are based on technology sectors and / or specific groupings e.g. universities, industry, agencies, NGOs. There is a lack of structures to support the kind of cross-sectoral, multi-disciplinary approach which has been identified as essential to the new EU agenda of addressing societal challenges in a holistic manner and ensuring a focus on innovation, commercialisation and deployment.

The principal relevant EU functions are illustrated in the diagram below:

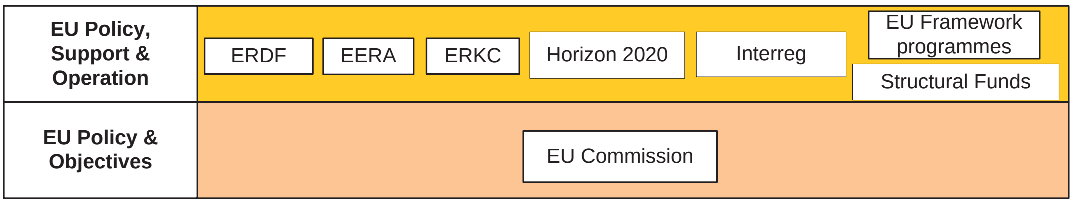


Figure 8: EU Policy Implementation in Scotland

3.4 Use of EU Funding Programmes

Scotland's performance in FP7

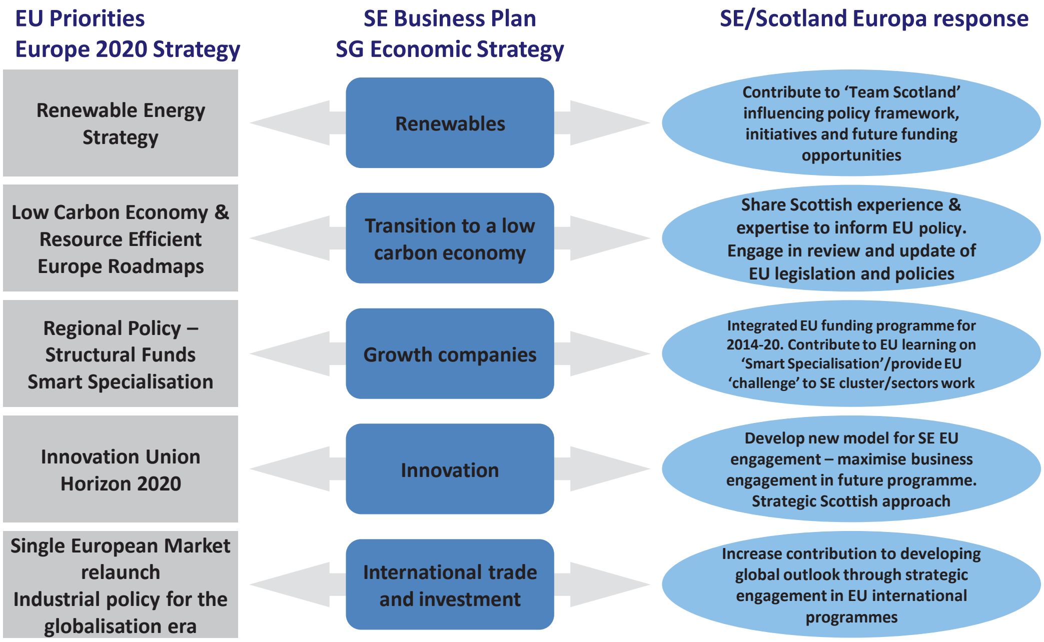
To 1 July 2013, Scotland had secured €505m of FP7 awards, considerably higher than under FP5 and FP6. Scottish Higher Education and Research Institutes are the main beneficiaries, receiving 89% of the funding to Scottish organisations. Scottish businesses have secured €46.5m of FP7 funding, of which €41m has been awarded to SMEs. The European Commission set a target of 15% of funding under the Cooperation sub-programme of FP7 to SMEs; Scotland is currently just above this target with 16% of funds awarded to SMEs. 70% of funds secured by Scottish organisations under the Cooperation sub-programme have been under three themes – ICT, Health and Food, Agriculture and Fisheries and Biotechnology. Funding secured under the Energy sub-programme to July 2013 is €9.4m Scottish organisations are involved in almost 1,100 FP7 projects. 19 Higher Education organisations and 141 businesses have been involved in approved projects. (Figures based on data received by UK Department of Business, Innovation and Skills).

Other funding programmes

The Scottish Government has successfully introduced a focus in the 2007-13 European Regional Development Fund Programmes on transition towards a low carbon economy and supporting the development of renewable energy. This has included a focused call for low carbon projects under the Research and Innovation priority of the Lowlands and Upland ERDF programme, which resulted in a number of knowledge exchange and SME support programmes, support for SME research and demonstration projects in the ocean energy sector though the Wave and Tidal Energy Research Scheme. Scottish partners have also made good use of the competitive, transnational EU funds, including Territorial Cooperation, Intelligent Energy Europe and FP7, with key strategic projects including ISLES (Irish Scottish Links on Energy Studies), under the Cross Border Programme between Western Scotland, Ireland and Northern Ireland. The original ISLES project was a major study into technical and economic feasibility of an integrated offshore electricity grid to connect offshore wind, wave and tidal energy developments in the Irish Sea / western coastal waters, while ISLES 2 will focus on progress towards implementation, including joint work on consenting, marine spatial planning and working towards support from the Connecting Europe Facility.

EU Priorities, Scottish Government Economic Strategy, Scottish Enterprise Business Plan: Alignment and Scottish Enterprise / Scotland Europa response:

The Scottish Government has given a high priority to the role EU engagement can play in implementing the Government Economic Strategy, as well as contributing to wider policy objectives, and has asked its departments and agencies to proactively examine opportunities. The diagram below illustrates some of the ways in which EU and Scottish policy are aligned, and the proposed response from Scottish Enterprise to maximising the opportunities this presents.



Source: Internal brief, 2013, Scotland Europa

Figure 9: Policy Alignment with Horizon 2020

3.5 Support for EU Collaboration in Scotland:

A range of services and networks exist in Scotland to support engagement in EU policy development, EU funding and other collaboration opportunities. Scotland Europa is part of Scottish Enterprise and also a membership organisation which works with and supports Scottish Enterprise, the Scottish Government and more than 50 organisations in the academic, public, private and charity sectors with EU networking and engagement. Scotland also has an Enterprise Europe Network, hosted by Scottish Enterprise. In 2009 the Scottish Government, in recognition of the importance of and opportunities in the energy sector, established the Scottish European Green Energy Centre (SEGEC). SEGEC has now been incorporated into Scottish Enterprise, to support the development of EU projects in key areas such as offshore renewables, smart cities and electricity grids. The Scottish Government is also developing a specific EU engagement strategy for energy, which will include developing strategic relationships with other regions with common interests.

Working together as the Scottish EU Research and Innovation Steering Group, the Scottish Government, Scottish Enterprise (SE)/Highlands and Islands Enterprise (HIE), Scotland Europa, Enterprise Europe Scotland (EES) and the Scottish Funding Council (SFC) have jointly developed a *Horizon 2020 Scottish Support Framework* to enhance Scottish participation in the new programme. The aim of this Scottish Support Framework is to contribute to the following objectives of the Steering Group:

- Deliver collaborative, strategic approach to EU Research and Technological Development (RTD) engagement for Scotland 2014-2020
- Enhance business engagement from Scotland (with particular focus on SMEs) in Horizon 2020
- Consolidate and expand Scottish leadership and participation in 'Academic excellence' elements of Horizon 2020 and wider EU RTD field
- Integrated and coordinated approach bringing together different support mechanisms and initiatives provided by the public sector partners mentioned above.

The Scottish Framework will also be coordinated with UK initiatives, such as the Knowledge Transfer Networks, NCPs and the UK stakeholder groups established by the Department for Energy and Climate Change.

The specific approach developed for Horizon 2020 will also be the basis for coordinated, strategic and sector specific activity to exploit opportunities under other funding programmes and initiatives, complemented by the Scottish approach to the European Structural and Investment Funds, which will seek build research and innovation capacity, support increased competitiveness of SMEs and the transition to a low carbon economy.

3.6 UK Policy Development & Implementation

The UK Government is the principal actor that fulfils this function, primarily through two separate Departments:

- Department for Energy and Climate Change (DECC); and
- Department for Business, Innovation & Skills (BIS).

Through DECC, it provides decarbonisation targets for the UK along with detailed measures to reform the electricity market (EMR). The Energy Act (2013) puts in place measures that are intended to attract £110 billion investment to replace current UK generating capacity and upgrade the grid by 2020 and to cope with rising demand for electricity.

BIS invests in skills and education, provides strategies for industry growth and wider support for innovation. It works through a large number of agencies, in particular, the Technology Strategy Board (TSB) which is now the UK's principal innovation agency as shown in the Facilitation and Direction of R&D level.

The Energy Research Partnership is a high-level forum bringing together key stakeholders and funders of energy research, development, demonstration and deployment in Government, industry and academia; plus other interested bodies, to identify and work together towards shared goals. It is designed to give strategic direction to UK energy innovation, seeking to influence the development of new technologies and enabling timely, focused investments to be made. It does this by (i) influencing members in their respective individual roles and capacities and (ii) communicating views more widely to other stakeholders and decision makers as appropriate. ERP's remit covers the whole energy system, including supply (nuclear, fossil fuels, renewables), infrastructure, and the demand side (built environment, energy efficiency, transport). The Partnership was instrumental in establishing the UK Energy Technology Institute, ETI (shown in Knowledge Creation and Development) and continues to oversee its development. It is co-chaired by Government and industry representatives.

The Engineering and Physical Sciences Research Council (EPSRC) is the UK's main agency for funding research in engineering and the physical sciences. EPSRC invests around £800 million a year in research and postgraduate training to help the UK handle technological change. It is therefore a principal source of funding for relevant academic research.

The Carbon Trust's mission is to accelerate the move to a low carbon economy and it operates independently of government. It advises all parties on low carbon and sustainable opportunities, certifies environmental footprints and seeks to develop and deploy low carbon technologies and solutions, form energy efficiency to renewable power.

The Crown Estate manages property across the UK owned by the Crown. It works supportively with government at all levels – Westminster, Scotland and at a local level. Its property portfolio covers urban and rural areas throughout the UK and most importantly for ENSEA, around half of the foreshore and almost the entire seabed around the UK. It therefore has key roles to play in facilitating the development of offshore energy activity. The Carbon Trust appear here as they offer direction at a UK level but are also included in the Scottish functions due to their influence on the system.

Architecture designed to fulfil this function

In its role as the key actor here, the UK Government has established a large number of agencies (e.g. the ERP) to fulfil its functions. There are extensive links among the Government Departments and Agencies.

It is important to recognise the impact of these ex-Scotland institutions and their policies on the potential for promoting the integration of energy in Scotland. Alignment of policy is critical to the success of research and commercialisation of systems integration activity.

Figure 10: UK Policy Development and Implementation of Policy

3.7 UK Renewable revenue support framework

Electricity Market Reform (EMR) will be phased in from 2014 and will fully replace the current system by 2017. It will be managed by Ofgem and National Grid. The Contracts for Difference system under EMR will set a strike price, £/MWh which includes the wholesale electricity price, for all technologies within an overall budget cap. Support will be provided for at least 17 years for a project however the level of support reduces over time to encourage early development of projects.

Table 7: Levels of EMR support in £/MWh by technology and total funds available to 2019

Table 3: CfD Strike Prices (£/MWh, 2012 prices)[31]

Technology	2014/15	2015/16	2016/17	2017/18	2018/19
Advanced Conversion Technologies[32] (with or without CHP)	155	155	150	140	140
Anaerobic Digestion (with or without CHP) (>5MW)	150	150	150	140	140
Biomass Conversion[33]	105	105	105	105	105
Dedicated Biomass (with CHP)	125	125	125	125	125
*Energy from Waste (with CHP)[34]	80	80	80	80	80
Geothermal (with or without CHP)	145	145	145	140	140
*Hydro[35] (>5 MW and <50MW)	100	100	100	100	100
*Landfill Gas	55	55	55	55	55
*Sewage Gas	75	75	75	75	75
Offshore Wind	155	155	150	140	140
*Onshore Wind (>5 MW)	95	95	95	90	90
*Solar Photo-Voltaic (>5MW)	120	120	115	110	100
Tidal Stream [36]	305	305	305	305	305
Wave[37]	305	305	305	305	305
Scottish Islands – onshore wind (>5MW)	-	-	-	115	115

Source: Electricity Market Reform Delivery Plan, December 2013, Department of Energy and Climate Change (p37)

Support for Grid Investment

The investment in grid infrastructure is regulated by Ofgem, the UK Network regulator. The two Scottish transmission network operators, Scottish Hydro Electric Transmission and SP Transmission, need to submit detailed investment plans to Ofgem for approval. Investment in network assets is funded through debt and equity - with Ofgem setting limits for the returns from investment.

Scope for foreign investment in grid infrastructure is rather limited and investment may not be very attractive due to the regulated nature of the returns. Bonds would be an option to meet the need for increased debt financing. For the period 2013-2021, Ofgem has set the cost of equity to 6.0-7.2% on the assumption that the risk profile of the network companies in that period is similar to their current risk profile.

Scottish Hydro Electric Transmission and SP Transmission have estimated the investment required in their transmission networks between 2013 and 2021 at £4bn and £2.14bn respectively. This includes both modernisation of the current network and expansion/reinforcement of the network to meet the Scottish Government's 100% renewables target in 2020

Grid Investment requirements to meet 2020 targets

From their respective Business Plans, the investment required for Scottish Hydro Electric Transmission and SP Transmission between 2013 and 2021 is:
* Scottish Hydro Electric Transmission Limited: £4bn (in 2009/2010 prices) - breakdown:
** Modernizing the current network: £949m
** Expanding/reinforcing the network to meet the renewables targets: £3,081m

* SP Transmission: £2.14bn (in 2009/2010 prices) - breakdown:
** Modernizing the current network: £0.7bn
** Expanding/reinforcing the network to meet the renewables targets: £1.43bn

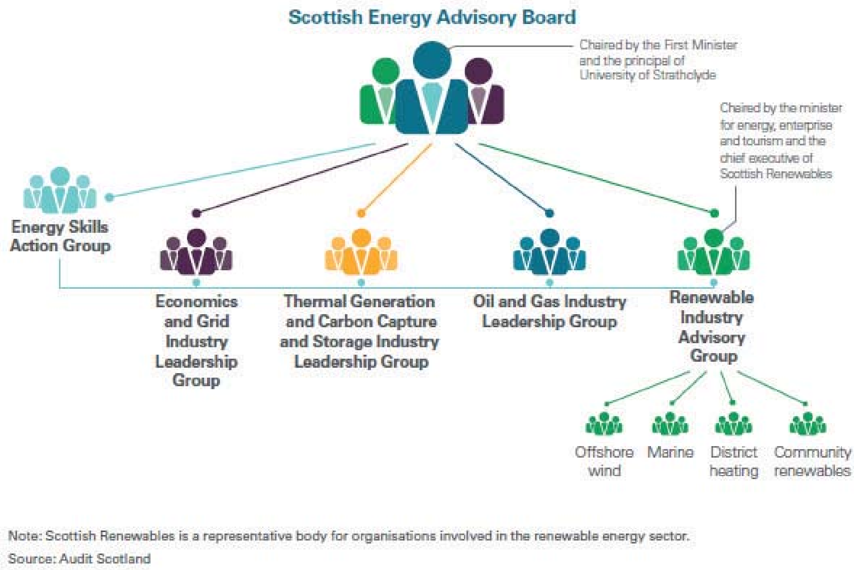
Investment in onshore network assets is funded through the balance sheet (debt and equity) - with Ofgem setting limits for the cost of debt and the cost of equity, thus effectively fixing returns from investment.

3.8 Scottish Formulation and Advocacy of Policy

The Scottish Government is the principal actor that fulfils this function. The Enterprise, Environment and Digital Directorate covers Business, Energy & Climate Change and Marine Scotland functions. Additional institutions include, Skills Development Scotland, Scottish Enterprise and Highlands and Islands Enterprise.

The Scottish Government has roles and influence across a number of functions including the formulation, advocacy and implementation of policy and also has input in the facilitation and direction of R&D.

The Scottish Energy Advisory Board has a pivotal role in developing the Scottish industry view on current and future energy challenges. It aims to develop the Scottish industry view on relevant issues, to include potential synergies between the oil and gas, thermal generation, carbon capture and storage, and the renewables sectors, delivering a low carbon economy and ensuring the security of Scotland's energy supply maximising opportunities in a sustainable way. It is currently co-chaired by the First Minister and the Principal of Strathclyde University. A number of SEAB sub-groups have been established including the Economics and Grid Group. A Smart Grid Working Group has also been established (including representation from industry and the Enterprise Agencies) which has produced a Scottish Smart Grid strategy.



Source: 'Renewable Energy', September 2013, Audit Scotland

Figure 11: The Scottish Energy Advisory Board and its sub groups

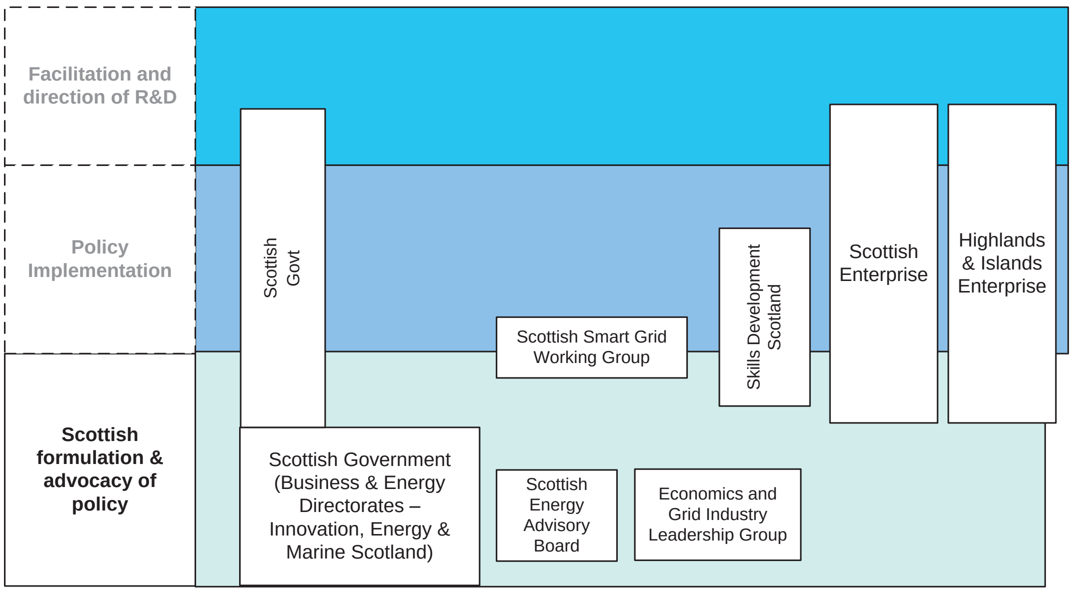


Figure 12: Scottish formulation and advocacy of policy

In its role as the principal actor, the Scottish Government has produced a number of key policy documents. The following are of particular relevance to ENSEA -

- 2020 Route map for Renewable Energy in Scotland - sets out a framework for action in the area of renewable energy for delivering the equivalent of at least 100% of gross electricity consumption from renewables by 2020.

http://www.scotland.gov.uk/Publications/2011/08/04110353/0

- Renewable Heat Action Plan - focuses on action required in the next two years to accelerate progress towards the target of 11% of the heat consumed in 2020 to come from renewable sources from 4% in 2011.

- Marine Energy Road Map - sets out the scenarios for growth in Scotland's marine renewables industry and the critical institutions for success.

- Offshore Wind Route Map - sets out the opportunities, challenges and recommendations for action to realise Scotland's full potential in offshore wind.

- National Renewables Infrastructure Plan - provides investors with the infrastructure required for the development of a globally competitive offshore renewables industry.

- Carbon Capture and Storage (CCS) Roadmap and the Section 36 Thermal Guidance for large scale power station applications over 50 MW - both detail a comprehensive set of measures to put Scotland at the forefront of CCS development.

- Climate Change Report on Proposals and Policies (RPP) – In compliance with the Climate Change (Scotland) Act 2009 the RRP sets out proposals and policies for meeting annual emissions reductions targets from 2010 to 2022. It sets out the pathway to meeting the Scottish Government targets. An Electricity Generation Policy Statement underpins this.

- Energy Efficiency Action Plan (EEAP) - focuses on climate change mitigation, but will aid adaptation in terms of reducing consumption and promoting micro generation. 12% reduction in total final energy consumption by 2020 planned.

Scottish Climate Change targets
Reduce emissions of greenhouse gases from 1990 levels by at least 42% by 2020 and at least 80% by 2050.

When the last inventory of Scottish emissions was made in 2010 they stood at 56Mt CO_2e (e – meaning ‘equivalent’ and including other greenhouse gases like methane) or 23% below 1990 levels.

Scottish Energy targets
- The equivalent of at least 30% of total energy demand supplied by renewable sources by 2020 (incorporating the following supplementary targets), comprising of:
  - •the equivalent of 100% of Scottish electricity demand (which is around 40TWh) from renewables*
  - 11% of heat demand from renewables
  - 10% of transport fuel from renewables
- Scotland's Energy Efficiency Action Plan includes a target to reduce total energy consumption by 12% by 2020 from 2010 levels.

Longer term targets include:
- A largely decarbonised electricity generation sector by 2030
- A largely decarbonised heat sector by 2050, with significant progress by 2030

Note: *The assumption supporting the 100% renewable (based on Scottish demand) electricity target is that installed capacity for onshore wind will be 7GW, offshore wind 6GW and marine 1GW by 2020, or 14GW of renewable capacity.

Renewables investment requirements to meet 2020 targets

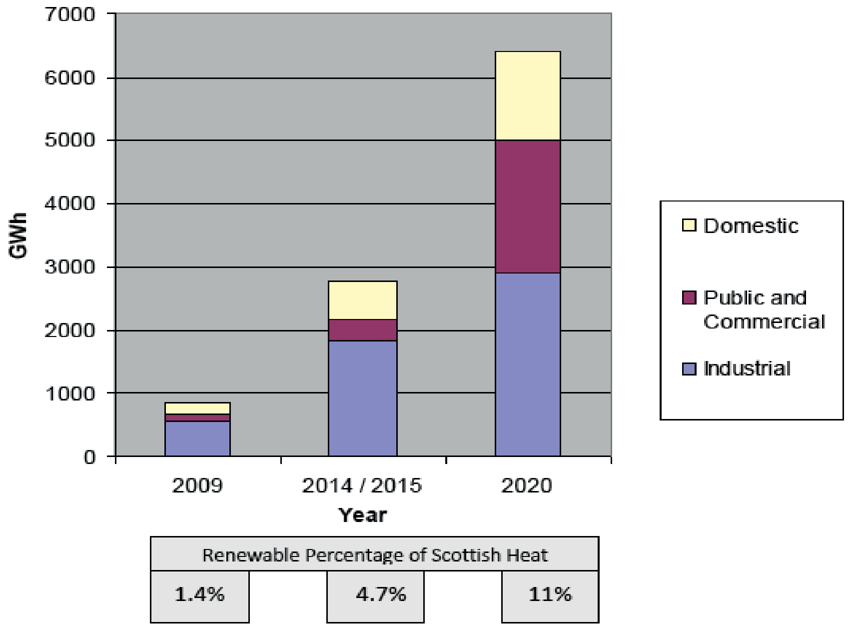
Based on the Scottish Government 100% renewable target, one scenario produced by them envisages an additional 2GW of onshore wind, 6GW of offshore and 1GW of marine devices would cost around £28.5BN to be delivered.

Table 8: Estimate of additional capacity and spend required to meet 2020 targets in Scotland

	MW	£M/MW	£M
Additional Onshore Wind	2000	1.5	3,000
Offshore Wind	6000	3.0	18,000
Marine	1000	7.5	7,500
			28,500

Source: Internal estimate, 2013, Scottish Enterprise

Meeting the Renewable Heat Action Plan 2020 target of delivering 11% of Scotland's projected 2020 heat demand from renewable sources, amounting to some 6.4TWh, is estimated to require an installed capacity of circa 2.1GW.



Source: 'Renewable heat Action Plan for Scotland' 2010, Scottish Government

Figure 13: Scottish Renewable Heat targets

The diagram above shows the estimated installed capacity needed to meet the 2020 Renewable Heat Target.

Policy Implementation

The main institutions delivering the policy implementation function are:

- Scottish Government
- Scottish Enterprise
- Highlands & Islands Enterprise
- Skills Development Scotland

The Scottish Government has the primary role and a number of agencies whose roles are predominantly in delivering the function of facilitating and directing R&D, also support the delivery of this function. These include the Scottish Funding Council, the Crown Estate and the Carbon Trust. All have important roles that relate, in particular, to the development of renewable energy. The Scottish and UK governments have strong influencing roles over these organisations.

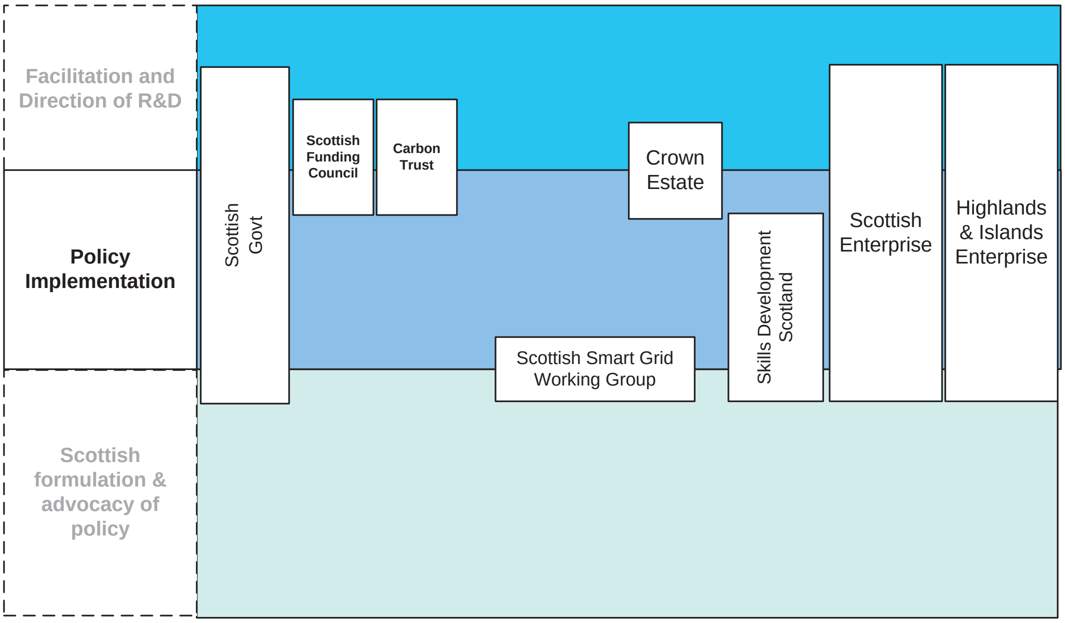


Figure 14: Policy Implementation

As Scotland continues to promote innovation and EU engagement, Smart Specialisation policies are playing an increasingly important role. With a long-standing combination of industry, sector and cluster approaches, Scottish Enterprise is both sharing and further refining its economic focus. In this context, it is participating in the TRES (Interreg IVC) project where a number of its approaches, including renewable energy, have been recognised as examples of good practice. Scotland has also recently joined a small group of EU regions in the Vanguard Initiative which brings together leading industrial regions in Europe to provide a positive impetus to inter-regional cooperation to help shape the industries of the future

The recent review of Scotland's Innovation System (A smart, sustainable nation? – A review of Scottish research and innovation policy in the context of the smart specialisation agenda, August 2012 undertaken for the European Commission, as part of its "Regional Smart Specialisation and Innovation Strategy" assessment, has helped to crystallise some of the key strategic challenges requiring attention and highlighted where changes in policy support are required to significantly improve Scotland's innovation performance and its contribution to productivity growth. In particular, it highlighted the following weaknesses of the system, namely:

- low number of enterprises involved in formal R&D and innovation activity.
- insufficient focus on innovation as a driver of growth across all sectors.
- over emphasis on funding for spin outs and R&D and for the transfer of IP/Technology from universities into companies.

- under emphasis on funding for collaborative innovation projects for smaller firms in partnership with 'companies of scale' and the HEIs.
- need to raise internal capabilities of smaller firms to access and assimilate technology.
- imbalance of human resources in the innovation system – too little in firms and overabundance in academia.
- insufficient dedicated sectoral innovation services for sectors where overall innovation activity is well below average.

The report concludes a significant increase in Scotland's productivity growth through innovation activities will require four key shifts in policy support:

- raise the 'game' in terms of innovation and broaden innovation activity away from the usual "technology" suspects.

- increase R&D activities especially collaborative approaches that engage more small companies and suppliers to Tier 1 companies.

- greater focus on demand side policies which stimulate lead market innovation and which are driven by real company and market demand.

- boost the capacity within firms to execute and commercialise innovation activity - developing the marketing, customer engagement as well as technical capabilities of our firms.

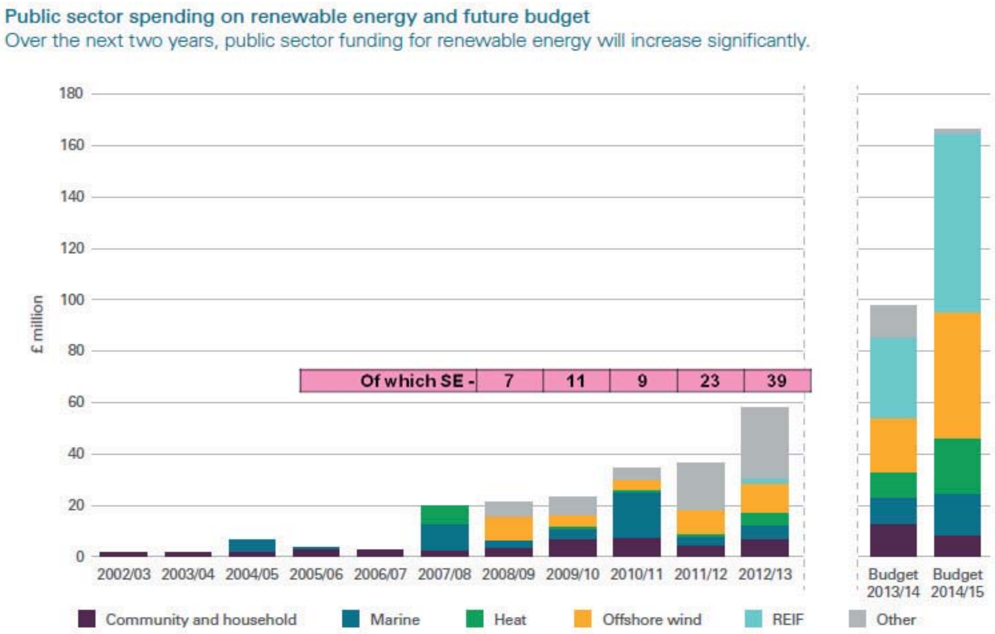
Audit Scotland has recently assessed the amounts spent on support for renewables (and Grid) by Scottish Enterprise and has produced the following information –

Table 9: Overview of Scottish Enterprise funding support for Renewables and Grid innovation

			Spend (£ millions)					
Funding / investment	**Category 1**		**2008/09**	**2009/10**	**2010/11**	**2011/12**	**2012/13**	**TOTAL**
Other Projects	Marine	Company Support	0.057	0.03	0.00	0.00	0.00	0.08
Other Projects	Marine	Development & Testing	0.041	0.00	0.28	2.75	2.13	5.20
	Offshore Wind	Company Support	0.01	0.10	0.10	1.00	0.82	2.02
Other Projects	Offshore Wind	Development & Testing	0.02	0.22	0.02	0.72	0.04	1.01
NRIF	Offshore Wind	Infrastructure	0.00	0.00	0.18	0.59	3.28	4.05
SIB investment	Other	Company Support	2.90	2.52	1.57	6.57	8.36	21.91
RSA grants	Other	Company Support	0.14	2.45	0.65	1.46	1.65	6.35
SMART grants	Other	Company Support	0.00	0.13	0.32	0.50	0.58	1.53
R&D grants	Other	Company Support	0.00	0.25	0.31	0.80	0.34	1.69
REIF	Other	Company Support	0.00	0.00	0.00	0.00	1.55	1.55
Other Projects	Other	Company Support	0.372	0.66	0.96	1.39	1.86	5.24
ITREZ	Other	Development & Testing	0.00	0.00	0.15	0.95	10.97	12.07
Fife Energy Park	Other	Development & Testing	0.676	0.98	0.39	0.00	0.04	2.08
Power Networks Demo Centre	Other	Development & Testing	0.00	0.04	0.23	1.57	3.59	5.43
Other Projects	Other	Development & Testing	0.41	0.53	0.28	0.38	0.28	1.87
Fife Energy Park	Other	Infrastructure	2.259	3.01	3.06	3.35	3.25	14.94
Dundee Port Renewables	Other	Infrastructure	0.00	0.04	0.00	0.77	0.14	0.94
Other Projects	Other	Infrastructure	0.00	0.05	0.05	0.09	0.01	0.19
			6.88	11.00	8.53	22.88	38.87	88.16

Source: 'Renewable Energy', September 2013, Audit Scotland

This Scottish Enterprise (SE) spend is equivalent to around 50% of all Scottish Government spending on renewables. The figure below provides a historic and forward projection of Scottish public sector support in these areas and puts historic SE spend in context.



Source: 'Renewable Energy', September 2013, Audit Scotland

Figure 15: Public Sector spend on renewable and future budget

3.9 Facilitation and Direction of R&D

There are numerous institutions delivering this function. The main ones are:

- EU bodies
- UK Government
- Scottish Government
- Scottish Enterprise
- Highlands & Islands Enterprise
- Energy Technology Institute

In addition, the Scottish Funding Council, the Crown Estate and the Carbon Trust all make important contributions to funding research and development work. The Technology Strategy Board and EU sources also have major influences on the direction and resourcing of research in this area.

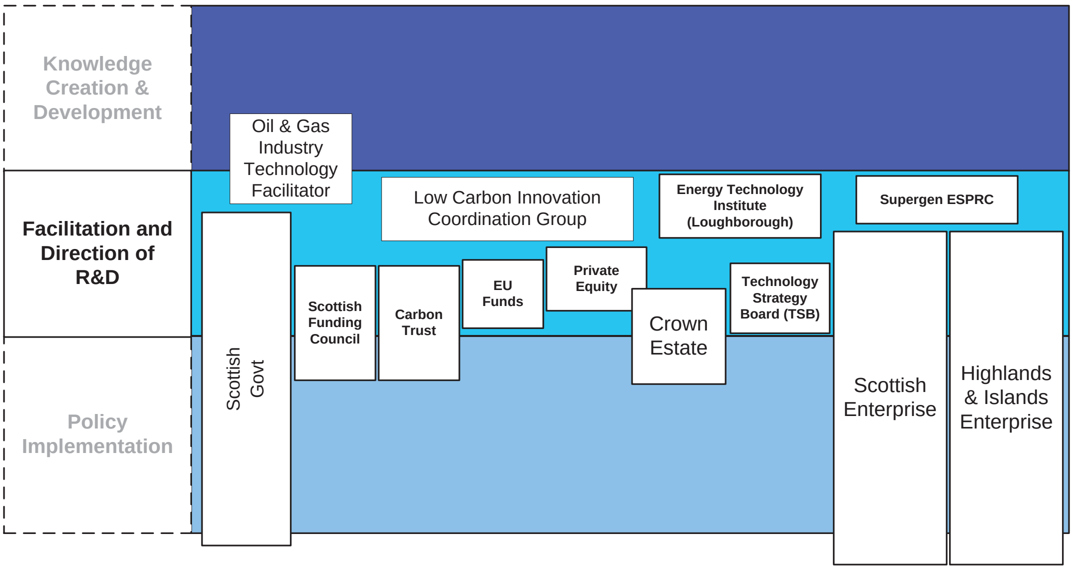


Figure 16: Facilitation and Direction of R&D

The progression of technologies through RDD&D is often described in terms of Technology Readiness Levels from basic research (TRL1-3) through applied research (4-5), demonstration (6-7) to full scale, pre-commercial deployment (8-9). Advancing through this range of TRLs is often very costly and time consuming and requires different types and levels of support at different times. The path is often strewn with obstacles including the cash-starved 'valley of death' around TRLs 4-6. The path is also rarely linear, the concepts of technology push and market pull in reality a recycling back and forth through the TRLs and learning by doing. In addition, different technology types are at different maturity / readiness levels and therefore require different support mechanisms, e.g. innovation focus for offshore wind is largely around cost reduction whereas for fuel cells is on efficiency and technology development. The design and delivery of a comprehensive and integrated suite of innovation funding mechanisms is therefore highly complex.

EU Innovation Funding

Energy is a priority area for EU innovation and is extremely well funded (FP7 – 2.35B€, Intelligent Energy – 0.7B€, NER300 – 4.5B€). However, the UK and Scotland have historically low levels of engagement and consequently low levels of participation in work programmes. Through the work of Scotland Europa and the Scottish European Green Energy Centre (SEGEC) this is now changing and there have been a number of recent successes.

Since its establishment, SEGEC has delivered over €110m of EU funding for low-carbon energy projects, facilitated several other key projects and continues to develop others. €40m has been secured from the European Economic Recovery Plan for the €200m European Offshore Wind Deployment Centre, to be located off Aberdeen and €74.1m towards a new €150m Moray Firth Offshore HVDC hub.

The UK Government has submitted 12 applications for consideration in the next round of the EU's New Entrant Reserve (NER) scheme where up to three projects may be supported per Member State. Three of the 7 CCS related applications are from Scotland (Ayrshire, Longannet, and Peterhead) as are 4 of the 5 renewable energy applications (all marine energy). SEGEC has provided direct support in two of these: Islay Tidal Project, €21m EU in total project value of

€95m and POWER (Pentland Orkney Wave Energy Resource), €78M out of €228m total. Scottish researchers and companies are also partners in a number of other significant EU funded projects, including: ISLES (offshore grid study), BioMara (Biofuels from marine biomass), and TWENTIES (transmission grid).

ETP universities also identified a strategic need to increase their level of influence within EU decision making bodies and now fund participation in European Energy Research Alliances (EERA) in wind energy, marine energy and CCS. EERAs will accelerate the development of new energy technologies through joint research programmes in support of the EU Strategic Energy Technology (SET) plan.

UK Innovation Funding

There is now much greater emphasis on aligning the work of the main energy-related UK funding bodies: Research Councils UK (RCUK), Carbon Trust, Energy Technologies Institute (ETI), Technology Strategy Board (TSB), and the Department of Energy and Climate Change (DECC). These funders meet as the Low Carbon Innovation Coordination Group (LCICG) to provide a more comprehensive and joined up range of support than would otherwise be possible. LCICG members retain their own focus, agree the 'natural owner' of activities, whilst coordinating with others. A summary of LCIG member roles is shown below.

LCIG focuses primarily on the delivery of work programmes to meet the UK's 2020 and 2050 low carbon targets. In addition, the Energy Research Partnership (ERP) brings together public and private sector funders to enhance opportunities for collaboration and identify shared priorities for research. ERP does not directly fund energy innovation and as such can function as a high-level advisory forum to develop strategic initiatives and make recommendations to LCIG and other funding bodies.

The Energy Technology partnership has unparalleled engagement with these main UK innovation funders and Scottish Enterprise is developing a number of joint calls for future projects with many of these bodies that reflect this greater clarity of innovation priorities to deliver support in line with the innovation challenges identified in areas such as offshore wind and marine energy technology.

Research Councils UK SUPERGEN (Sustainable Power Generation and Supply) is a flagship programme in the Research Council's Energy Programme. ETP member university involvement in SUPERGEN is substantial in a UK academic context, leading on 6 of the 14 programmes and actively contributing to 7 others. In addition, ETP hosts the prestigious UK Doctoral Training Centre in Wind Energy and UK Industrial Doctorate Centre in Offshore Renewable Energy that together will produce ~110 highly trained and 'industry ready' post-graduates. The latter centre is part-funded by ETI, evidence of the joined up thinking being championed by LCIG.

Carbon Trust, SSE Renewables and Scottish Power Renewables are major partners in the Offshore Wind Accelerator which is funding specific R&D work with a number of organisations in Scotland. The Marine Energy Accelerator ran from 2007-2010, reported in July 2011 and similarly had extensive engagement with Scottish companies and academics.

The Energy Technology Institute is an extremely well-funded (£1billion over 10 years), innovative and unique Limited Liability Partnership between major companies (Rolls-Royce, Shell, BP, Caterpillar, E.ON, EDF) and the UK government with a focus on speeding up the development and demonstration of energy technologies and shortening the lead times to market. ETP universities are members of seven project consortia in wind (3), marine (2), and CCS and transport programmes, further evidence of their excellent UK standing.

Table 10: Low Carbon Innovation Coordination Group (LCICG) Member Roles

Area	RCUK	Carbon Trust	ETI	TSB	DECC
Driver	Research excellence with impact	Reduce carbon	Develop new technologies	UK wealth creation	Removing barriers to deployment
Focus	R & D	R,D, D &D	Applied R&D and early demo-	Applied R&D and early demo-	Demo - and deployment
TRL	1-3	4-9	3-6	3-6	6-9
How	Grant funding	Customised interventions	Portfolio of large projects	Innovation funding, grants, networks	Grant funding and market pull mechanisms
Wind example	EPSRC – SUPERGEN Wind, DTC Wind	Reducing costs of Round 3	Future offshore turbine optimisation	Offshore Renewable Energy TIC	Renewables obligation

Source: 'Energy Technology Innovation Funding', 2013, Energy Technology Partnership

The overall function of the Technology Strategy Board (TSB) has already been noted. A recent major initiative is the planned investment of approximately £200m in a network of 6-8 UK Technology Innovation Centres (or Catapults). It is intended that these will help to drive future economic growth by creating a critical mass for business and research innovation whilst focusing on specific technology areas with strong UK capability and a large potential global market. The TSB Offshore Renewable Energy Catapult is now being set up in Glasgow.

TSB also manages a number of innovation programmes, e.g. Knowledge Transfer Partnerships (KTP), Grant for R&D Scheme (ex RDA), Small Business Research Initiative (SBRI) and these all have good engagement by Scottish organisations.

Department for Energy & Climate change operates mainly at the demonstration and pre-commercial deployment stage of the innovation chain, bridging the lengthy and often costly gap between a technology being ready and being widely deployed. Main recent funding has been ~£400m (2008-2011) in the Environmental Transformation Fund and ~£400m (2009-2011) in the Low Carbon Investment Fund. A number of Scottish organisations have benefited from the funds including, European Marine Energy Centre, Carbon Abatement demonstrator at Longannet and others will likely benefit from the new £20m Marine Energy Fund.

Beyond TRL9 and into commercial scale deployment of technologies, BIS is leading on the development of the £3billion Green Investment Bank that will accelerate private sector investment in the UK's transition to a green economy. Sectors likely to be eligible for intervention initially include offshore wind, non-domestic energy efficiency and waste.

Innovation Funding in Scotland

The majority of UK and EU innovation funding streams are available for Scottish organisations. Scotland also has a number of bespoke mechanisms and, similar to the rationale for LCIG, there has been a drive towards consolidation and increased coordination. The majority of these are now managed by Scottish Enterprise and span much of the TRL range: Proof of Concept (TRL 2-3), SMART (3-4), R&D grant (4-6), Enterprise Fellowships, High Growth Start Up. The various products within the Scottish Investment Bank (SIB) and Regional Selective Assistance (RSA) are also important enablers of technology innovation at TRLs 8-9 and into commercial deployment.

An excellent example of the co-ordinated delivery of such support is NGenTec, the Edinburgh based developer of innovative generator technology for wind turbines. Originally supported by proof of concept funding, spinning out from the Institute for Energy Systems at Edinburgh University, NGenTec then attracted £2M of investment funding, including co-investment support from the Scottish Investment Bank, and a further £800,000 from the DECC Environmental Transformation Fund. It has subsequently also secured further funding in an industrial partnership from David Brown Gears, part of the Scottish Blowers group and is testing prototypes both at the university and at the TUV NEL facility in the West of Scotland, while working with SDI to build links to international markets.

In addition to the Scottish Funding Council's core and Knowledge Transfer grant funding of Scottish universities and colleges, it also has a number of innovation and knowledge exchange focused programmes. From 2009-2011, SFC funded a £14m Strategic Priority Investments in Research and Innovation Translation (SPIRIT) programme to develop collaborative projects between academia and industry. ETP was awarded £1.2m to part–fund a prestigious £4m Industry Doctorate Programme that in partnership with industry and government is supporting 50 post-doctorate researchers to enhance industry innovation and knowledge exchange effectiveness. This programme has been hugely successful and highly valued by industry with funding now being sought for its continuation, in support of the Skills Investment Plan for the Energy Sector. The "knowledge connection for business organisation" Interface, manages, on behalf of SFC, the Innovation Voucher scheme aimed at building relationships between SMEs and HEIs.

In 2010, the Scottish Government launched the Scottish Innovative Low Carbon Fund, comprising £15.2m of European Regional Development Funds, to improve the competitiveness of business through increased innovation and fuller use of the Scottish academic base. ETP was successful with a bid to develop a new £3m Knowledge Exchange network (match funded by Scottish Government, SE, SFC and ETP) that will greatly enhance knowledge exchange and innovation with Scottish companies. A further six energy projects were also approved for ERDF funding and ETP coordinates this £12m total investment, to minimize duplication and derive added value through collaboration.

The Saltire Prize is Scotland's £10 million challenge to accelerate the commercial development of marine energy and is another excellent example of Scotland providing leadership on energy innovation.

The International Technology and Renewable Energy Zone (ITREZ) project, being developed in Glasgow, is a key element of the National Renewable Infrastructure Plan. It brings together industry and academia focusing on the development of offshore wind and other renewables. ITREZ includes the TSB Offshore Renewable Energy Catapult, the Strathclyde TIC and includes an industry engagement building.

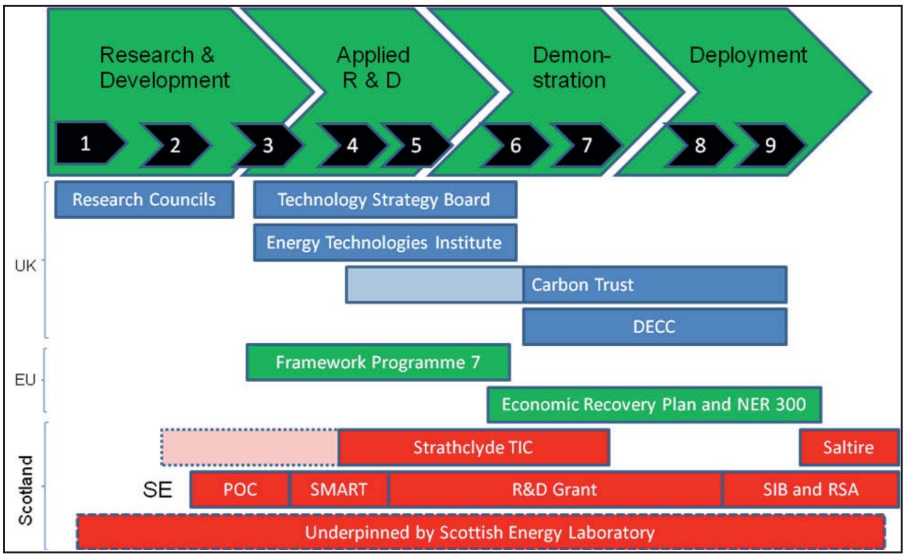


Figure 17: Innovation Funding set against Technology Readiness levels (1-9)

Source: 'Energy Technology Innovation Funding', 2013, Energy Technology Partnership

The University of Strathclyde's recent £89m investment in its Technology and Innovation Centre (TIC) is designed to accelerate collaboration between academia and industry by bringing together around 850 researchers, engineers and project managers to work side-by-side in a state of the art building in the heart of Glasgow. The focus of activities is on: power and energy, renewable technologies, photonics and sensors, advanced engineering, pharmaceutical manufacturing, bio-nano systems and the TIC will benefit from participation by large corporations and a large grouping of innovative SMEs. Many of these companies will also benefit from the business growth support structures that they can engage with alongside the innovation support. The streamlined continuum of support that now links from proof of concept, through SMART and R&D grants in to RSA as companies grow, coupled with the access to funding through the Scottish Investment Bank and support from account management and the SE high growth start-up unit. In the past 3 years, this has seen investment in energy innovation through SMART and R&D grants in projects representing some £27M in capital value.

Some of the work in the Strathclyde TIC will be relevant and complementary to the scope of the TSB's Offshore Renewable Energy Catapult. It is intended that the Strathclyde TIC will be an important contributor to the work of the Catapult and that joint programmes will be developed.

Under-pinning much of this funding is the Scottish Energy Laboratory (SEL) jointly developed by ETP and SE, that is a network of test and demonstration facilities across all key energy sectors and representing a combined public and private sector historical investment of >£250m. SEL is fundamental to the success of technology innovation by providing a coordinated and accessible set of test facilities across the TRLs that can be used to test new products, prototypes and full scale devices, thereby de-risking investments.

The need for improved coordination and alignment of funding streams has never been greater and there are many examples where this is happening with some success. Energy innovation funding in Scotland has been made more streamlined in recent years, yet can still appear complex to many, particularly to those new to innovation, which reflects the importance of early engagement with partners such as ETP, SEL and SE. This supportive engagement also ensures that emerging areas of challenge in funding innovation, such as prototype development in wind turbines and investment in marine energy companies to support commercialisation are addressed quickly, e.g. the development of the POWERS and WATERS programmes, part of SE's broader R&D Grant Scheme. The main funders of energy technology innovation in Scotland are building on the increased coordination in support of the Low Carbon Economic Strategy.

One example of a coordinating body is the Low Carbon Innovation Coordination Group (LCICG). As was noted earlier, this is a UK-wide group that seeks to maximise the impact of public sector funding for low carbon technologies. It was originally launched as an initiative between the Technology Strategy Board, the Carbon Trust and the Energy Technology Institute but it has since been expanded and its membership now includes all the main public sector bodies that have roles in this function and the Group's work is guided through the collaborative production of Technology Innovation Needs Assessments (TINAs) for their technology focus areas. The Electricity Networks and Storage TINA are particularly relevant to ENSEA.

It is not clear which organisation has primacy in this crucial function. There is strong alignment between the Scottish Government and among the main Scottish organisations – Scottish Enterprise, Highlands & Islands Enterprise and the Scottish Funding Council. There is also potential for confusion among so many bodies across the UK, thus the role of LCICG in coordinating and joining up the range of support is particularly important.

3.10 Knowledge Creation and Development

Knowledge generation is undertaken primarily within Higher Education Institutes (HEIs) and research institutes and R&D performing businesses. The latter group is dominated by externally-owned firms and includes a small number of large utility companies and multi-nationals.

There are fifteen Scottish universities many of which are ranked amongst the best in the UK. Proportionally, Scotland has more universities in World University Rankings' top 100 than any other nation in the world. The country produces 1% of the world's published research with less than 0.1% of the world's population, and higher education institutions account for 9% of Scotland's service sector exports.

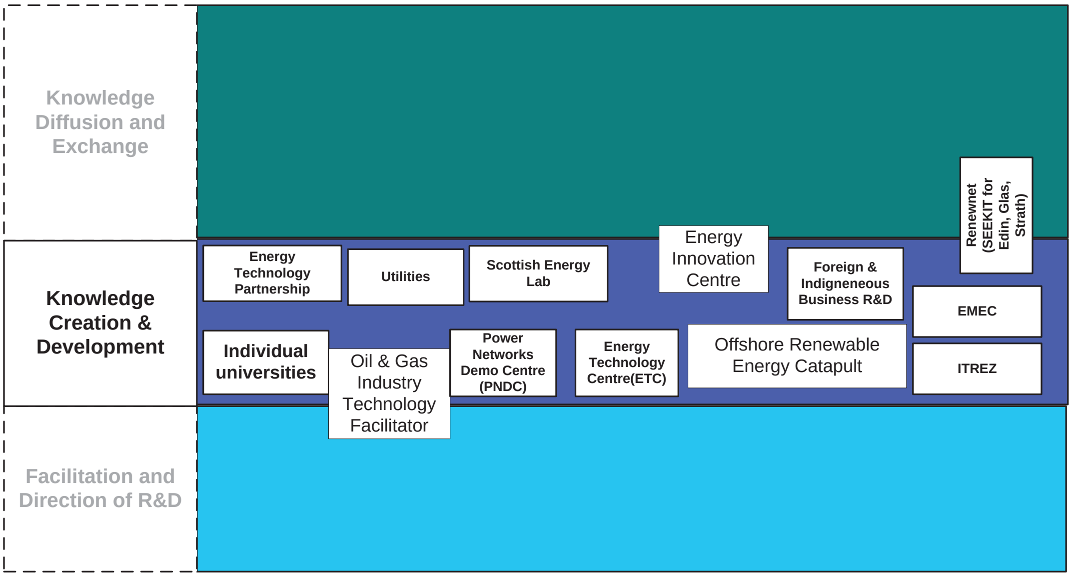
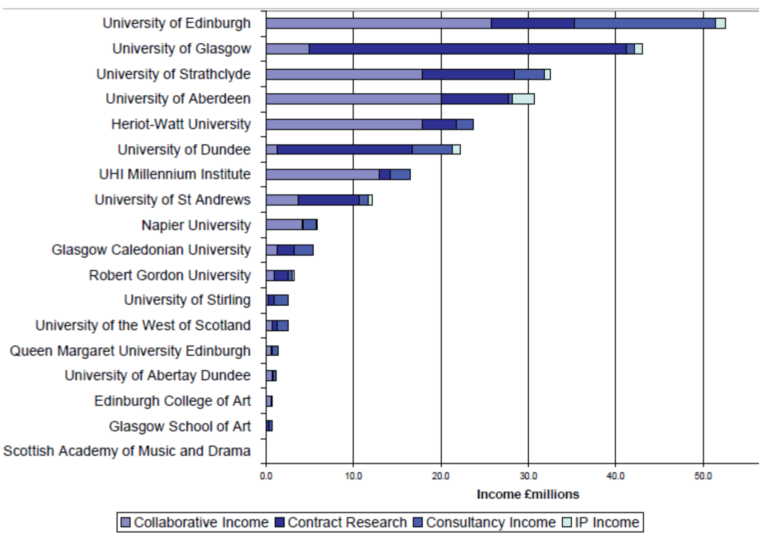


Figure 18: Knowledge Creation and Development

Over 250 academics and 3700 staff are in energy related work in Scottish Universities. Information relating to Research Council (BBSRC, EPSRC, ESRC, ETI, EU, and NERC) funding of energy-related research, in partnership with Scottish Universities, has been collated by Scottish Enterprise through a consultancy survey. This database will be added to, periodically, to include other public and private research funding sources in the energy research field. Work is ongoing to breakdown overall income figures to estimate the proportion of public and private funding relevant to energy research. Figures for private funding are not readily available, but an indication of the scale of private research funding may be achievable. See Appendix C for some initial figures of funding for energy research projects, mainly from public sector funding. All funding figures are for the total project value of projects which involve Scottish Universities.



Source: 'Business and Community Interaction Survey' 2012, Scottish Government

Figure 19: HEIs in Scotland and their main sources of income in 2008

Information from the Higher Education – Business and Community Interaction Survey: 2011-12 shows that over the last two years around £400M of research funding was provided to Scottish Universities annually (see Appendix B).

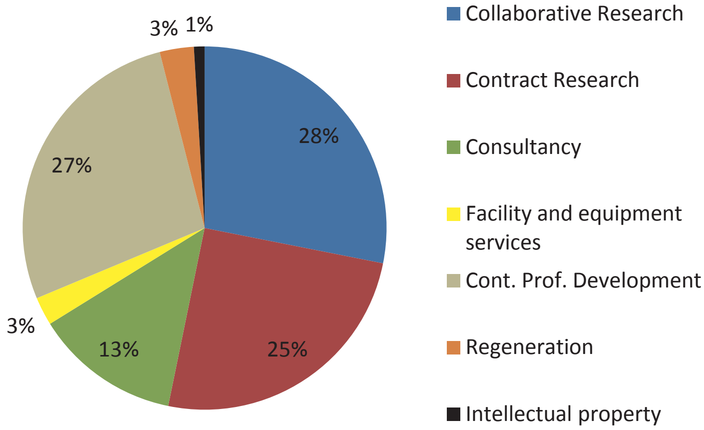


Figure 20: Income sources for Scottish Universities (all subjects) 2011 /12

Source: 'Business and Community Interaction Survey' 2012, Scottish Government

Latest data on expenditure on R&D performed by private businesses in the energy sector is shown in the table below. However it has not been possible to break this down into specific sub sectors.

Table 11: Expenditure on R&D performed within businesses in Scotland

Expenditure on R&D performed within businesses in Scotland			
Energy Growth Sector 1			
YEAR	2009	2010	2011
£ thousands	57,135	49,818	74,316

Source: ONS and Scottish Government

Notes:

1. Energy Growth Sector covers the following SIC codes:
   - SIC 05: Mining of coal and lignite
   - SIC 06: Extraction of crude petroleum and natural gas
   - SIC 09: Mining support service activities
   - SIC 19: Manufacture of coke and refined petroleum products
   - SIC 20.14: Manufacture of other organic based chemicals
   - SIC 35: Electricity, gas, steam and air conditioning supply
   - SIC 36: Water collection, treatment and supply
   - SIC 38.22: Treatment and disposal of hazardous waste
   - SIC 71.12/2 Engineering related scientific and technical consulting activities
   - SIC 74.90/1 Environmental consulting activities

The knowledge creation function is characterised by a number of important collaborations and initiatives to support delivery. These include:

- Energy Technology Partnership (ETP)
- Scottish Energy Laboratory (SEL)
- Power Networks Demonstration Centre (PNDC)
- International Technology and Renewable Energy Zone (ITREZ)
- The European Marine Energy Centre (EMEC)
- European Offshore Wind Deployment Centre (EOWDC)

Many are described elsewhere in this report and so will not be repeated.

The Power Networks Demonstration Centre is a venture between the University of Strathclyde, Scottish Enterprise, the Scottish Funding Council, Scottish Power and Scottish and Southern Energy aimed at accelerating the adoption of novel research and technologies into the electricity industry. It provides a platform for researching and developing electrical transmission, distribution and generation innovation and a realistic, controllable test bed for the development of emerging technologies to support the realisation of a de-carbonised grid. It is part of the SEL described above.

Located in Orkney, the European Marine Energy Centre (EMEC) is at the forefront of the development of marine-based renewable energy - technologies that generate electricity by harnessing the power of waves and tidal streams. As the first centre of its kind to be created anywhere in the world, EMEC offers developers the opportunity to test full scale grid connected prototype devices in unrivalled wave and tidal conditions. Beyond testing EMEC also provides:

- Assistance for other testing centres
- Off-site performance assessment
- Research and development project involvement
- Consultancy support

The European Offshore Wind Deployment Centre (EOWDC) is being developed by Aberdeen Offshore Wind Ltd, comprising Vattenfall Wind Power UK and Aberdeen Renewable Energy Group (AREG). Technip will also play a major role in the delivery of the project. The EOWDC will allow offshore wind farm developers and associated supply chain companies to test new designs, prove existing products and receive independent validation and accreditation before commercial deployment. Lessons learned will then be disseminated to the EU industry at large.

3.11 Knowledge Diffusion and Exchange

The institutions delivering this function can be characterised by two main groupings

- Sector and cluster groups (including industry bodies) – none of which have a focus on systems integration or knowledge exchange.
- Knowledge Transfer Bodies - these are typically formal knowledge transfer organisations but again, none has been identified with a focus on systems integration.

Many of the institutions here are regarded very highly in their sphere of activity. Despite this observation, no single actor or grouping has primacy in relation to systems integration and the overall landscape may be viewed as cluttered. This is not surprising because the scope of ENSEA across energy-related activity is so broad.

There are numerous industry associations and networks that function effectively within their communities. However, there is limited architecture in place to support delivery of this function in relation to systems integration.

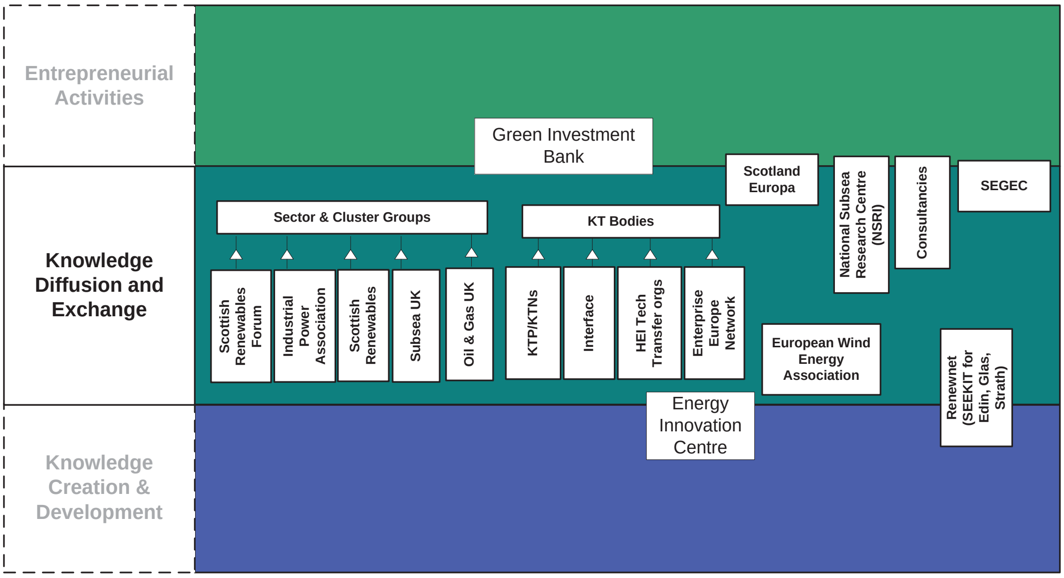


Figure 21: Knowledge Diffusion and Exchange

One example shown above is RenewNet. RenewNet offers graduate technical support and feasibility funding for SMEs wishing to undertake projects in renewable energy in power systems, drive trains or full electrical system design.

Entrepreneurial

Entrepreneurial activity is the function where companies engage in market transactions.

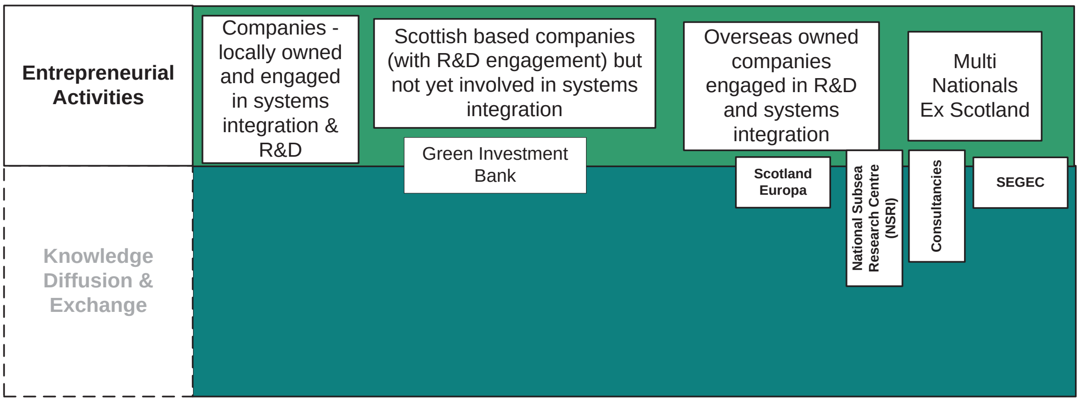
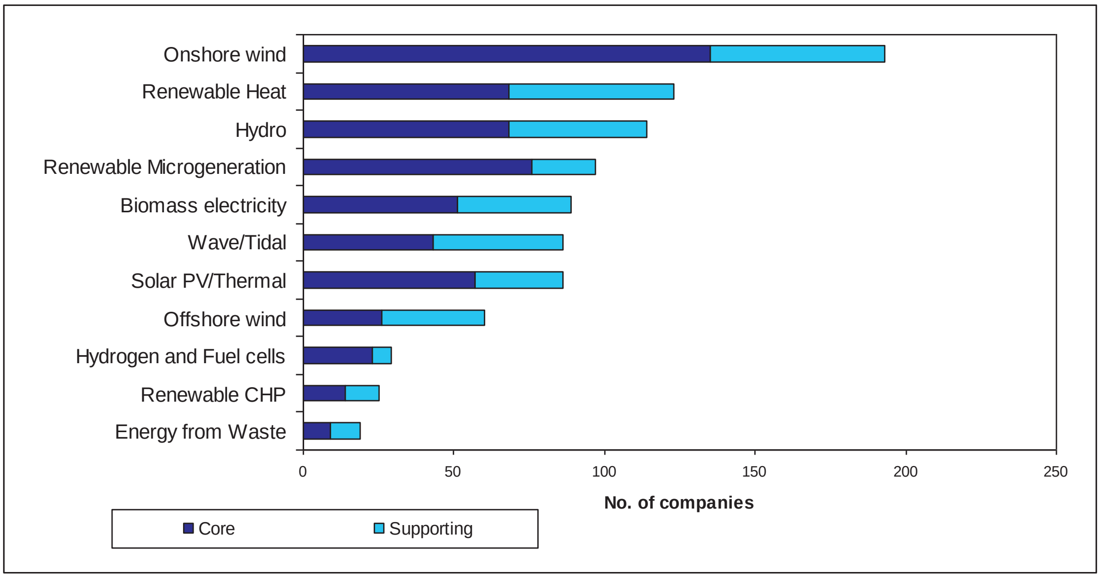


Figure 22: Entrepreneurial Activity



Source: SQW Baseline study 2009

Figure 23: Scottish Energy company numbers

Of the 358 companies' active in power generation, 153 were categorised as being active in renewable generation (when the last major survey of the Scottish company base was carried out in late 2009). A further 205 were identified as being involved in other forms of generation.

The distribution of companies currently working in renewables in Scotland shows that the majority were active in onshore wind.

Table 12: Number of companies active in key Energy market segments, by size (note some companies are active in more than one segment) (2013)

	Micro	Small	Medium	Large	Total
Customer energy management systems	5	13	8	26	52
Advanced metering infrastructure	2	6	4	36	48
Data acquisition and analysis	5	18	12	48	83
Network optimisation systems	2	14	6	33	55

Source: Scottish Smart Grid Foresighting study 2013

"Smart Grid" generally refers to any technologies or architectures – on the path from transmission to end user – which enable the grid to accommodate the changing patterns of demand and generation. As such it broadly matches with the 'System integration' concept of the ENSEA project.

A detailed supply chain mapping exercise in 2012 identified approximately 140 Scottish based companies which are currently involved in Smart Grid activities or have the capability to become involved. Two thirds of the companies identified are active in Data Acquisition and Analysis, which constitutes quite a considerable company base.

Approximately half of the companies on the SE database involved in Energy Systems / Smart Grid are large (more than 250 employees), a quarter are small (10-49 employees), one sixth are medium size (50-249 employees) and one tenth are micro-size (1-9 employees).

Noteworthy examples of micro to medium sized companies in each segment are:

- Customer Energy Management Systems: Ewgeco (the world's first and only three utility real time monitoring system for gas, electricity, water and renewables, established 2006) and Flextricity (one of the UK's market leaders in aggregated demand side management, founded in 2004).
- Advanced Metering Infrastructure: Abelon (embedded systems for applications incl. communications, oil and gas, and buildings management, set up in 2002; collaboration with Onstream recognised in the Metering Manufacturer & Technology of the Year and the Innovation of the Year awards at the European Smart Metering Awards) and Spark Energy (one of the "Little 6", specialising in better service and price proposition for the residential tenancy and housing association market).
- Data Acquisition and Analysis: M &C Energy (consultancy services on electricity usage and energy management, grown to 17 offices in 13 countries from 1976).
- Network Optimisation Systems: Smarter Grid Solutions (products and services to the power industry to manage technical constraints on distribution networks; spin-out from Strathclyde University (2008)) and Psymetrix (products and services which deliver significant benefits in the operation and planning of electrical power systems; recently acquired by Alstom).

Figure 24: Examples of Scottish companies involved in Smart Grid / Systems Integration activities (2013)

Source: Scottish Smart Grid Foresighting study 2013, Scottish Enterprise

Original Equipment Manufacturers (OEMs), such as Siemens or Alstom, can provide the breadth and depth of expertise required to develop and market a complex high value product. Large industrial companies will also understand the time and money needed to take a technology to market, and have sufficient resources to stand behind warranties and guarantees demanded by customers.

Table 13: Scottish Original Equipment Manufacturers (2013)

OEMs active in Scotland		
Company	**Location**	**Main Industry**
Aggreko	Dumbarton	Electrical
Babcock Marine	Rosyth	Defence/Marine
Balmoral Group	Aberdeen	O&G
Bosch Rexroth	Glenrothes	Automotive
Clyde Blowers	Glasgow	Power/O&G
FMC	Bellshill	Defence/Marine
Global Energy	Invergordon	O&G/Civil
Haliburton	Aberdeen	O&G
HySpec Engineering	Stewarton	Engineering
Lamond and Murray	Fife	Engineering
McKellar Sub-Sea	Grantown-on-Spey	O&G
McTaggart Scott	Edinburgh	Defence/Marine
Steel Engineering	Renfrew	Power
Sub sea 7	Aberdeen	O&G
Technip	Aberdeen	O&G
Weir Group	Glasgow	O&G
Wood Group	Aberdeen	O&G

Source: Scottish Marine Power Foresighting study 2013, Scottish Enterprise

3.12 Research and Innovation Support

Academic Research and Innovation Support Overview

The Energy Technology Partnership (ETP) has strong industrial and academic links throughout the UK and internationally and extensive experience of managing large collaborative research projects. ETP also has a successful track record in collaborative industry projects, working across the triple helix of academia-industry-public bodies, in support of Scottish Government policy. ETP activities in energy RD&D and innovation support are characterised by the following areas:

- Capacity Building - Deepening and broadening existing relationships and partnerships to promote increased collaboration by:
  - increasing collaboration between academics and researchers in ETP member universities,
  - fostering greater levels of awareness and sense of belonging to the partnership, and
  - developing the next generation of skilled employees through undergraduate and post-graduate training.

- Relationship-Building - Promoting the expertise and capabilities within the ETP, to develop new strategic relationships with industry, academia and others by:
  - developing and deepening relationships with various external stakeholders
  - ensuring coordination of ETP activities; and
  - creating new working relationships, (e.g. with public sector, industry; and other researchers in energy or across disciplines)

- Internationalisation - Projecting the scale and expertise of the ETP on the international stage in order to promote new outreach and knowledge exchange opportunities by:

    - continuing to grow ETP's international reputation for excellence, and
    - identifying and progressing opportunities by working closely with Scottish Development International (SDI), Scotland Europa and the Scottish European Green Energy Centre (SEGEC).
- Economic Impact - Connecting the work of the ETP with Scottish Policy and economic development opportunities for Scotland by:
    - focusing on both world class R&D excellence and its commercialization,
    - contributing to economic impact for Scotland,
    - increasing the influence of ETP on the broader economic development agenda
    - ensuring ETP is well-connected to policy through the Scottish Government and its Development Agencies,
    - ensuring alignment with policy-makers and lobby/influence where appropriate, and
    - increasing the knowledge exchange and commercialisation activity of ETP.

ETP Knowledge Exchange Network

ETP significantly increased its capacity for industrial engagement through the launch, in November 2011, of a £3m project funded by the European Regional Development Fund (ERDF), Scottish Government, Scottish Enterprise and the Scottish Funding Council. An experienced team of Business Development Managers is now in place, focused on supporting companies in the energy sector, in particular Scottish SMEs. This network of Business Development Managers are working as a catalyst to accelerate KE activity between academia and industry; increasing innovation and advancing development of the low carbon economy.

ETP offer a number of products which are designed to offer SMEs an end-to-end support framework in the development of new products, services and business processes. The interventions have the objective of promoting knowledge exchange between academia and industry. The products include:

- Company Support – half-day consultation to identify opportunities to collaborate.
- Consultancy Projects - the mechanism through which the knowledge transfer occurs.
- Industry Secondments – industry-focused secondments to academics and ETP's Scottish strategic SME industry partners for the development of long-lasting relationships.
- Energy mentorships - provide the ETP's Scottish SME industry partners with academic support to facilitate innovation through the knowledge transfer of research into industry.

ETP activities to support innovation are summarised in the table below:

Table 14: ETP Innovation Support Activities

ETP Activities	Description of Innovation Support Activities
Business Advice and support	• to explore a market opportunity including: technical advice and support; determining market size and competition; or developing collaborative networks. • to connect to over 1000 world leading academics and researchers within ETP universities. • ETP has supported nearly 100 companies and aims to work with at least 300 organisations during the first three years of the programme.
Energy Industry Doctorates	• A Doctorate programme which has been running since 2010 and currently supports nearly 60 high-quality PhD studentships, all with strong industry engagement. • It supports development of 'industry-ready' post-doctoral researchers to enhance energy industry innovation and knowledge exchange coupled with strong industry engagement. • Companies are co-investors, support project specification and engage with the research directly over a 3-year period. • The programme target is to deliver 100 PhD studentships. • Additional funding available for further studentships, in collaboration with industry partners, to develop projects relevant to the business' aims.
Energy Industry Masters	• programme to improve collaboration between companies and universities by providing opportunities for postgraduate masters students to undertake energy-related work based projects. These shorter (2-3 months) projects address real needs within organisations and ETP will work with companies to help scope out the project. ETP has more than 2000 Masters students, across over 100 energy-related courses.
CPD – Continued Professional Development	• ETP universities have a wide range of high quality CPD courses targeted at industry and those looking to enter into the energy sector. • ETP offers some attendees a 50% discount to make access to such courses easier and more attractive, especially to SMEs. • ETP collaborates with The Energy Skills Partnership (Scotland's colleges) who also deliver CPD and together can offer an integrated and diverse range of training opportunities for business. • In the past two years, over 70 courses have been delivered and over a 1000 learners have been trained.

Test and Demonstration Facilities - Scottish Energy Laboratory

Crucial to the pull-through of energy technology is the close physical and intellectual proximity of the academic and business communities with innovative demonstration and deployment facilities.

The Scottish Energy Laboratory (SEL) was launched by the First Minister in February 2011 and is a network of, and entry point into, Scotland's leading energy test and demonstration centres. There are over 50 facilities (60% in ETP and 40% in companies) with a combined investment value of over £250m. ETP, as a partner of the SEL, can offer an appropriate testing facility with the relevant academic support.

In partnership with ETP, energy sector test facilities have been brought together under the Scottish Energy Laboratory (SEL) umbrella. Some of the facilities of particular relevance to the key energy sectors are summarised in the table below:

Table 15: Scottish Energy Laboratory (SEL) Test & Demonstration Facilities

Scottish Energy Laboratory (SEL) Energy Test & Demonstration Facilities	
Marine facilities	•University of Aberdeen Ocean Lab sea testing facility
	•University of Edinburgh curved wave tank and wave flumes
	•University of Edinburgh machine and power electronics test laboratory
	•FloWave TT (University of Edinburgh) All Waters Combined Current and Wave Test Facility.
	•Heriot Watt University wave basin
	•University of Strathclyde Kelvin Hydrodynamics Laboratory
	•Energy Technology Centre - component test facilities
	•European Marine Energy Centre. World leading, grid connected test facility in the waters around Orkney
Wind facilities	•Myers Hill – Onshore Wind Turbine Testing
	•University of Glasgow - Wind Tunnel Test Facilities
	•Deep-water Offshore Wind Demonstrator
	•European Offshore Wind Deployment Centre
	•Integrated Marine Test Facility - Wind Tunnel
	•Marine Test Tanks
	•Energy Technology Centre - component test facilities
Bio-Energy facilities	•ETC mechanical test facility
	•Integrated energy materials facility
	•Thermal engineering test facility
	•Urban-micro renewables test facility
Solar facilities	The Scottish Institute for Solar Energy Research(SISER), is a key facility that can provide;
	•Modelling and data analysis
	•Cell and module fabrication
	•Optical characterisation
	•Electronic materials characterisation
	•Solar Cell characterisation
	•Testing (environmental test chambers and outdoor test site)
Energy Storage facilities	•St Andrews centre for advanced materials
	•Urban and micro renewables test facility
	•Integrated energy materials processing and characterisation facilities
	•The hydrogen office
	•Centre for advanced energy storage and recovery (CAESAR)
Power systems facilities	Power Networks Demonstration Centre (PNDC) - a purpose-built platform for researching and developing state-of-the-art electrical transmission, distribution and generation innovation. The facility is focused on accelerating the adoption of new technologies, from advanced power grids to electric cars and household appliances.
Energy Utilisation in Buildings facilities	•Environmental Test Chamber Hanger 17 BPAC – Building Performance assessment Centre
	•BRE Building Innovation Park, Ravenscraig
	•The Energy Technology Centre in East Kilbride

4 SWOT Analysis

Based on the data outlined above (and which is recognised as a sample of available information, rather than a comprehensive set of data) an initial Strengths Weaknesses Opportunities and Threats (SWOT) analysis was carried out by the ENSEA partners. The intention is to further develop and refine the SWOT analysis with key stakeholder groups, as more data becomes available (such as more complete figures to cover both public and private funded research) and when ENSEA expands to cover other North Sea regions.

The information provided below explores SWOTs for the Scottish innovation activity, then the Scottish Region in general in energy related aspects, and finally, with more specific reference to the components of the Scottish Energy System, split into the various energy themes relevant to Energy Systems Integration (ESI).

4.1 SWOT Summary – Scottish Innovation

Strengths and weaknesses in Scottish Innovation

The Regional Innovation Scoreboard (RIS) provides a useful mechanism for assessing the relative strengths and weaknesses of parts of the innovation system because it provides data that enables a relatively objective comparison with a region against other regions in the EU-27 and EU benchmark levels for activity.

Table 16: Summary of relative focus of Research, Government and Industrial Activity

Regional Innovation factor	Scotland
Human resources	Relatively well educated workforce
Research	Relatively high levels of research activity
Finance (public + VC)	Relatively high levels of public funding and venture capital available
Firm investments	•Many small SMEs •Levels of SME spend on innovation at EU -27 average
Linkages	•In house innovation and SME to SME and SME to university linkages at EU at EU -27 average
Intellectual assets	•Relatively high levels of intellectual asset generation
Innovators	•Levels of high growth SMEs and innovating SMEs at EU - 27 average
Economic effects	•Exports and new to market sales of products & services at at EU -27 average

This information covers the whole of the economy (not the energy sector) and so will miss insights, However, innovation activity can be characterised meaningfully at this broad level because many factors can be the same across sectors (for example the level and type of Government support provided to assist commercialise innovation do not generally change across these sectors).

Information provided in the 2013 RIS indicates that Scotland has a relatively strong research base and an educated workforce.

However it also shows that levels of investment by SMEs on innovation are at levels equivalent to the broad average for all the regions in the EU-27. Similarly linkages between local SMEs and with the research base are also very average as are the number of SMEs classified as ‘innovating’ or as high growth spin-outs from Universities.

Table key

Red colour	below 10% of EU-27 benchmark RIS score for this metric
Amber colour	within +/- 10% of EU-27 benchmark RIS score for this metric
Green colour	above 10% of EU-27 benchmark RIS score for this metric

Source: Regional Innovation Scoreboard 2012, 2013, EU Commission

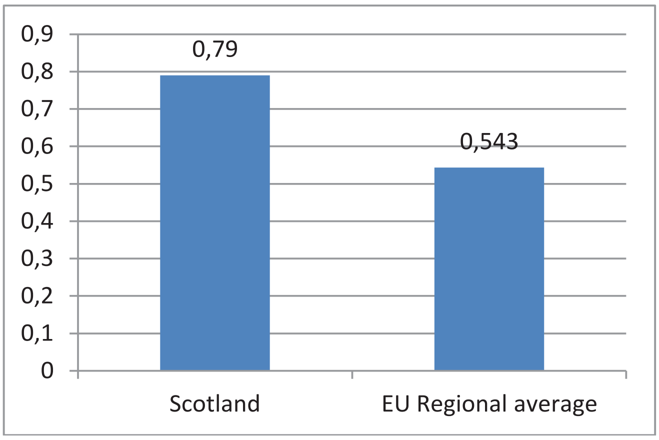
The economic impact of innovation activity in Scotland is also at EU benchmark levels in terms of new products or services being brought to market by Scottish firms and export sales. Although not examined by this study, these effects are likely because of Scotland's industrial mix and a company base comprising a large proportion of very small firms which often lack the resources or skills to innovate.

The RIS data suggests that innovation activity across the company base needs to be improved if Scotland is to benefit from its research strengths.

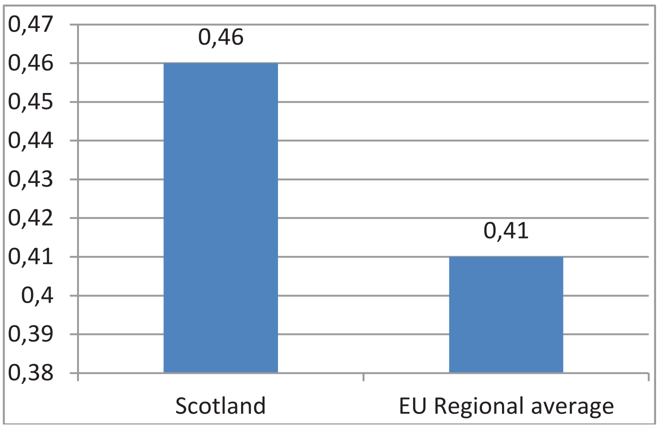
The tables below summarise the relative position of Scotland in key measures set against the EU average and reinforces these observations.

Table 17: Composite table of key RIS scores for Scotland relative to average scores for all regions in EU

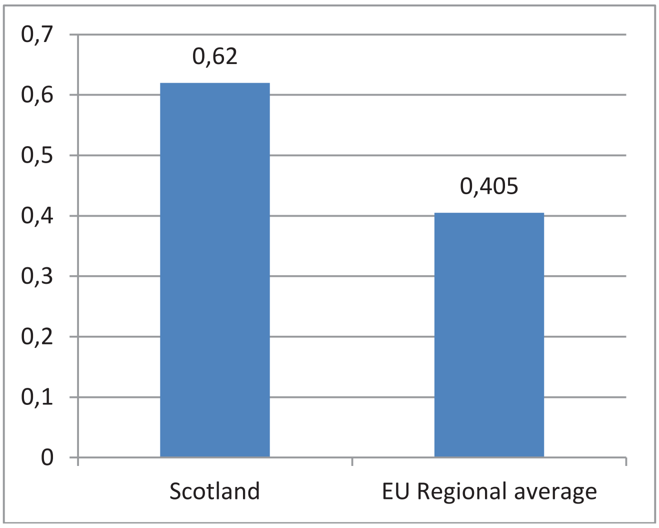
Population with tertiary education per 100 population aged 25-64



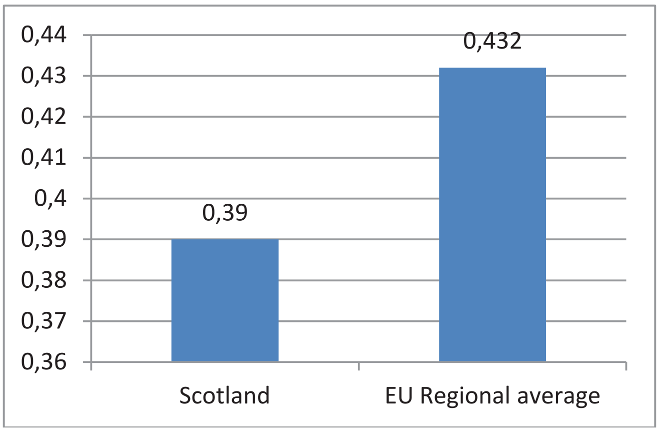
EPO patents per billion GDP



Public R&D expenditures as % of GDP



R&D expenditure in the business sector as % of GDP



Non-R&D innovation business expenditures (% of total turnover)

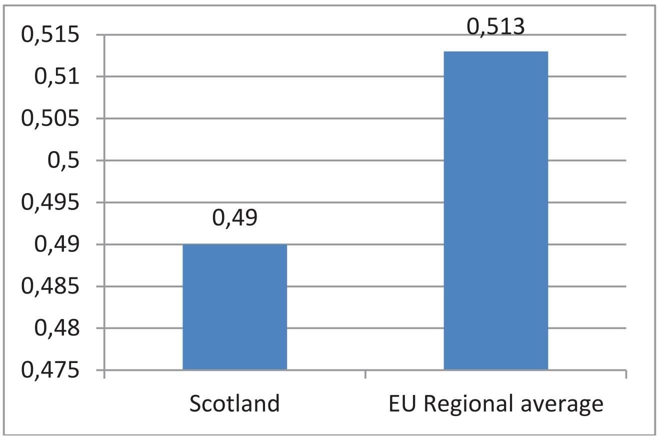


Table 18: SWOT Summary -Innovation Factors

SCOTTISH REGION ENERGY SECTOR: INNOVATION	
STRENGTHS	**WEAKNESSES**
Existing energy clusters (EMEC/Energy Academy HWU/ETP/UERG/ ETTC/ IES/ East Kilbride, etc.). Additional strength is Scotland's development of wave energy technology especially, a leading hub for wave & tidal project development and research.	Relatively low SME innovation in Scotland compared to EU average. Within the energy sector, low numbers of innovative companies in e.g. hydro & CCS.
World-class Higher Education Institutes in Scotland should continue to generate new innovation.	Innovation is dependent upon government support but there is a lack of certainty about future levels of investment. Lack of grant funding. Uncertainty in planning.
The region is relatively sparsely populated and has a very varied geography (islands, mainland, urban, rural, wilderness etc.) which provides a wide range of environments for a range of renewable generation and opportunities as a 'test bed' for technologies.	The switch towards renewables develops much faster in the surrounding areas (Germany, Scandinavia) than in Scotland. The traditionally strong fossil production base in the region therefore remains dominant, and in fact the region takes advantage from cheap renewable power from the neighbouring countries. Together this slows down the tendency to innovate towards renewable sources.
The region covers a broad range of energy innovation activities, ranging from oil and gas exploration and production to wind energy, biomass application, decentralized cogeneration, smart grids and smart metering. Opportunities for cross fertilization (e.g. oil and gas to offshore wind).	International and national policies regarding climate issues, renewables, energy system integration and efficiency develop slowly and in a stop-go fashion, such that incentives become unpredictable and not convincing to the market or investors. This could result in the energy transition slowing down and innovations not being progressed or implemented. Lack of a firm targets beyond 2020.
Highly regarded energy-related innovative research activity is already taking place in, and/or initiated from, Scotland.	
Energy training is rapidly expanding.	
Common and ambitious policies on Climate Change across EU/ globe create a strong pull for Energy Systems Integration solutions.	

OPPORTUNITIES	THREATS
Obtaining test and demonstration zone leases from the Crown Estate to support innovation in the energy sector related to energy system integration.	Lack of interest or support from investors for the innovation of the energy sector.
As much of the energy related research activity is already taking place in and/or initiated from Scotland and energy training is rapidly expanding, there is a good base for innovative activities to support energy systems integration.	The energy research and innovative capacity in the region may develop too slowly, and remain too fragmented to generate the critical mass and quality required before new energy research and training activity is developed elsewhere.
The region’s broad base, and wide range, of new energy activities offers many opportunities for energy system optimisation experiments and related research and training.	Slow pace of development of crucial international and national policies which could facilitate energy systems integration, could result in the energy transition slowing down and innovations not being progressed or implemented.
Scotland, with its diverse geographic features and climate, coupled with relatively sparsely populated areas, offers diverse energy test and demonstration opportunities; both in terms of technology and engineering, as well as in terms of policy and social acceptance.	
Enhanced and more collaborative training & skills development to facilitate taking forward innovations related to energy systems integration.	

4.2 SWOT Summary – Scottish Region in General

Table 19: SWOT Summary - Political Factors

SCOTTISH REGION IN GENERAL: POLITICAL FACTORS	
STRENGTHS	**WEAKNESSES**
Legislation in line with European Directives and policies in Scotland and often sets more ambitious targets or further-reaching policies relating to sustainability.	Need to further improve levels of cooperation and communication between the public and private sectors (relative to cooperation shown by other ENSEA partners e.g. Energy Valley).
A strong triple helix collaboration framework, the Scottish Energy Advisory Board, was set up about 5 years ago by the Scottish government. It involves industry and the research community and has benefitted from a strong a consistent policy focus, in support of overall energy and sustainability activity in the region, from the Scottish Government for almost a decade	Need to further improve levels of cooperation and communication between the Scottish and UK Government.
The Scottish Government has had a very clear and consistent focus on offshore renewables in the last 10 years	Legislation/policies, yet to be complete, are frequently changed and present uncertainty to potential investors.
The Scottish Government and key stakeholders work with a 'Team Scotland' approach to deliver policy, guided by the Scottish Energy Advisory Board.	Lack of strategic energy planning at regional and local level.
Very clear and consistent focus on offshore renewables within Scotland region.	Funding for energy innovation or associated infrastructure is often difficult to access.
Public sector stakeholders very aligned regionally, through the 'Team Scotland' approach.	Local authority activities and regional policy aims may not be aligned at times.
Scotland has ambitious sustainable energy targets in line with, and often surpassing, UK and EU targets.	Electronics and chemical industries in Scotland are not growing.

OPPORTUNITIES	THREATS
Financial market development to facilitate secure & longer-term funding for priority and strategic initiatives.	Misalignment with UK policy and/ or policy uncertainty could affect the delivery of advances in Energy System Integration (causing investment to be put on hold for example).
Increasing the benefits from the triple helix effect of industry collaborating with academic institutions and public sector partners	Disruption caused by EU periphery problems could cause instability in the market and lack of confidence from investors.
EU energy targets mean that, as an energy exporter with ambitious renewable targets, Scotland could receive considerable assistance.	Continuing uncertainty about UK policy support for renewables and other green policy targets. Additional threat is lack of progress setting UK/EU 2030 targets on emissions and renewables.
Development of measures to further increase regional alignment of public sector stakeholders (through the Team Scotland approach).	Potential change to Ofgem incentives scheme (Network Innovation Allowance) may negatively impact on infrastructure and innovation spend.
EU funding for harmonisation activities creates opportunities for the Scottish region to address shortfalls in e.g. SME innovation investment.	Lack of flexibility regarding funding.

Table 20: SWOT Summary - Economic Factors (Strengths & Weaknesses)

SCOTTISH REGION IN GENERAL: ECONOMIC FACTORS	
STRENGTHS	WEAKNESSES
Existence and focus of the newly-formed Green Investment Bank in Scotland provides confidence and support for renewable energy development.	Business uncertainty regarding investment pending outcome of Scottish independence vote in 2014.
Presence of well-established large companies relating to energy and renewables industry.	Limited financial resources especially in the public sector.
Scotland has significant natural, physical and infrastructure assets suitable for virtually every sustainable energy source.	A need to increase confidence in technologies to stimulate capital funding.
An established industrial skills-base in energy sector and other related industries.	Need to further increase efficiency and effectiveness of the services provided by the business support organisations.
Qualified and well-prepared work force which has potential to adapt to up-coming energy sector needs.	Scotland is located relatively far away from the main European centres of energy demand.

Scotland has important untapped potential (especially e.g. wave, tidal, solar).	The main focus of Government energy policy and research is renewable and sustainable energy. However, the activities of the company base in Scotland are predominantly focused on oil and gas.
Scotland has a range of business and financial support for energy-related innovation/ technological development through Scottish Enterprise, ETP, the Carbon Trust, and other initiatives.	Oil and gas acts as a magnet for resource activities, making developing alternatives harder (although this base could also make development easier).
With its considerable oil, gas and power-generation assets, Scotland is a significant exporter of power and has good interconnecting power and gas transmission grids.	Given the strong engineering record of the oil and gas service sector, collaboration and support with the offshore renewable sector is still relatively weak.
Significant economic activity is based on the offshore oil and gas industry and downstream services for that exploration activity (such as the Grangemouth refinery). This provides a reservoir of skilled engineering companies.	The company base is predominantly relatively small SMEs. This base is displaying relatively low levels of innovation (in terms of linkages with local Universities, investment in innovation).
There are a number of strong Original Equipment Manufacturers supporting the industry (Wood Group, etc.).	Levels of business innovation activity are on a par with European averages. This likely reflects the lack of resources (particularly financial in these SMEs) but could also reflect a lack of ambition to innovate.
High concentration of renewable (hydropower, onshore wind) and conventional power production capacity in Scotland relative to the rest of the UK.	The economic impact of SME innovative activity is also 'average' – in terms of levels of new products & services, high growth start-ups.
Oil and gas industry has created a reservoir of skilled engineering companies in Scotland.	Oil industry dominance of sector but resource will decline.
Scotland is strengthened through being part of ENSEA; ENSEA partners are in top 6 export markets.	Rising energy prices impact negatively on renewable policy.
Very large renewable resources exist offshore and on the mainland of Scotland.	Subsidy required for energy innovations until costs reduce and commercially viable operation can be reached.
Demand for energy (oil and gas, electricity) continues to be strong in England (and more widely) benefiting Scotland as a net energy exporter and provider of energy services. Very large renewable resources exist offshore and on the mainland of Scotland.	

Table 21: SWOT Summary – Economic Factors (Opportunities & Threats)

SCOTTISH REGION IN GENERAL: ECONOMIC FACTORS	
OPPORTUNITIES	**THREATS**
Developing public and private sector partnerships to support innovative initiatives for increased energy systems integration.	Levels of SME innovation in Scotland fails to rise or declines more.
Adapting existing skills-base (e.g. in oil & gas) to renewables industry needs.	Uneven economic development/policy focus and prioritisation at county level.
Strong demand for energy outside Scotland. Energy Systems Integration initiatives and being part of ENSEA will further strengthen Scotland's future role as a net energy-exporter and provider of energy services.	Migration of the qualified work force under the pressure of global crisis and economic instability.
Upgrade or re-purpose existing old/ degraded buildings & facilities.	Subsidies for renewables are not continued.
Given the strong oil & gas sector in the region, power production and export functions, the region is in a position to become a front-runner area for energy system integration.	Scotland proposes that offshore renewables should deliver half of the new capacity needed to meet its 2020 targets but issues such as site conditions or technological challenges could curb projected market growth.
The potential for Energy Systems Integration development is further reinforced by Scotland's geography – bordering the North Sea with a number of well-located harbours for servicing offshore activity.	Domestic oil and gas production is scheduled to decline in the coming decades to significantly smaller volumes to come to a standstill in about forty years. This may reduce local oil and gas activity and have implications for existing active firms.
The infrastructure links to depleting Scottish offshore oil and gas fields offer potential for storage of gases (including captured CO_2).	Magnitude of capital outlay required to delivery policy targets on renewables and network upgrades may be difficult to achieve without subsidies or industrial support.
ENSEA project partners are in Scotland's top export markets by value, so developing initiatives which reinforce already strong connections, should be less problematic than establishing new markets.	Rising energy prices may impact negatively on renewables policy.
Shortfall in generating capacity in England may create short-term export income windfall – more power exporting is a future possible strength/opportunity..	Single major market for energy exports (England) may persist, in spite of increased energy systems integration in the North Sea region (although this presents opportunities as well for exports).
Potential for development is very large for renewable resources around Scotland. Potential opportunities for offshore renewable resources (offshore wind and marine energy) are particularly significant.	Buy-ups of innovators by non-regional companies.

Energy Systems integration has the potential to provide a regional solution, to not just high levels of renewables, but also network congestion and ageing.	Supply chain for new sectors might not develop, which may mean most activity in Scotland may not be by local firms.
	Oil industry continues to dominate energy sector (this is not a threat to the economy per se but could impact a transition to lower carbon technologies).

Table 22: SWOT Summary – Technological Factors

SCOTTISH REGION IN GENERAL: TECHNOLOGICAL FACTORS	
STRENGTHS	**WEAKNESSES**
High concentration of industrial parks in the Region.	Lack of reliable collated data and continuous monitoring of the energy sector.
Diverse mix of energy resources, technologies and services in Scotland (including exports).	Lack of local production of renewable energy equipment.
Well-developed infrastructure and support programmes e.g. ports and harbours programme and NRIP.	Infrastructure delivery should be both strategic as well as responsive.
	Low number of innovative companies in some energy sectors (e.g. hydro & CCS).
	Greater understanding of potential environmental effects of offshore marine technologies are required.
	New business models and ways of supplying the market are required to support the transition to increased energy systems integration.
	Cross-boundary market obstacles may limit the progress for integration of the energy system.
OPPORTUNITIES	**THREATS**
The need to fulfil the European standards through modernisation, implementation of new technologies and improvements related to products, processes and services.	Limited capacity of the National Power Grid to balance and absorb electricity from renewable energy sources.
Focused and targeted development of the energy sector and related services/sectors.	The optimum renewable resources are in technically challenging areas.

Diverse mix of energy resources, technologies and services in Scotland creates a good base for developing energy system integration initiatives.	Scotland's 2020 target relies on a very demanding 6GW of new offshore renewable capacity
Energy Systems Integration is a flexible solution that can include a variety of local solutions and developments (e.g. hydropower in Norway, PV in Lower Saxony etc.)	Decommissioning of existing conventional generating capacity creates challenges that divert industry from integration of energy systems.
Developing cross-boundary markets and new business models to support energy systems integration.	Obstacles to developing cross-boundary markets and new business models are numerous and complex.
Data is getting cheaper.	Development of common standards a key factor for Energy Systems Integration.
	Access to and ownership of data for energy systems integration could become an issue.

Table 23: SWOT Summary – Academic Factors

SCOTTISH REGION IN GENERAL: RD&D/ ACADEMIC FACTORS	
STRENGTHS	**WEAKNESSES**
Traditionally high quality research with good representation at Scottish, UK and EU collaborative working groups on energy research.	Further collaboration between industry and academic RD&D required facilitating Scottish innovation getting into market.
Energy R&D expertise in Scotland has strong track record and many very large funded programmes across key energy themes.	Research collaborations within universities and between departments should be further encouraged and facilitated.
Scotland has world renowned Higher Education faculties and a significant portion of their activity is energy related.	R&D translation into innovative market opportunities encounters many barriers, in spite of generally supportive innovation support system.
OPPORTUNITIES	**THREATS**
Excellent opportunities in R&D in renewables, particularly in wind, marine, grid and CCS.	Potential barriers to collaboration e.g. due to institutional obstacles, intellectual property issues, lack of available funding.
ENSEA as a vehicle to support collaboration and draw for funding.	High competition for funding.
ENSEA as a vehicle to provide a focus for demand-driven research which will support the transition to increased energy systems integration.	Intellectual property rights issues present an obstacle to translating R&D to market.

Table 24: SWOT Summary – Environmental Factors

SCOTTISH REGION IN GENERAL: ENVIRONMENTAL FACTORS	
STRENGTHS	**WEAKNESSES**
Scotland supports common and ambitious Environmental policies on Climate Change across EU/globe.	Greater understanding of potential environmental effects of offshore marine technologies are required.
Scotland has relatively high environmental standards.	
Scotland has good natural environmental conditions for renewables generation with around a quarter of Europe's wind and wave resource and a tenth of its tidal energy resource.	
OPPORTUNITIES	**THREATS**
Scotland's diverse geography (islands, mainland etc.) is a natural test bed for energy technologies to support energy system integration solutions.	Environmental concerns could impact the delivery of new renewable capacity both on and offshore.

Table 25: SWOT Summary - Societal Factors

GENERAL RENEWABLE ENERGY: SOCIETAL FACTORS	
STRENGTHS	**WEAKNESSES**
Generally well-informed, interested and active public engagement in renewable energy agenda.	Significant public resistance to new large-scale energy initiatives, such as the Beauly-Denny Transmission reinforcement (10 years in development).
Skilled & educated workforce capable of absorbing and developing new ideas.	Lack of skilled personnel to drive sector growth in renewables.
Public largely supportive of renewables developments and grid strengthening.	Lack of clearly defined competences at regional/ local level.
	Public objections to long-standing support programmes for renewable e.g. growth of anti-wind groups.
	Solutions to resolving energy system integration issues require changes to consumer behaviour.
OPPORTUNITIES	**THREATS**
Developing and adapting skills of current workforce to support and stimulate innovative technological development relevant to energy systems integration.	Lack of market confidence may discourage industry investment in training workforce.
Energy price spikes and shortages create a public awareness of the need for solutions to lack of integration of energy systems.	Public resistance may become a stronger issue such that much of the energy innovation, (notably wind and biomass-related), may be slowed down.
Creating new employment opportunities in energy sector.	Political disagreements between local and national policy making bodies.
	Consents and planning issues - public resistance to new projects may grow, slowing energy development.
	Solutions to resolving energy system integration issues require changes to consumer behaviour. This may take some time and encounter difficulties if consumers do not have informed choices or sufficient support.

4.3 SWOT Summary – Scottish Energy System

Table 26: SWOT Summary -Carbon Capture & Storage (Strengths & Weaknesses)

CARBON CAPTURE & STORAGE		CARBON CAPTURE & STORAGE	
	STRENGTHS		WEAKNESSES
Economic	Well-established and nearly user-ready infrastructure for components of the transport and storage chain in Scotland and North Sea area suitable for adaptation/ use for CCS.	**Technology**	Cost-reductions are required to make CCS fully commercially viable.
Economic	Current oil & gas SME expertise and skills-base can easily be adapted to CCS industry.	**Technology**	There is a perception that CO2 offshore storage technology is unproven despite existing active projects e.g. Schleipner in Norway.
RD&D/ Academic	CCS Research in Scotland is one of the few leaders in the early stage RD&D field, world-wide, with very large funded research programmes.	**Technology**	There has been no large-scale full chain demonstration as yet, but all of the components of the chain have been demonstrated or piloted.
RD&D/ Academic	Research into novel CO2 Capture technologies and improved efficiency of near-market and commercially available technologies	**Economic**	Scottish Government lacks funding for large-scale projects.
RD&D/ Academic	Internationally renowned research expertise in CO2 Storage and experience in complimentary areas e.g. modelling of reservoirs; seismic surveys; subsurface fracture & leakage modelling; extensive archives of core samples, measurement, monitoring and verification techniques to ensure storage is proven and safe, etc.	**Economic**	Some businesses have pulled out of the CCS sector due to funding fluctuations and the lack of long-term policy and economic signals.
RD&D/ Academic	Edinburgh University was the first in the world to provide a CCS MSc and there is currently an application for the University to have a post-doctoral training centre (4Q2013).	**Political**	Some businesses (particularly the power sector) are awaiting a signal from the EMR and the CfD strike price before committing investment.

RD&D/ Academic	Large archives of legacy information from previous oil & gas-related studies; and specific analysis of geological storage in the Central North Sea, such as "Opportunities for CO2 storage around Scotland", Progressing Scotland's CO2 storage Opportunities" and CASSEM "CO2 aquifer storage site evaluation and monitoring"	**Political**	CCS policy needs to be revived and clear signals sent from the EU that CCS is on its low carbon agenda.
RD&D/ Academic	SCCS was founded in 2005, a partnership of 3 research institutes in Scotland with CCS expertise extending across the full chain; largest CCS research group in UK; includes 10 additional institutes across Scotland though the Energy Technology Partnership.	**Political**	CCS Liability (National/ international/ regional/ industrial) lacks clarity e.g. when CO2 is transported or use is changed from waste to resource.
Technological	Existing Oil & Gas industry engineering skills and technology are directly applicable to the CCS industry	**Political**	For CCS, long-term liability for the costs associated with monitoring and CO2 leaks as defined in the CCS Directive may create a potential obstacle for taking forward opportunities.
Technological	Well-developed and commercialised CO2 capture technologies are in already proven and in use.	**Societal**	CCS is a little known low carbon sector - untested in Scotland and therefore a public acceptance grey area.
Technological	In addition to depleted oilfields in the North Sea area there are previously identified saline aquifers which could potentially be used for CO2 storage, from past surveys by O&G Industry and analyses by SCCS.		
Political	CCS enables decarbonisation of the gas/coal power sector, enabling avoidance of nuclear power for base load power; can contribute to helping Scotland meet its ambitious carbon emissions reduction targets		
Political	Several of the world's most carbon-intensive industries have no alternatives to CCS for deep emissions reduction; CCS enables decarbonisation: of the steel industry and hence of renewables and of fertiliser manufacture which has an impact on decarbonising agriculture.		

Political	CCS is supported by UK Government - Significant funding available to subsidise exploratory projects, possibly in Scotland (Grangemouth/Peterhead/Teeside potential projects).		
Political	CCS is strongly supported by Scottish Government.		
Collaboration	SCCS closely collaborates with large industry (e.g. DECC funded CCS projects, Joint Industry Projects, Linked to UK CCS Research Council)		
Innovation	Research in novel technologies throughout the CCS chain, including measurement, monitoring and verification, capture technologies, etc.		

Table 27: SWOT Summary -Carbon Capture & Storage (Opportunities & Threats)

CARBON CAPTURE & STORAGE		CARBON CAPTURE & STORAGE	
	OPPORTUNITIES		THREATS
Economic	CO2 based enhanced oil recovery technologies could facilitate transition to CO2 storage by extracting further economic value from depleted oil fields and providing ready-made storage facilities.	**Political**	CCS industry is currently operating in a largely untested regulatory environment. Effective management of the regulatory framework will be crucial, and learning will come from demonstration project application and implementation.
Economic	Piloting CCS projects in North Sea region would extend the life of the oil & gas industry and could create opportunities for developing transferable skills, infrastructure, physical assets, etc.	**Political**	Legal barriers currently impede CO2 transportation for geological storage and need addressing. A series of bilateral agreements on permitting processes and liabilities, for cross-border CO2 transport and trans-boundary CO2 storage projects, will be essential.
Economic	In USA, CO2 on land-based Enhanced oil recovery is bought by oil & gas industry to use for injection in oil & gas fields. Therefore there is market potential for the North Sea Area/ Northern Europe for CO2 derived from capture technologies.	**Political**	The realisation of large-scale, full chain CCS is threatened by delays in securing funding from, for example, the UK's CCS Competition and the EU's NER300 scheme for funding clean energy projects (due to lower than anticipated carbon prices)

Economic	CCS has the potential to be a low carbon industry enabler; industry could incorporate CCS into low carbon products e.g. Life Cycle Analysis would result in lower levels of embodied carbon.	**Environmental**	The possibility of CO_2 leakage from abandoned oil & gas well drill holes exists. There is also the potential for CO_2 leakage from storage injection wells. There is a need to continue with the analysis of potential impacts on marine environments, characterisation and validation of suitable storage sites, and R&D into monitoring, measurement and verification processes to underpin a safe and viable CCS industry.
Economic	Potential for inward investment and job retention in NE coast economic area if CCS were provided with early stage support.	**Societal**	Levels of public awareness and acceptance can impact on project progress, as has been witnessed in Germany and Italy. There is a need to step up public engagement on CCS
Economic	Scotland Central North Sea has the potential to store Mt of CO_2 for Europe, hence of great potential economic value to Scotland.	**Economic**	Investment in large-scale projects is delayed by the lack of clear signals from the EU and UK Government
Economic	CCS has the potential to support provision of base load energy supply through fitting CCS technology to fossil fuel powered plants.	**Economic**	Weak signal of ETS carbon price does not act as a driver for CCS
Political	Using CCS on fossil-fuel power generation avoids the need for nuclear for base-load power, in-line with Scottish Government policy.	**Economic**	ETS is viewed by industry as a loss of profit rather than a driver to invest in CCS infrastructure
RD&D/Academic	Innovation in Scotland, strong CCS research base e.g. reducing the costs of capture/ developing future materials and novel technologies.	**Economic**	Insurers are reluctant to back CCS until the full chain has been demonstrated on power generation and industry and liability issues have been resolved. This has an impact on building a viable business case for projects
RD&D/Academic	Huge potential for economic saving where RD&D can address the issue of high costs for CO_2 capture.		
Innovation	Clustering potential of industry/ academic/ economic interests for CCS at the regional, North Sea and Northern Europe levels.		
Societal	Early as possible public engagement is likely to facilitate planning approval for full-scale pilot CCS projects.		

GRID		GRID	
	STRENGTHS		WEAKNESSES
Economic	Planned multi-billion pound infrastructure spend by key Distribution Network Operators (DNOs); SSE and Scottish Power over next 5 years.	**Economic**	Drop-off in infrastructure spend is an outcome of market uncertainty linked to Electricity Market Reform (EMR) and political influence on energy sector policy. But Grid has reached capacity in many areas and upgrades are very expensive.
Economic	Renewables & distributed generation pushing electricity flow from North to South, where the current demand is highest.	**Economic**	Lack of a skilled workforce to support energy sector growth and innovation in renewables i.e. training needed for adapting skills or up-skilling
Economic	Current oil & gas SME expertise and skills-base can easily be adapted to grid industry's need to diversify in order to incorporate increasing role of renewable energy generation.	**Societal**	Ongoing public debate about continuing growth of onshore wind industry for large scale and long-distance distribution. Local and rural wind projects in community-owned developments are well-supported.
Economic	Improving funding landscape for community renewables schemes and innovation (e.g. TSB funding)	**Economic**	Scottish government lacks funding for key strategic projects on grid development or integration.
Economic	Local Distribution Network Operators and vertically integrated utilities seen as innovative and financially stable by some	**Technology**	Slower than expected development of offshore wind market and potential for further funding/ technology delays due to Crown Estate development delays.
Political	Scotland's current (2013) governing party (SNP) is highly supportive of renewables growth and grid innovation. Now rolling out a coordinated Smart Grid strategy.	**Innovation**	Lack of smart grid focused SME community/ supply chain
Political	Scotland has a key role to play in assisting UK with EU low carbon targets	**Technology**	Lack of experience and expertise relating to HVDC as not a developed sector as yet.
Technological	Grid innovation ongoing at network and community levels	**Technology**	Slow pace of new technology adoption on the network because of very conservative/ risk-adverse market.
Technological	SSE and Moray Firth hub will support HVDC and supergrid learning e.g. exploring options for meshing AC/ HVDC	**Economic**	Lack of funding for community renewables schemes

Technological	Scotland's Development of the Power Networks Demonstration Centre to accelerate innovation in smart grid technologies	**RD&D/ Academic**	Out-sourcing of innovation by Distribution Network Operators to academic institutions may slow down pace of technology development (PhDs rather than solutions). DNOs have no internal innovation division.
Innovation	Strong, long-term focus of University of Strathclyde on grid issues can stimulate innovation and support Distribution Network Operators	**RD&D/ Academic**	Dominance of University of Strathclyde in power systems may discourage other institutions from focusing on this sector and developing collaborations with industry players.
Innovation	Supergrid ideal for trialling approaches and as a test-bed for projects due to the small size of the country and only two major industry players (SSE & Scottish Power)	**Technology**	Smart grid is still being defined as it is still an idea rather than a fully-fledged and deliverable concept
RD&D/ Academic	Established academic knowledge base in grid research with an evolving and growing knowledge base (mainly in University of Strathclyde as is UK and International leader in the field),		
RD&D/ Academic	Universities currently collaborate closely with key Distribution Network Operators and National Grid on research and technology development (e.g. NINES & Smarter Grid Solutions)		
RD&D/ Academic	Very high capability, primarily in University of Strathclyde and also in other universities (e.g. Edinburgh, Aberdeen & Glasgow Caledonian).		
RD&D/ Academic	UK's lead on Supergen and UK representative on EERA.		
RD&D/ Academic	Substantial investment from industry in academic research collaborations/ projects with very large funded programmes.		
Innovation	SME community capable of supporting development of automation and network optimisation market		
Innovation	East and West Interconnectors will stimulate and grow HVDC environment		

Innovation	In terms of EU activity, Scotland's early development of electric vehicle infrastructure can provide expertise to further develop technology and expertise (e.g. wireless technology).		
Innovation	Demand-side & energy storage projects already on-going and learning may be used across Scotland (e.g. SSE and NINES)		
Innovation	Small geographical region (Scotland) may more effectively support roll-out of new technology initiatives		
Societal	1/3 of Scotland with no access to gas network - so electrical grid critical to rural and remote communities		
Societal	Dispersed rural population enables community renewables agenda to be explored and trialled (e.g. more self-sufficiency and innovative approaches)		
Societal	Existing distribution generation provides platform for industry pilots and projects directly		
Societal	Growing awareness of skills agenda, with new investment taking place in CPD development and apprenticeships		
Environmental	Scottish government has set ambitious renewables generation targets as part of strategy to deliver strong environmental policies		

GRID		GRID	
	OPPORTUNITIES		**THREATS**
Technology	Development of offshore wind farms will stimulate innovation and connect to onshore networks	**Economic**	Drop off of infrastructure spend linked to company financial state, uncertainty around the EMR and political interference in energy sector
Technology	Along with rest of UK, Scotland will see introduction of smart meters from 2015 - providing new scope for network innovation and consumer engagement	**Economic**	Declining generation capability in UK and threat of blackouts, if systems integration is not improved, may slow down innovation (as focus may be on keeping lights on).
Political	Political stability after independence vote could allow for new focus on network development and renewables agenda	**Societal**	Focus on value of energy efficiency (among homeowners) may minimise need for and impact of Distributed Network Operator innovation.
Innovation	Energy efficiency agenda could minimise need for new infrastructure spend (e.g. Smarter Grid Solutions and Orkney project) and free up investment for elsewhere in network	**Economic**	Economic shock or downturn may alter government policy and energy sector spending plans
Innovation	Continued interest and investment in innovation agenda by local Distribution Network Operators (DNOs).	**Economic**	Scottish government lacks funding to support key projects
Innovation	The Power Network Demonstration Centre (PNDC) in Cumbernauld has potential for accelerating new technologies on to network	**Technology**	Continued growth in renewables generation could lead to grid stability issues
Innovation	Opportunity to learn from network innovation projects such as NINES (Energy storage & demand side project), Moray Firth Hub and East/ West Interconnector projects.	**Societal**	Continued growth of renewables (e.g. wind) could exceed capacity of network to absorb it - leading to reduction of activity and need for innovation.
Innovation	Supergrid ideal for trialling approaches and as a test-bed for projects due to the small size of the country and only two major industry players (SSE & Scottish Power)	**Economic**	Foreign ownership, by Iberdrola, of Scottish Power could result in changes of strategic direction and focus related to network development which are not in Scotland's best interests.
Innovation	Need to upgrade network to cope with renewables generation provides ongoing opportunity for network innovation (e.g. Smarter Grid Solutions)	**Societal**	Academic institutions unable to meet demand for skilled personnel with courses not evolving to meet industry needs

Innovation	In terms of EU activity, Scotland's early development of electric vehicle infrastructure can provide expertise to further develop technology and expertise (e.g. wireless technology).	**Economic**	Investment environment not supportive enough of innovation and start-ups capable of meeting grid supply chain challenges
Innovation	Dispersed rural population enables community renewables agenda to be explored and trialled. More self-sufficiency provides a good model to learn from and stimulates innovation.	**RD&D/ Academic**	Slow and conservative DNOs fail to push innovation agenda, relying on incentive schemes to enable future developments
Innovation	Scotland could potentially play a significant role in development of new EU supergrid - linked to offshore wind and HVDC developments	**Economic**	Loss of subsidies and incentives at UK level hit investor confidence and slow down innovation growth
Economic	Development of new supply chains around HVDV developments and growing interest in region from international players (e.g. Siemens, Alstom)	**Technology**	Failure to develop appropriate solutions to enable integration of distributed generation on to network.
Economic	Increasing funds available from major economic development body (Scottish Enterprise) to support growth of sector and innovation in renewables in 2014 & 2015.	**Societal**	Risk of increased blackouts in the future reduces public/ policy- makers' confidence in renewables in terms of their importance in the energy mix.
Economic	Scotland could serve as a test-bed for new technologies, attracting new industry players and promoting start-up innovation	**Political**	Risk of growing political support for nuclear or other traditional forms of generation if concerns about ability of renewables to meet base load demand grow – this would mean grid adaptation for renewable could be delayed or cut back.
RD&D/ Academic	Continuing availability of funding support for grid related innovation at project, SME and academic level (e.g. TSB, ESPRC, GIB)	**RD&D/ Academic**	Academic base unable to effectively meet the technical challenges presented by the required evolution of the electrical network
RD&D/ Academic	Focus on innovation requirements of industry will further develop knowledge base within academic institutions	**Technology**	Scottish SME community may be unable to meet technical challenges presented by evolving grid stressed by distributed generation
RD&D/ Academic	UK and international collaboration opportunities presented by new Horizon 2020 project funding in relation to integration of energy systems.		

SOLAR		SOLAR	
	STRENGTHS		**WEAKNESSES**
Innovation	Well established UK-wide industry trade networks	**Economic**	Under-developed solar installation in both large and small scales.
Innovation	Small geographical region (Scotland) may more effectively support roll-out of new technology initiatives.	**Innovation**	There are a limited number of new product developers and innovators in solar thermal and PV
RD&D/ Academic	Well established network of solar energy researchers across Scottish Universities and a collaborative centre for research - SISER	**Technology**	Vast number of different PV technologies on the market makes it confusing for the consumer to make informed choices on best available technologies.
Technological	Solar panels can be readily incorporated into existing structures and does not conflict with use of other energy generation.	**Economic**	Too many products on the market related to PV (especially from China) are effectively a barrier to innovation and new product development.
Economic	Moderate to high numbers of SMEs (mainly solar thermal/PV installers). Solar thermal companies are well established and PV SMEs have been developing more recently due to economic incentives favouring small-scale PV installation.	**Technology**	Feed-In-Tariff favours building-applied PVs and de-incentivises building integrated PVs and the development of new technologies.
Economic	Improving funding landscape and good levels of support for use of solar in community renewable schemes and innovation	**Innovation**	Feed-In-Tariff potentially de-incentivises development of new technologies as it only applies to those products on the MCS accreditation list. The process for getting accreditation has a fairly long lead-in time (note disagreement with this statement by Scottish Renewables).
Societal	Growing awareness of skills agenda, with new investment taking place in CPD development and apprenticeships	**Environmental**	Significant power fluctuations dependent upon seasonal and weather conditions leads to variability in output.
Societal	High public support for solar in Scotland and UK-wide	**Collaboration**	Lack of effective collaboration between DNOs and installers which can cause unnecessary delays to projects
		Political	No Scottish government strategy explicitly for solar industry development and deployment.

		Societal	Lack of public awareness of the potential effectiveness, productivity and benefits of solar thermal and PV in Scotland.
		Economic	Regulatory Feed-In-Tariff financial incentives are regressing. Rate of reduction might not match rate of technology development and cost of energy reduction.
		Economic	ROCs (Renewables Obligation Certificates) are steadily being reduced. This will reduce the value paid out per kwh of solar energy being produced.
		Political	EU procurement regulations prevent Local Councils deploying solar installations within a reasonable timeframe to enable them to take advantage of the Feed-in-Tariff and ROCs incentives, thus significantly delaying decisions.
		Technology	UK grid capacity for solar PV has been set to accommodate up to 10 giga watts installed capacity (currently approx. 2.5GW, 2013) to prevent issues arises relating to grid instability (through lack of storage facilities or export capability).
		Economic	Levelled costs of electricity are higher than fossil fuel and some other renewable technologies (e.g. on shore wind).

Table 31: SWOT Summary - Solar (Opportunities & Threats)

SOLAR		SOLAR	
	OPPORTUNITIES		**THREATS**
Economic	Under-developed solar installation in both large and small scales (note disagreement with this statement by Scottish Renewables).	**Political**	If the grid network is not upgraded at a sufficiently fast rate it may prevent further deployment of renewables as it will constrain capacity
Technology	Potential for developing networks and clusters of district heating using solar thermal storage technologies and facilities.	**Political**	Current deployment dependent on subsidies
Innovation	Commercialisation of existing and current research into new products	**Political**	Regulatory or technological development in the energy market and uncertainty of the outcome of the EMR
Innovation	Development of systems combining solar thermal, PV (and potentially other technologies e.g. heat pumps) and storage options for the user	**Political**	Potential for other legal restrictions developing.
Technology	Increasing the efficiency of systems	**Political**	Complex approval and licensing procedure to develop solar farms could be a cost barrier to development
Technology	Development of technologies specific for northern hemisphere environmental conditions e.g. diffuse light and lower light levels	**Political**	Political uncertainty from UK government changing current policy stance which is currently supportive of solar.
Technology	Development of suitable storage methods and facilities	**Environmental**	High risk of damage to installations from extreme weather events
Societal	Opportunity for development of larger-scale community district heating and PV projects e.g. Especially important for energy security and independence in rural and island communities in Scotland.	**Economic**	Increasing number of trade rivals worldwide
Collaboration	Strengthening and further development of networks and collaboration between industry networks and clusters.	**Economic**	Business uncertainty following possible Scottish independence vote

RD&D/ Academic	UK and international collaboration opportunities presented by new Horizon 2020 project funding	**Economic**	Difficulty in getting access to investment funds and financial markets
RD&D/ Academic	Continuing availability of funding support for innovation at project, SME and academic level (e.g. TSB, ESPRC, GIB)	**Societal**	Future blackouts reduces confidence in renewables in terms of their importance in the energy mix
Innovation	Need to upgrade network to cope with renewables generation provides ongoing opportunity for network innovation (e.g. Smarter Grid Solutions)		
Economic	Scotland could serve as a test-bed for new technologies, attracting new industry players and promoting start-up innovation		
RD&D/ Academic	UK grid capacity for solar PV has been set to accommodate up to 10 gigawatts installed capacity to prevent issues arises relating to grid instability. Therefore, research needed to further improve storage technologies and facilities.		

Table 32: SWOT Summary - Marine (Strengths & Weaknesses)

MARINE		MARINE	
	STRENGTHS		WEAKNESSES
Political	Strong political backing from Scottish Government	**Political**	Success of industry may depend on extent of support framework from Government
Economic	Presence of well-established large companies.	**Economic**	Electricity costs are high and increasing; unfavourably affecting cost-benefit of marine generation.
Economic	Scotland has significant proportion of wave and tidal resource and huge natural resource potential	**Economic**	Scottish companies are being taken over, which means that expertise could increasingly leave the country

Economic	Wealth of SME activity	**Economic**	The challenge of getting from the product development stage of technological development through to commercialisation (Valley of death) is still an issue for the industry.
Economic	Capacity in infrastructure (harbours and docks)	**Economic**	The skills gap needs to be filled. Training need for adapting skills from existing industry to provide an appropriate workforce.
Economic	Focused financial support from Government	**Technological**	Lack of data sharing an issue
Societal	High public buy-in and local involvement	**Technological**	Lack of local production of renewable energy equipment.
Technological	Academic and industrial clusters	**Technological**	Lack of grid connectivity to the islands
Technological	Legacy industry	**Technological**	Wave and tidal still unproven at array scale
Environmental	World-leading consenting procedure (although still in need of improvement)	**Innovation**	Perceived distance between academia and industry
RD&D/ Academic	Traditionally high-quality Scottish research with UK lead on Supergen, UK representative on EERA, and lead on many EU programmes.	**Innovation**	Lack of data sharing from ETI funded projects
RD&D/ Academic	Very high capability, primarily in University of Edinburgh but also in Heriot-Watt University and University of Strathclyde.		
RD&D/ Academic	Edinburgh and Strathclyde universities run the Marine Doctoral Training Centre.		
Innovation	Innovation leaders in wave and tidal renewable energy production.		
Innovation	Existing marine energy clusters- E.g. European Marine Energy Centre (EMEC) in Orkney Islands.		

Table 33: **SWOT Summary** -Marine (Opportunities & Threats)

MARINE		MARINE	
	OPPORTUNITIES		**THREATS**
Political	Financial market development to facilitate secure & longer-term funding for priority and strategic initiatives.	**Political**	Lack of flexibility regarding funding.
Economic	Upgrade or re-purpose existing old/ degraded buildings & facilities.	**Political**	Legislation/policies, yet to be complete, are frequently changed and present uncertainty to potential investors.
Economic	Public and private sector partnerships.	**Economic**	Lack of an integrated system of support to stimulate investments.
Societal	Up-skilling/training current workforce and creating new employment opportunities in energy sector.	**Economic**	Subsidy required until costs reduce and commercially viable operation can be reached.
Technological	The need to fulfil the European standards through modernisation, implementation of new technologies and improvements related to products, processes and services.	**Technological**	Limited capacity of the National Power Grid to balance and absorb electricity from renewable energy sources.
Technological	Focused and targeted development of the energy sector and related services/sectors.	**Technological**	The optimum renewable resources are in technically challenging areas.
Innovation	Acquiring test and demonstration zone leases from the Crown Estate.		

Table 34: **SWOT Summary** - Storage & Conversion (Strengths & Weaknesses)

STORAGE & CONVERSION		STORAGE & CONVERSION	
	STRENGTHS		WEAKNESSES
ALL STORAGE & CONVERSION		***ALL STORAGE & CONVERSION***	
Policy	Strong government support for renewable energy technologies.	**Policy**	Lack of understanding of the kind of investment needed for energy storage development from Government and Generators
Technological	Energy storage is critical for the efficient deployment of renewables.	**Technological**	No North Sea electrical interconnector.
Economic	Large quantities of renewable generation.	**Economic**	Lack of refuelling infrastructure for low carbon vehicles.
PUMPED HYDRO STORAGE		***PUMPED HYDRO STORAGE***	
Technological	Two large existing pumped storage facilities (Cruachan 420MW and Foyers 300MW).	**Technological**	Scale of pumped hydro storage is insufficient in comparison to the scale of government renewable targets.
Economic	Scotland based pumped hydro operator (SSE).	**Technological**	Few sites for further expansion of capability.
HYDROGEN & FUEL CELLS		**Economic**	Large amounts of finance required.
Technological	Availability of isolated gas networks.	***HYDROGEN & FUEL CELLS***	
RD&D/ Academic	Academic strength in catalyst for fuel cells and electrolysis.	**Technological**	The gas network can only currently support relatively low levels of hydrogen injection.
RD&D/ Academic	Academic strength in thermodynamics and modelling.	**Economic**	No native manufacturers of active fuel cell components e.g. catalysts, etc.
RD&D/ Academic	Academic strength in systems integration.	***BATTERIES***	
RD&D/ Academic	Academic strength in hydrogen storage materials.	**Economic**	No native battery cell manufacturer or chemical company.
Economic	World largest fuel cell installer (Logan Energy) is a Scottish SME.		
Societal	Academic strength in hydrogen as energy storage for remote communities.		

BATTERIES			
Economic	EU's largest supplier of battery packs (Axeon) is a Scottish firm.		
RD&D/ Academic	Academic strength in battery active materials research		
RD&D/ Academic	Academic strength in redox flow batteries.		
CHEMICAL STORAGE			
RD&D/ Academic	EU R&D centre for Sasol in St Andrews, expertise in chemical conversion of energy.		
RD&D/ Academic	Academic strength in catalysis and the chemical conversion of energy.		

Table 35: SWOT Summary – Storage & Conversion (Opportunities & Threats)

STORAGE & CONVERSION		STORAGE & CONVERSION	
	OPPORTUNITIES		THREATS
ALL STORAGE & CONVERSION		***ALL STORAGE & CONVERSION***	
Policy	Government incentive to deploy low carbon vehicles.	**Economic**	Demand side management and "smart" technology are competing for resources.
Economic	University of St Andrews is developing a large industrial site as a research, development and demonstration facility.	**Economic**	Loss of government support in the market place, including removing environmental taxes from conventional generation.
Economic	Large number of chemical firms with transferable knowledge.	**Social**	Safety fears regarding some of these technologies may result in a loss of public support.
Technological	Numerous test facilities for testing energy storage in conjunction with renewables at various scales.	***PUMPED HYDRO STORAGE***	
PUMPED HYDRO STORAGE		**Environmental**	The newly proposed sites are in the Great Glen and so there may be opposition based on the destruction of an area of natural beauty.
Economic	Two large pumped storage facilities in planning process (Balmacaan 600MW and Coire Glas 600MW).	**Economic**	The power companies are unlikely to invest in new capability unless it is de-risked by government.

Economic	Scottish firm commercialising fuel cells for combined heat and power (IE-CHP).		
Economic	Scotland has Europe's most active hydrogen and fuel cell association (SHFCA).		
Economic	A number of demonstration projects are under way or in planning (buses, ferries, wind balancing etc.)		
Economic	Large number of Oil and Gas firms with transferable knowledge.		
BATTERIES			
Technological	Scottish SME (Sunamp Ltd) supported by ETP in developing RE heat storage battery based on Phase change materials		
Economic	Scottish manufacturer of battery electric vehicles (Allied Vehicles)		

Table 36: SWOT Summary – Wind Energy (Strengths & Weaknesses)

WIND ENERGY		WIND ENERGY	
	STRENGTHS		**WEAKNESSES**
RD&D/ Academic	Academic strength in control systems.	**Economic**	No native offshore wind turbine OEMs, and only one native Onshore Wind OEM.
RD&D/ Academic	Academic strength in condition monitoring	**Economic**	Grid and interconnector infrastructure not currently suitable for mitigation of wind energy intermittency.
RD&D/ Academic	Academic strength in asset management systems	**Economic**	Offshore Wind sector working to reduce costs to become more competitive with other energy sources. Scottish sites face particular challenges, e.g. deep water.
RD&D/ Academic	Academic strength in wind turbine adaptation for marine environment (for offshore applications)	**Economic**	Boom in Oil and Gas industry has made experienced offshore workers too expensive to attract to offshore wind industry.
RD&D/ Academic	Academic strength in civil engineering, particularly concrete technology	**Technological**	Lack of demonstration sites for new foundation designs is limiting innovation
RD&D/ Academic	Academic strength in wind resource assessment.		
RD&D/ Academic	Academic leadership of SuperGen Wind Research Programme		
RD&D/ Academic	Offshore Renewable Energy Catapult located in Glasgow		
Economic	Scotland has significant proportion of EU offshore wind resource.		
Policy	Strong government support for offshore wind research, infrastructure and supply chain.		
Economic	Wealth of Offshore Oil & Gas experience to feed in to Offshore Wind.		
Economic	Capacity in infrastructure (harbours and docks)		
Economic	Focused financial support from Government		
Societal	Offshore wind resources have lower visual impacts than onshore projects; opposition may come from other groups, however (e.g. fisheries, environmental NGOs)		

Table 37: SWOT Summary - Wind Energy (Opportunities & Threats)

WIND ENERGY		WIND ENERGY	
	OPPORTUNITIES		THREATS
Technological	Scottish Offshore Wind requires bigger turbines in deeper waters than elsewhere, so Scotland can become a technology leader in this area.	**Technological**	Failure to deploy Round 3 Offshore Wind in a timely fashion will allow other territories to catch and overtake Scotland
Technological	Condition monitoring and asset management techniques are more important in Scottish Offshore Wind sites than elsewhere, so Scotland can build a technology lead in these areas.	**Technological**	Floating turbine technology may make it possible for the entire turbine & foundation components and installation process to be sourced from outside Scotland
Economic	Large number of Oil and Gas firms with transferable knowledge.	**Economic**	Policy uncertainty and insufficient subsidy levels may make Financial Investment Decisions impossible for Round Three Offshore Wind.
		Economic	Insufficient grid capacity and interconnector capacity may make Round 3 Offshore Wind non-viable
		Economic	UK Government may withdraw subsidies from Offshore Wind if a credible path to lower LCOE does not become apparent soon.

Table 38: SWOT Summary - Bioenergy (Strengths & Weaknesses)

BIOENERGY		BIOENERGY	
	STRENGTHS		WEAKNESSES
Political	Strong political backing from Scottish Government for renewables	**Political**	Limited support due to impact on food production and prices, biodiversity and other environmental objectives, and international development and poverty reduction.
Economic	Wide range of companies from supply of biomass feedstock, processing, converting into biofuel.	**Economic**	Continuous supply of feedstocks for sustainability.

Economic	With significant forest cover (17% land cover) and well developed forest processing industry, principal biomass feedstock is wood and wood products.	**Economic**	Underdeveloped wood and waste management system
Economic	Municipal and other commercial waste; Animal waste product	**Economic**	Lack of finance as each stage of technology development
Economic	Focused financial support from Government	**Economic**	The skills gap needs to be filled. Training need for adapting skills from existing industry to provide an appropriate workforce.
Societal	Broad public support for small scale, heat/CHP installations.	**Societal**	Planning restrictions and limited site availability for the plants
Technological	Academic and industrial clusters established.	**Technological**	Less developed technology for feedstock processing
RD&D/ Academic	Strong academic groups in marine biomass such as Scottish Association for Marine Science (SAMS), Glasgow University on micro, macro algae technology for biofuel.	**Technological**	Lack of technology gasification, CHP plant, AD plant engineering
RD&D/ Academic	Development of second generation of biofuels such as Napier University, Robert Gordon, St Andrews, University of Aberdeen	**Societal**	Negative Public perception on bioenergy competing with food price.
RD&D/ Academic	Strong group on Pyrolysis and anaerobic digestion from Herriot Watt University, Edinburgh, Glasgow Caledonian	**Research**	Perceived distance between academia and industry
RD&D/ Academic	Gassification, Heat pump Strathclyde University, Glasgow And energy crops: Dundee University, Scottish Agriculture college	**Research**	Lack of data on resource availability and limited supply chain
Innovation	Research towards generation new second generation biofuel such as Biobutanol	**Research**	Lack on data of quality and quantity of waste produced

Table 39: SWOT Summary - Bioenergy (Opportunities & Threats)

BIOENERGY		BIOENERGY	
	OPPORTUNITIES		THREATS
RD&D/ Academic	Further research & development of current and new second generation biofuels.	**RD&D/ Academic**	Unaddressed data gaps on resource availability and limited supply chain
RD&D/ Academic	Building on already strong academic groups in marine biomass such as Scottish Association for Marine Science (SAMS), Glasgow University on micro, macro algae technology for biofuel.	**RD&D/ Academic**	Unaddressed data gaps on quality and quantity of waste produced
Economic	Potential to build on already wide range of companies from supply of biomass feedstock, processing, converting into biofuel.	**Societal**	Negative Public perception on bioenergy competing with food prices could affect development of opportunities.
Technological	Potential for developing technology for feedstock processing	**Societal**	Planning restrictions and limited site availability for the plants could affect development opportunities.
Technological	Potential for developing for gasification, CHP plant, AD plant engineering	**Economic**	Continued lack of funding at each stage of technology development
Economic	Developing training for adapting skills from existing industry to provide an appropriate workforce.	**Political**	Lack of progress as a result of limited support due to impact on food production and prices, biodiversity and other environmental objectives, and international development and poverty reduction.
Political	Focusing biomass power generation should on co-firing and conversion of existing coal power plants. New developments are only at small scale.		

Table 40: Matrix of sampled data used to infer relative focus of energy related activities in research, Government and the company base

Themes	Academic	Government (Scottish Enterprise)	Company base	Overall for region
Supply flexibility	**Tbc**	**£0M**	**46 SMEs**	Relatively low levels of recent Government activity, but recent EU focus in energy systems is beginning to be reflected at the UK level. Moderate numbers of SMEs may appear to be an issue, but these are mature and established technologies hydropower, coal generation, etc.. Scotland has very high academic capability in flexibility of supply with very large funded programmes.
Storage	**3* Projects, £2.6M**	**£0.1M**	**55 SMEs**	Moderate levels of Government support identified. Established company base associated with pumped storage hydropower, which is a mature technology, thus relatively low levels of SMEs. Great potential for further storage innovation activities in other areas, especially in large scale pumped storage, where there are plans for schemes in the Highlands. Scotland has low academic capabilities in hydro storage and medium capabilities in chemical and other storage areas.
Demand flexibility	**Tbc**	**£0.3M**	**49 SMEs**	Moderate levels of Government support to date. Increasing importance reflected in Scottish Smart Grid Strategy 2013. Particular SME activity in Smart meters. Increasing focus in all areas. Scotland has medium academic capability in demand side management in energy use in buildings and very good capability in demand flexibility relation to grid integration.
Grid / Infrastructure	**11 Projects, £8.3M**	**£5.5M**	**77 SMEs**	Significant activity and focus in this area as it relates to electricity networks, with emerging coordination occurring in Smart Grid due to the Smart Grid Strategy 2013. Significant infrastructure enhancement is still required and is causing delays to project development, particularly connection to the islands and offshore projects. Less innovation activity and infrastructure in conventional gas or heat, but heat is now a policy focus. Very high academic capabilities in grid and power networks with very large funded programmes. Scottish universities are UK's lead on Supergen and representatives on EERA.

Integration Methods	**Tbc (*EU & Research Council only)**	**£5.6M**	**274 SMEs**	Significant activity and focus in this area, particularly in ICT, data and Power Electronics. Less activity or coordination in conventional gas or heat. Academic capabilities are very high, including a strong focus on the grid integration of distributed renewables e.g. power electronics, control, HVDC. Scottish universities are UK's lead on Supergen and representatives on EERA.
Boundary Conditions	**Research active in these areas but mostly covered as part of wider research**	**£0M (but see adjoining text)**	**33 SMEs Significant public sector input**	Core activity for Government (ie not funded projects but staff work focus), Is a priority focus in Scottish policy. Figures for SMEs relate to those with technical activities, further companies to be reviewed for policy, planning, etc. Academic coverage in these areas is undertaken across the full range of energy disciplines. As such, capabilities are generally good, and are widespread and generally integrated within specific energy research programmes.
Renewable generation	**Tbc**	**£82M**	**647 SMEs**	Significant activity and focus in this area, particularly in marine and offshore wind. Very high capability in academic sector with world-class leading research in marine, wind, and grid, and very large funded programmes. Highest SME numbers in onshore wind and hydropower, as these are established industry areas. Potential to improve manufacturing base.
Carbon Capture & Storage	**29 Projects, £28.4M 1 EU Project, €3M**	**£0.4M***	**16 SMEs**	Some Government activity with demonstrator projects proposed. Large market potential, internationally. However, currently low numbers of SMEs identified. This is a very new and high capital expenditure technology and accordingly, companies associated with it are typically large. Established capabilities in oil & gas engineering industry offer potential to feature strongly in this market. Very high academic capability Scotland runs the UK CCS group. SCCS has very large funded research programmes and has a UK representative on EERA.

***Government spending shown on these tables is Scottish Enterprise spending which made up around 75% of Scottish Government spend in these areas but not shown is UK Government spend (such as for CCS Front End Engineering Design work)**

Table 41: Expanded Renewable Energy section of sampled data used to infer relative focus of energy related activities in renewable generation in research, Government and the company base

Themes	Academic (*EU & Research Council only)	Government (Scottish Enterprise)	Company base	Overall for region
Across all renewables	**Tbc**	**£82M**	**647 SMEs**	Significant activity and focus in this area, particularly in marine and offshore wind. Highest SME numbers in onshore wind and hydropower as these are established industry areas.
Wind onshore	**5* Projects, £6.5M** **1 Project, €1.2M**	**£0.1M**	**193 SMEs**	Public sector policy support, financial incentives, and excellent natural resources have encouraged development of the industry. Largest number of SMES identified. This possibly reflects maturity of sector. Scotland's academic sector has a very high capability in both on- and offshore wind with very large funded programmes. Scotland has the only UK Wind Doctoral Training Centre, is UK's lead on Supergen and representative on EERA.
Wind offshore	**2* Projects, £0.2M**	**£8.9M**	**60 SMEs**	Significant research activity and policy focus in this area. Relatively low number of companies likely reflects relative newness of the sector, and the large size of project development companies and high capital expenditure of projects. Scotland's academic sector has a very high capability in both on- and offshore wind with very large funded programmes. Scotland has the only UK Wind Doctoral Training Centre and is UK's lead on Supergen.
Solar	**23*projects, £17.9M** **2* Projects, €8.8M**	**£0M**	**86 SMEs**	High numbers of SMEs mostly small PV installers identified. Government supported installation of PV through financial incentives. Scotland has a low to medium academic capability but good collaboration through the SISER research partnership.

Geothermal	**tbc***	**£0.1M**	**5 SMES**	Little activity and information in this area, overall. To be further verified. Identified resources exist in Scotland but development is still at a very early stage.
Bioenergy	**14* projects, £8.1M 6* projects, €181M**	**£1.5M**	**89 SMEs**	3rd largest number of SMEs mostly in small-scale boiler installations. A significant proportion of industrial-type activity undertaken by large organisations e.g. waste management operators, local authorities and third sector organisations. Mixed public support with increasing uncertainty, especially in relation to dedicated electrical plants with no renewable heat element. Academic sector has low to medium capability.
Hydropower	**tbc***	**£0M**	**114 SMEs**	2nd Largest number of SMEs but little research or public support identified. Industry and technology is well established and market is mature. Low academic capabilities in this area possibly reflect the mature nature of the hydropower industry and high capabilities of the established industry-base.
Marine power	**10* Projects, £11.8M**	**£24.3M**	**86 SMEs**	Major focus and significant activity in this area. Low number of SMEs, mainly start-ups, as this is a new and emerging industry. RD&D activity in the sector is very high, relative to other countries. Very high academic capability with very large funded programmes and Scottish university is UK's lead on Supergen UKCMER.
Energy from waste	**2* Projects, £1.3M**	**£0.2M**	**19 SMEs**	Relatively low levels of SME activity. A significant proportion of industrial-type activity undertaken by large organisations e.g. waste management operators, local authorities and third sector organisations. Moderate levels of Government support. However, with biogas a potential contributor for heat targets, focus may increase. Academic capabilities are low to medium.

Scottish regional strengths and weaknesses

Scottish strengths and weaknesses in the Energy System

The scope of the Energy System is covered in the ENSEA project by 7 broad areas which in turn comprise 41 topics. The broad areas are:

- Supply flexibility (covering flexible generation like standby diesel generators);
- Storage (covering hydro pumped storage and other energy storage);
- Demand flexibility (covering all forms of demand side management);
- Grid / Infrastructure (covering the electricity, gas and heat networks),
- Integration Methods (covering data communications & systems management) Boundary Conditions (covering environmental and policy aspects of energy systems); and
- Renewable generation (covering all forms of renewable). .

The colour code used in the matrix below shows relative strength and weaknesses within the specific areas listed based on sampled data. The figures in the matrix shows the ranking according to 1= strongest and 8= weakest / not main focus for the regional actors. The ranking presented for the industrial sector reveals only the power producing industry's interest area.

The last column, 'Overall for Region', summarises the perceived relative ranking of activity in each area and the degree of coordination between research, Government (Scottish Enterprise) and company base. These summaries are based on a combination of professional judgement of experienced project partner organisations and initial collated sample data (readily available). Tables showing summaries of initial data collation are provided in Appendices A-C). Identification of information gaps is part of this process and recommendations will be made to address key information gaps.

Based on this broad summary analysis, there appears to be a broad match between the Research and Development activities being carried out by Scottish Higher Education Institutes (HEI) and company activity.

Table 42: Summary matrix showing relative focus and alignment of research, Government and company activity

Themes	Academic	Government (Scottish Enterprise)	Company base	Overall for region
Supply flexibility	++		+	Relatively low levels of recent Government activity, but recent EU focus in energy systems is beginning to be reflected at the UK level. Moderate numbers of SMEs may appear to be an issue, but these are mature and established technologies (hydropower, coal generation, etc.). Scotland has very high academic capability in flexibility of supply with very large funded programmes.
Storage	+	+	+	Moderate levels of Government support identified. Established company base associated with pumped storage hydropower, which is a mature technology, thus relatively low levels of SMEs. Great potential for further storage innovation activities in other areas, especially in large scale pumped storage, where there are plans for schemes in the Highlands. Scotland has low academic capabilities in hydro storage and medium capabilities in chemical and other storage areas.
Demand flexibility	++	+	+	Moderate levels of Government support to date. Increasing importance reflected in Scottish Smart Grid Strategy (2013). Particular SME activity in Smart meters. Increasing focus in all areas. Scotland has medium academic capability in demand side management in energy use in buildings and very good capability in demand flexibility relation to grid integration.
Grid / Infrastructure	++	++	+	Significant activity and focus in this area as it relates to electricity networks, with emerging coordination occurring in Smart Grid due to the Smart Grid Strategy (2013). Significant infrastructure enhancement is still required and is causing delays to project development, particularly connection to the islands and offshore projects. Less innovation activity and infrastructure in conventional gas or heat, but heat is now a policy focus. Very high academic capabilities in grid and power networks with very large funded programmes. Scottish universities are UK's lead on Supergen and representatives on EERA.

Integration Methods	++	++	++	Significant activity and focus in this area, particularly in ICT, data and Power Electronics. Less activity or coordination in conventional gas or heat. Academic capabilities are very high, including a strong focus on the grid integration of distributed renewables (e.g. power electronics, control, HVDC). Scottish universities are UK's lead on Supergen and representatives on EERA.
Boundary Conditions	+	+	+	Core activity for Government (i.e. not funded projects but staff work focus) and is a priority focus in Scottish policy. Figures for SMEs relate to those with technical activities, further companies to be reviewed for policy, planning, etc. Academic coverage in these areas is undertaken across the full range of energy disciplines. As such, capabilities are generally good, and are widespread and generally integrated within specific energy research programmes.
Renewable generation	++	++	+	Significant activity and focus in this area, particularly in marine and offshore wind. Very high capability in academic sector with world-class leading research in marine, wind, and grid, and very large funded programmes. Highest SME numbers in onshore wind and hydropower, as these are established industry areas. Potential to improve manufacturing base.
Carbon Capture & Storage	++	+		Some Government activity with demonstrator projects proposed. Large market potential, internationally. However, currently low numbers of SMEs identified. This is a very new and high capital expenditure technology and accordingly, companies associated with it are typically large. Established capabilities in oil & gas engineering industry offer potential to feature strongly in this market. Very high academic capability Scotland runs the UK CCS group. SCCS has very large funded research programmes and has a UK representative on EERA.

Table 43: Summary matrix expanded for renewable energy showing relative focus and alignment of research, Government and company activity

Themes	Academic	Government (Scottish Enterprise)	Company base	Overall for region
Across all renewables	++	++	+	Significant activity and focus in this area, particularly in marine and offshore wind. Very high capability in academic sector with world-class leading research in marine, wind, and grid, and very large funded programmes. Highest SME numbers in onshore wind and hydropower, as these are established industry areas. Potential to improve manufacturing base.
Wind onshore	++	++	+	Public sector policy support, financial incentives, and excellent natural resources have encouraged development of the industry. Largest number of SMES identified. This possibly reflects maturity of sector. Scotland's academic sector has a very high capability in both on- and offshore wind with very large funded programmes. Scotland has the only UK Wind Doctoral Training Centre, is UK's lead on Supergen and representative on EERA.
Wind offshore	++	++	+	Significant research activity and policy focus in this area. Relatively low number of companies likely reflects relative newness of the sector, and the large size of project development companies and high capital expenditure of projects. Scotland's academic sector has a very high capability in both on- and offshore wind with very large funded programmes. Scotland has the only UK Wind Doctoral Training Centre and is UK's lead on Supergen.
Solar	+	+	+	High numbers of SMEs identified (mostly small PV installers). Government supported installation of PV through financial incentives. Scotland has a low to medium academic capability but good collaboration through the SISER research partnership.
Geothermal				Little activity and information in this area, overall. To be further verified. Identified resources exist in Scotland but development is still at a very early stage.

Bioenergy	+	+	+	3rd largest number of SMEs (mostly in small-scale boiler installations). A significant proportion of industrial-type activity undertaken by large organisations (e.g. waste management operators, local authorities and third sector organisations). Mixed public support with increasing uncertainty, especially in relation to dedicated electrical plants with no renewable heat element. Academic sector has low to medium capability.
Hydropower		++	++	2nd Largest number of SMEs but little research or public support identified. Industry and technology is well established and market is mature. Low academic capabilities in this area possibly reflect the mature nature of the hydropower industry and high capabilities of the established industry-base.
Marine power	++	++	+	Major focus and significant activity in this area. Low number of SMEs, mainly start-ups, as this is a new and emerging industry. RD&D activity in the sector is very high, relative to other countries. Very high academic capability with very large funded programmes and Scottish university is UK's lead on Supergen UKCMER.
Energy from waste		+	+	Relatively low levels of SME activity. A significant proportion of industrial-type activity undertaken by large organisations (e.g. waste management operators, local authorities and third sector organisations). Moderate levels of Government support. However, with biogas a potential contributor for heat targets, focus may increase. Academic capabilities are low to medium.

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5 Summary and Conclusions

Main findings from SWOT analysis in relation to the Scottish Energy System

Scotland is a major energy exporter, has world-class research in energy. It has two, vertically-integrated, power utilities and supporting companies and an extensive oil and gas industry. The Government is actively aligning research, innovation and commercialisation in areas that relate to energy systems (notably Smart Grids) and has very ambitious sustainable energy targets. However ,given its considerable strengths, Scotland's levels of innovation and SME-base are not realising its technological and economic potential.

Energy systems
Scottish academic research covers the broad range of areas related to energy system integration. For example, the Systems, Power and Energy Research Division in Strathclyde University is tackling system problems at a strategic level, while Edinburgh's Institute for Energy Systems School of Engineering is more focused at the scale of optimizing systems within electrical devices for example. There is company activity in this area in relation to the supply of electricity and gas, both within Scotland, and the exports to England (such as in power trading or power network planning).

Electricity supply
Scotland has strong research and a good company base developed around managing its two power networks (Scottish and Southern Energy and Scottish Power) and their interconnections with England, along with the associated generation and supply of electricity.

Innovation activity is well aligned by the Scottish Energy Advisory Board, particularly in Smart grids. A Smart Grid Working Group has also been established (including representation from industry and the Enterprise Agencies), which has produced a Scottish Smart Grid Strategy and Action Plan.

Heat supply
It's not clear if Scotland (relative to the EU) is particularly strong or active in research in this area. There is relatively limited physical coverage of Scotland (and in the UK as a whole) by heat networks. A relatively small company base exists that is focused on installing domestic biomass boilers. However, Scotland does have ambitious heat-related policy targets and this will become an increasing priority in Scotland.

Fuel supply
Scotland has a very strong company base again associated with the two power utilities (which supply gas and manage gas networks) and also associated with Scotland's downstream oil and gas industry (which covers Grangemouth and other major industrial facilities and a major gas transmission network running from Aberdeen to England).

Data (and other subjects relating to management of power systems such as ICT and electronics)
There is significant research and company activity and alignment in this area particularly were it relates to electricity network management (such as in Information & Communications Technology, data management and Power Electronics. There appears to be less activity or coordination of activity relating to conventional gas or heat systems.

Innovation activities in the Energy System
Scotland is above the European average for innovation but company activity and the economic benefits of innovation are less strong. There is broad alignment between the key stakeholders involved, but these could be improved.

World-class research and development and a well-educated workforce mean Scotland is well positioned to develop innovation to support increased Energy Systems Integration, particularly in relation to electricity or Smart Grid related aspects.

Linkages with other HEIs outside Scotland and multinationals are good but need improving with the local SME base. However, a significant part of these have limited resources and capacity to innovate due to their small size.

A dominance of smaller companies which are relatively lacking in resources means that levels of spend on innovation, level of in-house innovation and local SME-University linkages are similar to benchmark levels for the whole of the enlarged EU-27. As a result the numbers of high growth SMEs and innovative SMEs are also average, as are the economic effects of innovation, as measured by exports and new to market products and services.

The Scottish Government has a Smart Grid development policy and Action Plan which is under the management of the Energy Advisory Board.

As with Scotland, there is no explicit UK policy support for energy systems. However, one major arm of the UK Government's innovation support (the Technology Strategy Board) is now in the process of setting up a new Technology Innovation Centre focused on energy systems.

Energy Systems Integration is now part of the latest European Strategic Energy Technology Plan (SET-Plan) which is one of the main drivers of Horizon 2020 work.

Table 44: Summary of Potential Key Opportunities for Increasing ESI

	Summary of Potential Key Opportunities Supportive of Increasing Energy Systems Integration.
	Political
General	Financial market development to facilitate secure & longer-term funding for priority and strategic initiatives.
General	Increasing the benefits from the triple helix effect of industry collaborating with academic institutions and public sector partners
General	Development of measures to further increase regional alignment of public sector stakeholders (through the Team Scotland approach).
Grid/ Infrastructure	Political stability after independence vote could allow for new focus on network development and renewables agenda
CCS	Using CCS on fossil-fuel power generation avoids the need for nuclear for base-load power, in-line with Scottish Government policy.
Bioenergy	Focusing biomass power generation should on co-firing and conversion of existing coal power plants. New developments are only at small scale.
	Economic
General	Developing public and private sector partnerships to support innovative initiatives for increased energy systems integration.
General	Adapting existing skills-base (e.g. in oil & gas) to renewables industry needs.
General	The potential for Energy Systems Integration development is further reinforced by Scotland's geography – bordering the North Sea with a number of well-located harbours for servicing offshore activity.
General	The infrastructure links to depleting Scottish offshore oil and gas fields offer potential for storage of gases (including captured CO2).
General	ENSEA project partners are in Scotland's top export markets by value, so developing initiatives which reinforce already strong connections, should be less problematic than establishing new markets.
General	Potential for development is very large for renewable resources around Scotland. Potential opportunities for offshore renewable resources (offshore wind and marine energy) are particularly significant.
General	Energy Systems integration has the potential to provide a regional solution, to not just high levels of renewables, but also network congestion and ageing.
General	Upgrade or re-purpose existing old/ degraded buildings & facilities.

Grid/ Infrastructure	Development of new supply chains around HVDV developments and growing interest in region from international players (e.g. Siemens, Alstom)
Grid/ Infrastructure	Increasing funds available from major economic development body (Scottish Enterprise) to support growth of sector and innovation in renewables in 2014 & 2015.
Grid/ Infrastructure	Scotland could serve as a test-bed for new technologies, attracting new industry players and promoting start-up innovation
CCS	Piloting CCS projects in North Sea region would extend the life of the oil & gas industry and could create opportunities for developing transferable skills, infrastructure, physical assets, etc.
CCS	CCS has the potential to support provision of baseload energy supply through fitting CCS technology to fossil fuel powered plants.
Pumped Hydro Storage	Two large pumped storage facilities in planning process (Balmacaan 600MW and Coire Glas 600MW).
Pumped Hydro Storage	Scotland has Europe's most active hydrogen and fuel cell association (SHFCA).
Pumped Hydro Storage	A number of demonstration projects are under way or in planning (buses, ferries, wind balancing etc.)
Pumped Hydro Storage	Large number of Oil and Gas firms with transferable knowledge.
All Storage & Conversion	University of St Andrews is developing a large industrial site as a research, development and demonstration facility.
All Storage & Conversion	Large number of chemical firms with transferable knowledge.
Marine	Upgrade or re-purpose existing old/ degraded buildings & facilities.
Marine	Public and private sector partnerships.
Solar	Under-developed solar installation in both large and small scales
Solar	Scotland could serve as a test-bed for new technologies, attracting new industry players and promoting start-up innovation
Bioenergy	Potential to build on already wide range of companies from supply of biomass feedstock, processing, converting into biofuel.
Bioenergy	Developing training for adapting skills from existing industry to provide an appropriate workforce.
Wind	Large number of Oil and Gas firms with transferable knowledge.
	Societal
General	Creating new employment opportunities in energy sector.
General	Developing and adapting skills of current workforce to support and stimulate innovative technological development relevant to energy systems integration.

Marine	Up-skilling/training current workforce and creating new employment opportunities in energy sector.
Solar	Opportunity for development of larger-scale community district heating and PV projects e.g. Especially important for energy security and independence in rural and island communities in Scotland.
	Technological
General	The need to fulfil the European standards through modernization, implementation of new technologies and improvements related to products, processes and services.
General	Focused and targeted development of the energy sector and related services/sectors.
General	Energy Systems Integration is a flexible solution that can include a variety of local solutions and developments (e.g. hydropower in Norway, PV in Lower Saxony etc.)
General	Developing cross-boundary markets and new business models to support energy systems integration.
Grid/ Infrastructure	Development of offshore wind farms will stimulate innovation and connect to onshore networks
Grid/ Infrastructure	Along with rest of UK, Scotland will see introduction of smart meters from 2015 - providing new scope for network innovation and consumer engagement
All Storage & Conversion	Numerous test facilities for testing energy storage in conjunction with renewables at various scales.
Solar	Increasing the efficiency of systems
Solar	Development of technologies specific for northern hemisphere environmental conditions e.g. diffuse light and lower light levels
Solar	Development of suitable storage methods and facilities
Bioenergy	Potential for developing technology for feedstock processing
Bioenergy	Potential for developing for gasification, CHP plant, AD plant engineering
Wind	Scottish Offshore Wind requires bigger turbines in deeper waters than elsewhere, so Scotland can become a technology leader in this area.
Wind	Condition monitoring and asset management techniques are more important in Scottish Offshore Wind sites than elsewhere, so Scotland can build a technology lead in these areas.
Marine	Focused and targeted development of the energy sector and related services/sectors.
Solar	Potential for developing networks and clusters of district heating using solar thermal storage technologies and facilities.
	Environmental
General	Scotland's diverse geography (islands, mainland etc.) is a natural test bed for energy technologies to support energy system integration solutions.

	R&D/ Academic
General	Excellent opportunities in R&D in renewables, particularly in wind, marine, grid and CCS.
Grid/ Infrastructure	Continuing availability of funding support for grid related innovation at project, SME and academic level (e.g. TSB, ESPRC, GIB)
Grid/ Infrastructure	Focus on innovation requirements of industry will further develop knowledge base within academic institutions
Grid/ Infrastructure	UK and international collaboration opportunities presented by new Horizon 2020 project funding in relation to integration of energy systems.
CCS	Huge potential for economic saving where RD&D can address the issue of high costs for CO2 capture.
CCS	Clustering potential of industry/ academic/ economic interests for CCS at the regional, North Sea and Northern Europe levels.
Solar	UK and international collaboration opportunities presented by new Horizon 2020 project funding
Solar	Continuing availability of funding support for innovation at project, SME and academic level (e.g. TSB, ESPRC, GIB)
Solar	UK grid capacity for solar PV has been set to accommodate up to 10 gigawatts installed capacity to prevent issues arises relating to grid instability. Therefore, research needed to further improve storage technologies and facilities.
	Innovation
General	Obtaining test and demonstration zone leases from the Crown Estate to support innovation in the energy sector related to energy system integration.
General	The region's broad base, and wide range, of new energy activities offers many opportunities for energy system optimisation experiments and related research and training.
General	Enhanced and more collaborative training & skills development to facilitate taking forward innovations related to energy systems integration.
Grid/ Infrastructure	Energy efficiency agenda could minimise need for new infrastructure spend (e.g. Smarter Grid Solutions and Orkney project) and free up investment for elsewhere in network
Grid/ Infrastructure	Continued interest and investment in innovation agenda by local Distribution Network Operators (DNOs).

Grid/ Infrastructure	The Power Network Demonstration Centre (PNDC) in Cumbernauld has potential for accelerating new technologies on to network
Grid/ Infrastructure	Opportunity to learn from network innovation projects such as NINES (Energy storage & demand side project), Moray Firth Hub and East/ West Interconnector projects.
Grid/ Infrastructure	Supergrid ideal for trialling approaches and as a test-bed for projects due to the small size of the country and only two major industry players (SSE & Scottish Power)
Grid/ Infrastructure	Need to upgrade network to cope with renewables generation provides ongoing opportunity for network innovation (e.g. Smarter Grid Solutions)
Grid/ Infrastructure	In terms of EU activity, Scotland's early development of electric vehicle infrastructure can provide expertise to further develop technology and expertise (e.g. wireless technology).
Grid/ Infrastructure	Dispersed rural population enables community renewables agenda to be explored and trialled. More self-sufficiency provides a good model to learn from and stimulates innovation.
Grid/ Infrastructure	Scotland could potentially play a significant role in development of new EU supergrid - linked to offshore wind and HVDC developments
CCS	Clustering potential of industry/ academic/ economic interests for CCS at the regional, North Sea and Northern Europe levels.
Solar	Commercialisation of existing and current research into new products
Solar	Development of systems combining solar thermal, PV (and potentially other technologies e.g. heat pumps) and storage options for the user
Solar	Need to upgrade network to cope with renewables generation provides ongoing opportunity for network innovation (e.g. Smarter Grid Solutions)
Marine	Acquiring test and demonstration zone leases from the Crown Estate.
Solar	Strengthening and further development of networks and collaboration between industry networks and clusters.

5.1 Next Steps

Work package 2 (WP2) of the ENSEA project involved analysis of the research capabilities, activities, roles and connectivity of participating project partners.

WP2 assembles an information base and includes SWOT analyses which will help the ENSEA partners to identify opportunities to work together to address the challenges of Energy Systems Integration.

It also provides a critical analysis of existing performance of the institutions involved in R&D, innovation and regional economic development work and identifies opportunities for best practice and synergies across regions.

This creates the basis for the Joint Action Plan to be developed in WP3. WP2 also includes an analysis of EU and international links and cooperation as part of ENSEA internationalisation strategy.

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Regional Report of the Energy Valley Region

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1 General overview of the Energy Valley region

1.1 Geography

Some ten years ago in the North of the Netherlands the initiative was taken by the local authorities together with the energy industry, to set up a new triple helix organisation, called Energy Valley, in order to coordinate the ongoing and future economic activity in the area of energy and sustainability. The underlying idea was that, based on the super giant Groningen gas field, a major industry had grown since the beginning of the sixties, to explore, transport, store and market considerable volumes of natural gas both for domestic use and exports mainly to North Western Europe. On top of the ongoing gas related activity the production of power increasingly shifted to the Northern shore of the Netherlands; moreover renewable activity, particularly based on wind and biomass, also strongly took off in those days.

Since then Energy Valley not only has grown as a strategic organisation supporting energy activity and investment in the North of the Netherlands, but also Energy Valley has become a concept well known both nationally and internationally, symbolizing the significant energy activity and the rapid extension of energy investment in the region. As an illustration one can refer to the estimate of the investment amount in the Northern region for the next five years in the order of €25 bn, an amount which is almost unprecedented throughout Europe given the scale of the area covering the provinces of Groningen, Fryslân and Drenthe, and the Northern part of the province of Noord-Holland. (The Energy Valley region has a surface of roughly 13.5 mln square kilometres, and a population of roughly 2.2 mln).

Various explanations can be provided why energy production, storage, transport and trading activity, as well as innovation, knowledge development, R&D and training are increasingly concentrated in the Northern part of the Netherlands, demonstrating a trend that equally applies in Germany and probably elsewhere in the North Sea area where energy activity also seems to be increasingly concentrated near the shore.

First, increasingly strict rules with regard to cooling water make it consistently less attractive to position conventional fossil fuelled power plants inland at the riverside.

Second, in order to optimize economic return, modern power plants increasingly focus on multi source engineering designs, i.e. capable of absorbing various primary energy sources (coal, gas, biomass, etc.) in various mixes. This requires easy access to such sources. Near (sea)harbour, sighting of such multi source plans is currently the preferred option in order to be able to attract the various sources of primary energy.

Third, energy plans are increasingly included in co-siting initiatives, where various production facilities are, or can be properly organized, linked together in order to optimize, among others, energy (re-)use. Such co-siting requires the presence of industrial production conglomerates, or (eco) industry parks, which can often be found close to harbours.

Fourth, the traditional offshore gas sector in the North Sea basin provides an interesting stepping stone for other offshore activities, such as offshore wind. Considering that the North Sea area is a so called ‘mature’ gas and oil production area, offshore wind can be an interesting renewable option to retain a strong offshore sector.

Finally increasingly strict environmental standards drive the power production facilities (both fossil and renewable) away from population centers towards e.g. coastal areas, especially those which are still not overly densely populated.

1.2 Economy

As was argued already, the Energy Valley region has meanwhile developed a strong and innovative energy position. Almost the entire domestic natural gas production (over 58.5 bn cubic meter a year) and one fifth of the large scale power production (over 3,875 MW) is concentrated in this area. The region is also strategically positioned, centrally in the European gas and power grid, and directly at the North sea with excellent harbour facilities for transport of raw materials and offshore wind developments.

Companies, knowledge institutes and governments work closely together to create a sustainable energy economy and new green jobs. Currently there are over 4,000 companies and 32,500 employees in the Northern energy cluster. The energy investments as argued already exceed €25 bn in the coming decade. These investments are closely interrelated and form a powerful European energy machine. This makes the energy sector in the Northern Netherlands not only an important engine for the Dutch economy, but also a leading player in Europe.

So, with almost the entire Dutch gas production, one third of the national oil production, a fifth of the central electricity capacity and almost a quarter of the total renewable energy production, the Northern part of the Netherlands plays a key role in the Dutch energy system. With regard to green energy the Northern Netherlands has a particular large share in wind onshore (37%), biogas (34%) and green gas (33%). The total green energy production in the Energy Valley region has increased with 12% compared to 2010 whilst nationally the increase represented an 8% rise. Especially the share in waste incineration plants (REC Harlingen), wind energy and biofuels (BioMCN Delfzijl) has increased in the Energy Valley region.

The Northern energy sector covers almost 4,000 companies (for some more details, see fig.1) and 32,500 jobs in terms of direct employment (see also fig. 2 for more details) The share of direct energy related employment and the overall employment in the region is about 4%, and 5.8% if related to the market based employment only (see fig. 3). If indirectly related employment would be added to this figure, the amount could easily double. The production and installation of energy technology covers almost 60% of all economic activity in the Northern energy sector.

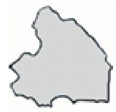
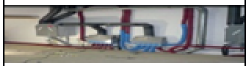
	 EV-region	 N-H Noord	 Fryslân	 Groningen	 Drenthe
 Primary	725	195	215	135	180
 Secondary	2.260	785	595	450	430
 Tertiary	955	295	240	220	200
Total Energysector	**3.940**	**1.275**	**1.050**	**805**	**810**
Share of Enterprises	-	32,4%	26,6%	20,4%	20,6%

Figure 1 Overview of energy related companies (2011)

Source: LISA.
Primary: Economic activity related to energy production and supply.
Secondary: Economic activity related to energy installation and maintenance.
Tertiary: Economic activity regarding all energy related services.
N.B. In the table the traditional multiplier of economic activity - usually estimated between 2 and 4 – has not been included by lack of data; actual economic activity generated therefore is probably underestimated.

	EV-region	N-H Noord	Fryslân	Groningen	Drenthe
Primary	10.425	1.375	2.500	3.525	3.025
Secondary	18.600	4.400	4.950	4.675	4.575
Tertiary	3.425	1.300	650	1.000	475
Total Energysector	**32.450**	**7.075**	**8.100**	**9.200**	**8.075**
Share of Full Time Employment	-	21,8%	25,0%	28,3%	24,9%

Figure 2 Overview of energy related employment (2011)

Source: LISA.
For an explanation of the variables, see also fig. 1.

	EV-region	N-H Noord	Fryslân	Groningen	Drenthe
Total energysector	32.450	7.075	8.100	9.200	8.075
Total market sectors	557.800	140.850	161.950	136.950	118.050
Total all sectors	817.250	200.350	229.550	215.050	172.300
Energy jobs in relation to market sectors	5,8%	5,0%	5,0%	6,7%	6,8%
Energy jobs in relation to all sectors	4,0%	3,5%	3,5%	4,3%	4,7%

Figure 3 Share of energy jobs in relation to total (market) sector (2011)

Source: LISA.

The Northern part of Noord-Holland and Fryslân show a high density of SME's, whilst in the Groningen-Assen area the share of larger companies is higher. The total number of Northern energy related companies in the Energy Valley region has increased with 1.5% compared to 2010 with the strongest growth in Groningen (5%) and Fryslân (2.5%). The number of energy companies in the Eemsdelta even increased by as much as 10%, while the number for Drenthe decreased by 1.2%(mainly due to the loss of about ten smaller consulting agencies).

The amount of energy related jobs is more or less equally distributed among the provinces within the Energy Valley. However, there is a concentration in the Groningen-Assen area. The employment in the energy sector has done well recently: the number of energy-related jobs has grown with 1% since 2010, against a drop of overall employment of 0.8-1%. Energy related employment grew some 3.2% in the province of Groningen, some 0.7% in the province of Drenthe, some 2.3% in the Groningen-Assen region, some 5.9% in the Eemsdelta region, while there was small decline in Fryslân (-0.4%) and the north of the province of North-Holland (-0.1%).

In spite of the overall economic decline both nationally and in the Energy Valley area, energy investment activity in the area maintained its booming trend. Information on future investment suggests this trend to strongly continue in the years ahead. To illustrate, the Woodspirit(bio-methanol) and Gemini (700 MW of Offshore Wind) projects both in the EV region are in the top-three of 'sustainable investments' in the Netherlands. They represent investment amounts of €500-700 mln, and €2.3 bn, respectively. Moreover, the construction of the subterranean gas-storage of Taqa (called Bergermeer), representing a private investment of €800 mln, is one of the largest private investments nationwide at this moment. Based on these, and other, investments, it seems safe to predict a further growth in jobs and entrepreneurship within the Northern energy-sector for the years to come.

As a result of the various past energy investments in the EV region, a mere 40% of all Dutch energy-related revenue is currently generated in the Energy Valley region. This share is likely to grow further in the coming years, especially if North Sea energy activity is further taking off.

1.3 Education / research

See chapter 3.3 on this issue.

1.4 Important regional plans covering for example energy, climate change and economic development

Especially due to its strong natural gas position, the Energy Valley region traditionally plays a strategic role in the fossil energy supply of North Western Europe (gas roundabout). In the area of gas the headquarters of some major gas industry players, such as Gasunie GTS, Gasterra, NAM are located in the area, as well as an extended network of subcontractors and knowledge facilities. The electricity cluster is also well developed with large-scale power production, European grid connections and innovative companies. The region has a key position for future European energy supply because of the scope for interaction between the power and gas sector.

The strong agro and waste industry is also actively involved in the emerging energy activities, e.g. by developing new innovative technologies to use organic waste for energy products. The region has a lead position in the development of Green Gas Hubs, and has a strong position in the field of bio methanol and bio coal. As was argued already, the development of the energy cluster is supported by a strong expansion of the knowledge infrastructure with various national and international research programmes for instance on the role of gas as transition fuel flexibility/balancing and offshore wind.

The energy investment in the region shows a clear upward trend: investment volumes during 2008-11 were six times larger than those of 2004-7. As is illustrated in figure 4, cumulative investment (since 2004) are likely to reach the level of €25 bn by 2018. Because this figure only covers the initiatives and plans as currently known, it is well possible that the cumulative figures will rise further, especially if new offshore activity (offshore wind, offshore infrastructure, offshore power-to-gas, offshore (green) decommissioning and offshore exploration and storage) will take off in the near future. The information on investment so far suggests that some 70% of energy investment in the region is related to fossil activity, and the remaining 30% to renewable and energy transition activities (see fig. 5).

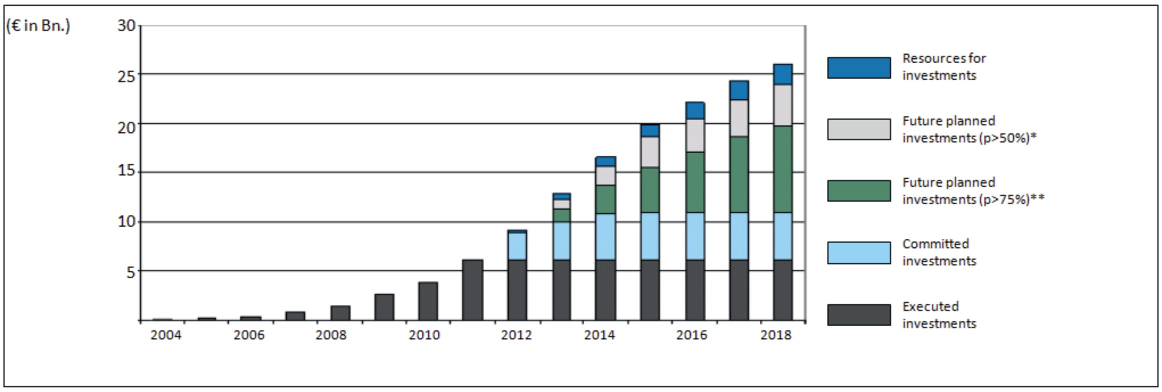


Figure 4 Cumulative investments in the energy sector in the EV-region (2011)

Source: Energy Delta Institute/ EDIaal (2013).
***= Concrete investment projects of which the investing decision has not been taken yet, but implementation is relatively certain (over 50%).**
****= Concrete investment projects of which investing decision has been taken and implementation is relatively certain (over 75%). Only in extraordinary circumstances, e.g. economic decline, there is a small chance that investment plans will be cancelled.**

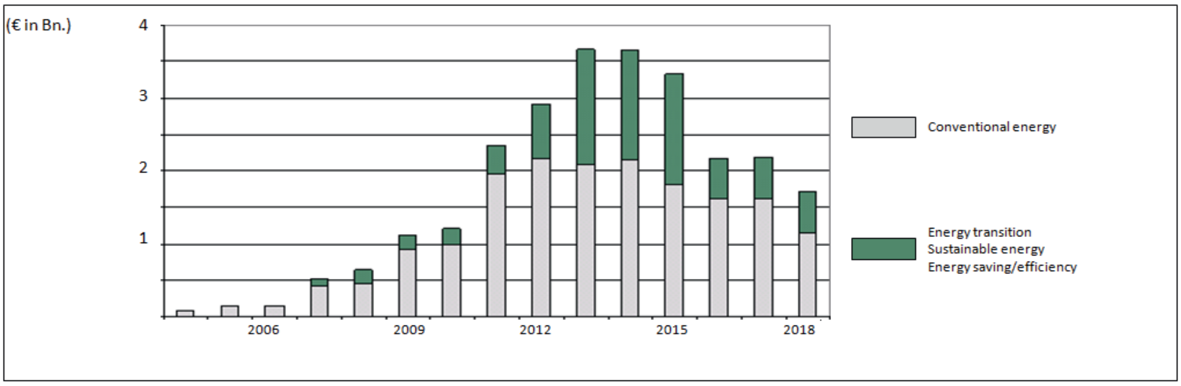


Figure 5 Size of energy investments (2011)

Source: Energy Delta Institute/EDIaal (2013).

The overall economic activity in the Energy Valley region covers roughly some 10 - 12% of total national economic activity (depending on whether or not the gas production is attributed to the EV region). This percentage is more or less in line with the share in the overall population as well as the share in national CO2 emissions (fig. 6). The latter figure is surprising in view of the relatively large energy sector in the Energy Valley region (some 22%) as compared to the nation as a whole (some 7.3%). The reason why greenhouse gas emissions from the Energy Valley region are yet relatively modest is due to: the fact that a considerable part of energy value added is related to the production of gas, which is used elsewhere; the relatively strong focus on renewables (some 20%; see also fig. 7); and the various efforts in the Energy Valley region to take a leading role in green technology and energy efficiency. In order to reinforce this green regional focus, in 2007 an accord was reached between the Energy Valley region authorities and the then ruling national government to enhance the ongoing trend towards a greener economy. This accord was terminated by 2010 by the fall of that cabinet. Currently some initiatives are underway to once again establish such an accord with the national government.

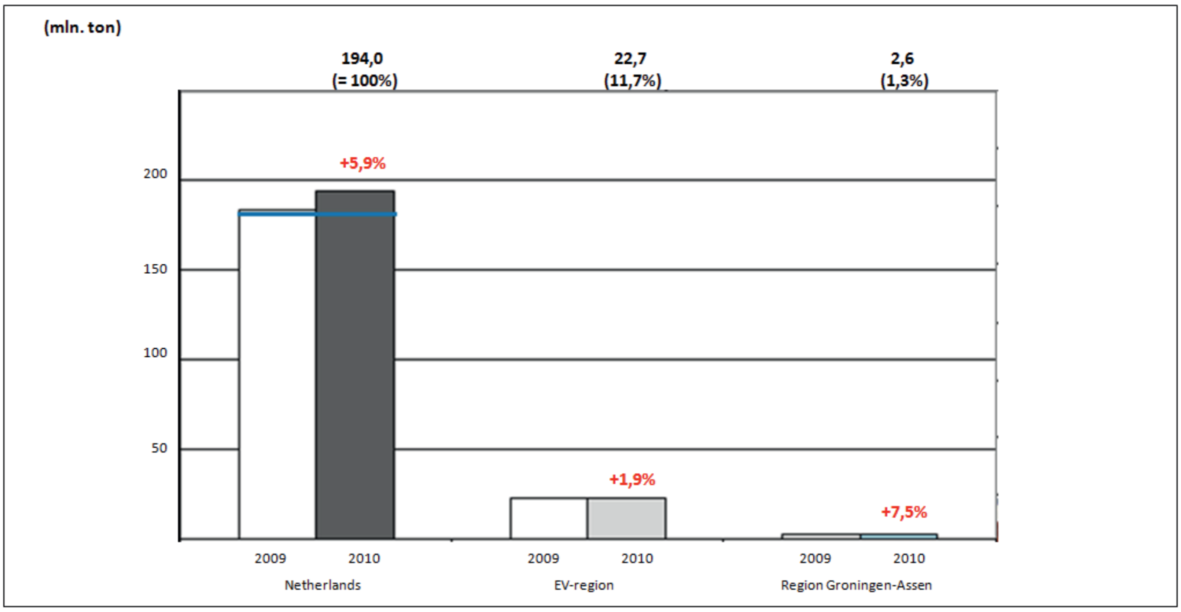


Figure 6 Regional CO_2 emissions (2010)

Source: Netherlands' emissions registration / Agentschap NL (2013).

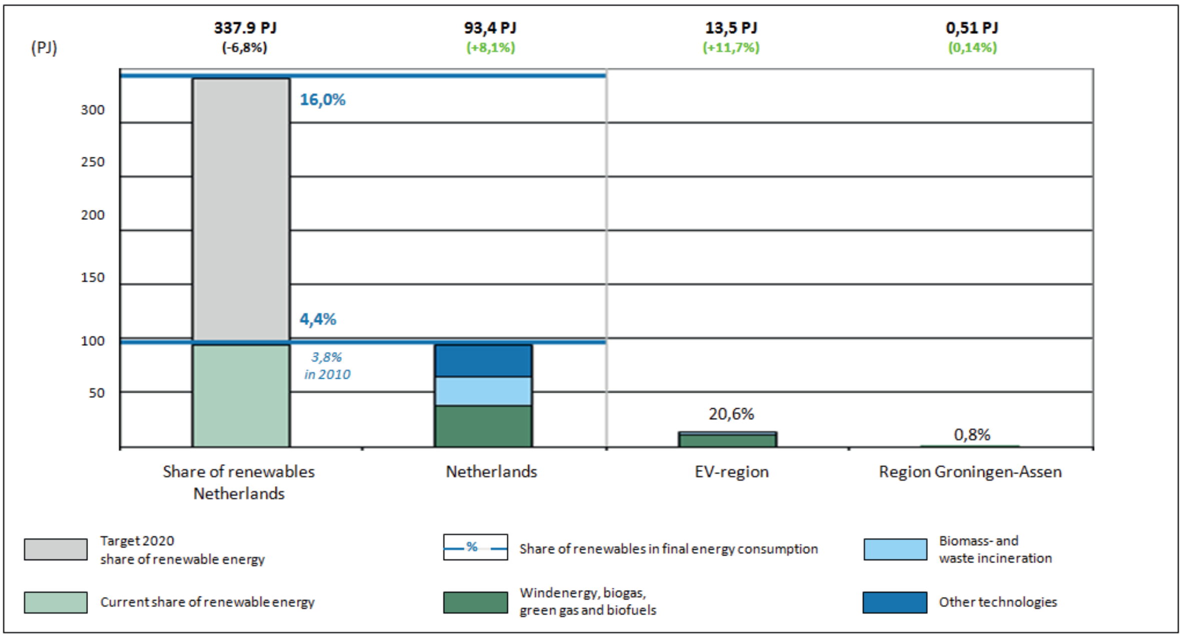


Figure 7 Overview of sustainable energy production (2011)

Source: Energiemonitor Noord-Nederland 2013.

In the course of 2013 the main stakeholders in the national policy spectrum came to an agreement on a so called national energy accord for sustainable growth ('het Nationale Energieakkoord'). This agreement sets the stage for the Netherlands energy policy for the coming years. Energy Valley has been asked to indicate, on the base of a coherent plan, how the national accord could be worked out in the Energy Valley region. This plan has recently been launched under the name SWITCH. It sets the Energy Valley agenda for the coming years. Its main focus points are: gas in transition (production of green gas by gasification, small scale LNG, green gas hubs, power-to-gas); wind energy (capacity development both onshore and offshore, testing facilities, pilots and a mobile working island); smart power generation (pilots and testing facilities for smart energy system integration, energy storage via power-to-gas, compressed air energy storage and advanced offshore hydro pumped storage); energy saving; and decentralized production (energy efficiency in the built environment, pilots on labelling, introduction of highly efficient boilers, smart metering experiments, development of small-scale solar parks, etc.).

In addition Energy Valley plans to strongly focus on cross-cutting themes such as: the introduction of clean tech in small- and medium-sized enterprises; the provision of conditions and room for all kinds of innovative energy experiments both technically and economically/social acceptance driven; a strong focus on human capital development and research in a coherent setting (a.o. via the Energy Academy Europe); and considerable assessment of social acceptance, business perspectives and legal conditions of new energy investment projects.

2 Description of the regional energy system

2.1 Consumption, production, storage and transport of energy

The share of energy consumption in the Energy Valley region in national demand is slightly higher, some 16%, than one would have expected based on the share in overall economic activity, some 11%. In 2010 Energy Valley consumed some 475 PJ compared to 2,981 PJ for the country as a whole. One reason why energy consumption is relatively high has to do with the fact that about a quarter of the national chemical industry is located in the area, as well as one of the main steel production units (Aldel). Another explanation is the relatively heavy representation of energy exploration and production (see also next).

As far as energy production is concerned, the Energy Valley region plays a strategic role in the overall energy production of the Netherlands. In fact the importance of this role is still growing to such an extent that it is fair to conclude that Energy Valley is a prime energy region not only of the country, but also of the wider area of North Western Europe.

This picture is first of all based on the strong gas production activity in the region. To illustrate, natural gas production in the Energy Valley region amounted to some 54 bcm (2011), mainly from the so called Groningen field (estimated original reserve some 3,000 bcm; exploration since beginning of the 1960's about two-thirds. Remaining proven reserves some 900 bcm, or some three quarter of overall national gas reserves). This amount covers almost all (97%) of the national onshore gas production. The gas production corresponds with some 59% of total Netherlands' primary energy demand. The headquarters of gas production (NAM, Assen), gas transport services (Gasunie, Groningen) and gas trading (Gasterra, Groningen) are all located in the Energy Valley region.

Also in terms of national gas storage, the Energy Valley region completely dominates the national situation. Since 1997 all four natural gas storages are concentrated in this region (location/ working volumes: Grijpskerk/1 bcm; Norg/3 bcm; Zuidwending/0.2 bcm; Alkmaar/0.5 bcm). By 2012 it was decided to introduce another major gas storage site near Alkmaar (Bergermeer/4.1 bcm). This site, again located in the Energy Valley region, will be one of the largest in Europe.

Next to the substantial gas production volumes, also some oil exploration takes place in the Energy Valley region. Production, mainly from the Schoonebeek field in Drenthe, amounted to some 425,000 cm (2011), or about a third of the national production volume. The Schoonebeek production is expected to increase to levels some ten times higher, such that Schoonebeek will become the dominant oil production site of the country.

As was argued already, power production gradually shifts to coastal areas and the Energy Valley region in particular. If one disregards power production capacity under construction, overall capacity of the Energy Valley power plants currently is slightly less than 4,000 MW, almost all gas-fuelled. This corresponds with some 20% of national power production capacity. Currently power production capacity in the Energy Valley region is extended with some 3,000 MW (especially RWE-Essent/coal-biomass, and NUON/Vattenfall-gas; most of this capacity will be ready by 2013-2014). As a result the share of power production in the Energy Valley region will probably increase to some 40%. If, as was recently decided in the spirit of the 'Energie Akkoord', in addition five coal-fired power plants in the southern and western part of the country will be closed down in the foreseeable future, this percentage can even further increase.

To sum up, as far as the fossil energy production is concerned the overall broad picture is that the Energy Valley region almost completely dominates national gas production and storage; that the Energy Valley region now produces some one-third of national oil, but is likely to become the dominant producer in the foreseeable future; and that the share of national power production from fossil sources, currently some 20% of the national capacity, will probably soon double to some 40%, a figure which may well rise even further in the more distant future.

Renewable energy production is still relatively modest in the Netherlands as compared to a number of other EU member states. One explanation may be the large gas reserves and gas penetration rate, which may have reduced the sense of urgency regarding dependence on foreign supply. Anyhow, the figure below (2011) illustrates both for the country as a whole as well as for the Energy Valley region the overall renewable energy production and its composition. It shows that the renewable production in the Energy Valley region represents some 15% of the national volume, and that in the Energy Valley region especially wind energy and energy from waste treatment are represented relatively strongly.

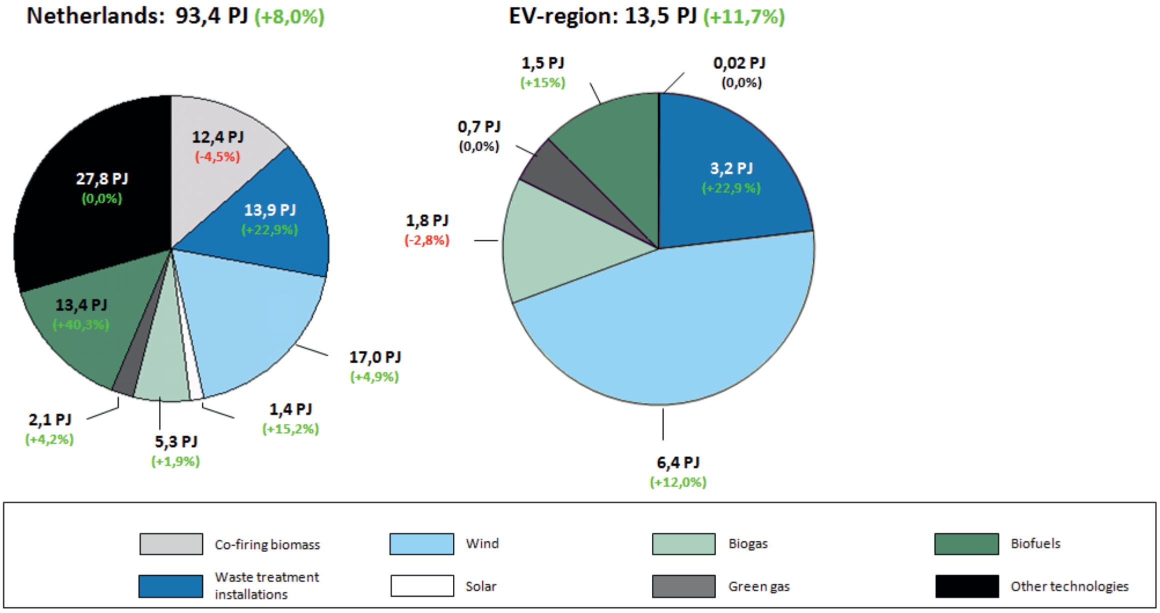


Figure 8 Composition renewable energy production (2011)

Source: Energiemonitor Noord-Nederland 2013.

In the following somewhat more detail will be provided on the two far dominant renewable energy sources in the region, wind and biomass.

In general scenarios for wind capacity in the North Sea area for 2030 still show a wide variety in terms of scale and location. The explanation why is that much of the offshore wind energy capacity is subsidy dependent and therefore sensitive for policy decision making, which is inherently liable to changes. The figure below shows how installed wind capacity could look like by 2030, and suggests a heavy concentration of wind farms at a number of North Sea locations, notably in the southern North Sea area where the sea soil is relatively stable and the sea on average only some 30 meters deep. One of the projected wind capacity hot spots is located some 60 km north of the Energy Valley North Sea coast (although most of the power produced is in the German section and therefore likely to be transported to the German shore). Given the location of Eemshaven, it seems likely that a serious part of assembly and servicing activities related to wind farm construction will take place from that spot and in fact already does.

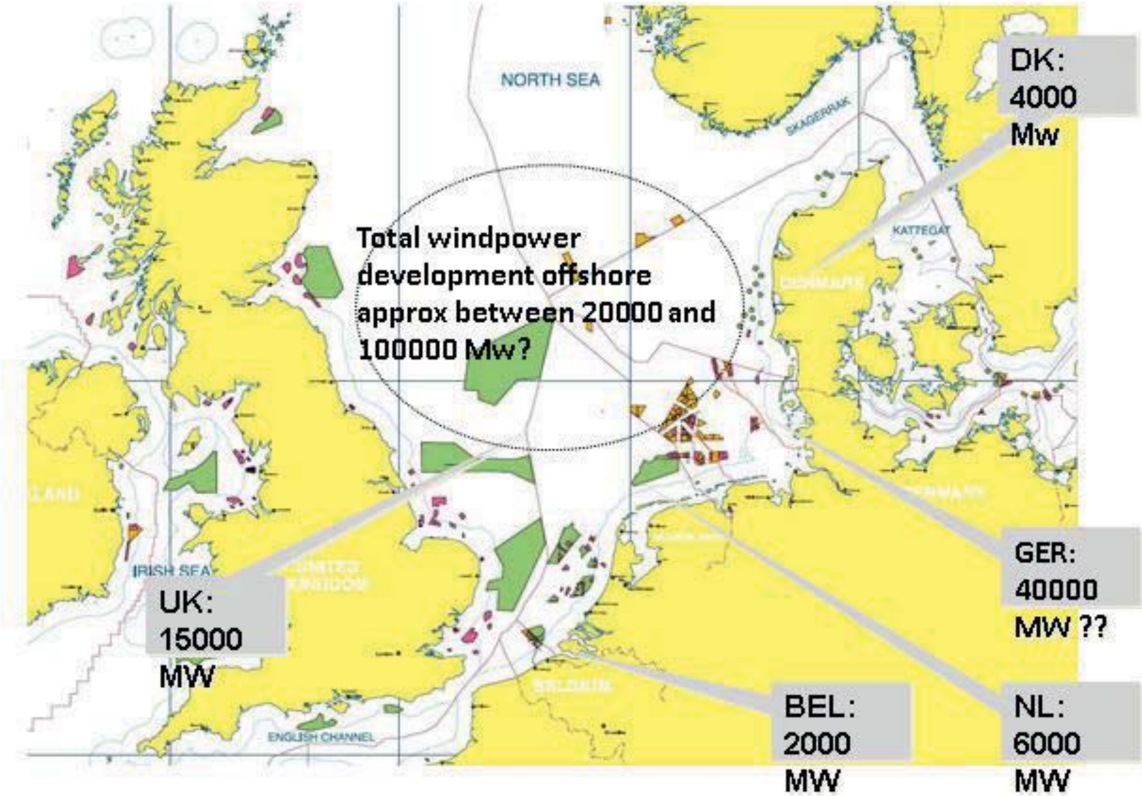


Figure 9 Projected wind capacity by 2030

Source: Energy Valley publication (2011).

As far as wind capacity in the Netherlands is concerned, most (about 87%) of the capacity is still onshore (some 2,000 MW of the total of some 2,300 MW). Of this capacity some 40% is located in the Energy Valley region (see fig.10).

The current long-term plans of the government are to extend onshore wind capacity to some 6,000 MW and offshore capacity to some 4,500 MW. The most recent project in this regard is the recently decided so called ‘Gemini Windpark’, an offshore wind farm of 600 MW capacity, located some 85 km from the Energy Valley coast (North of the island of Schiermonnikoog). This park is expected to generate some 2.6 TWh power per annum. Also considerable onshore wind capacity is currently planned in the Energy valley region, which on average has the best onshore wind profiles of the country. Because the current onshore plans are meeting some public resistance, it is still unclear how much and how fast onshore wind capacity will expand in the Energy Valley region. Also the location of future offshore wind capacity is not yet fully decided.

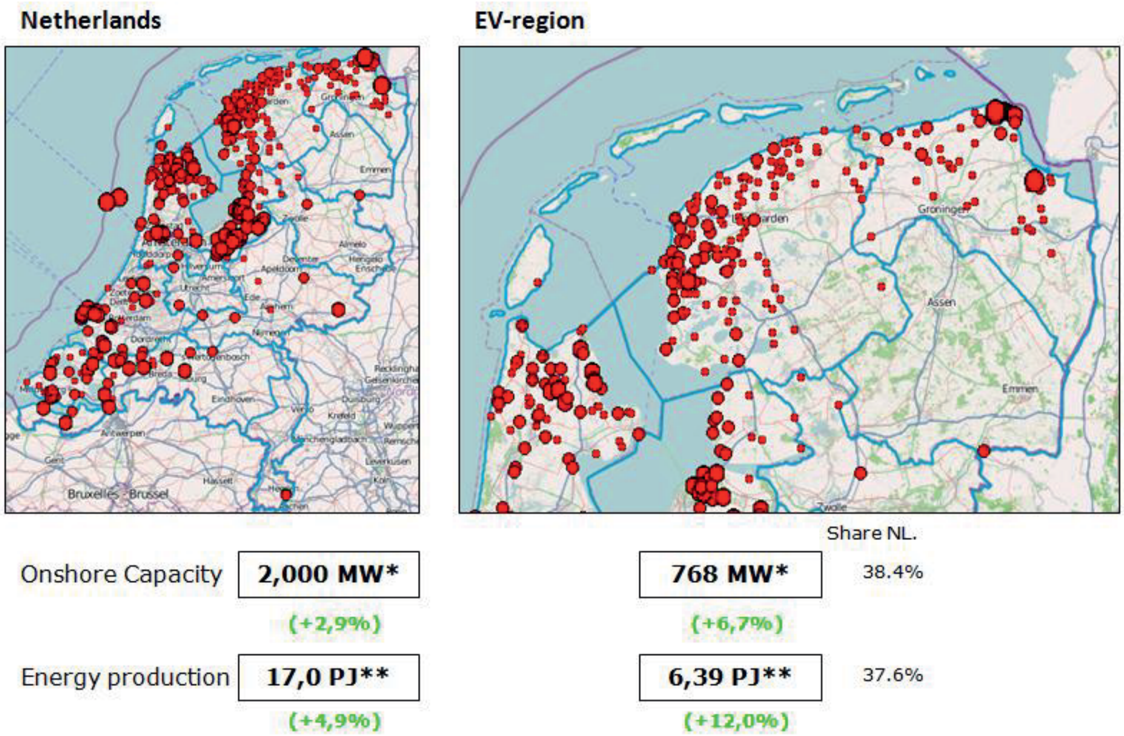
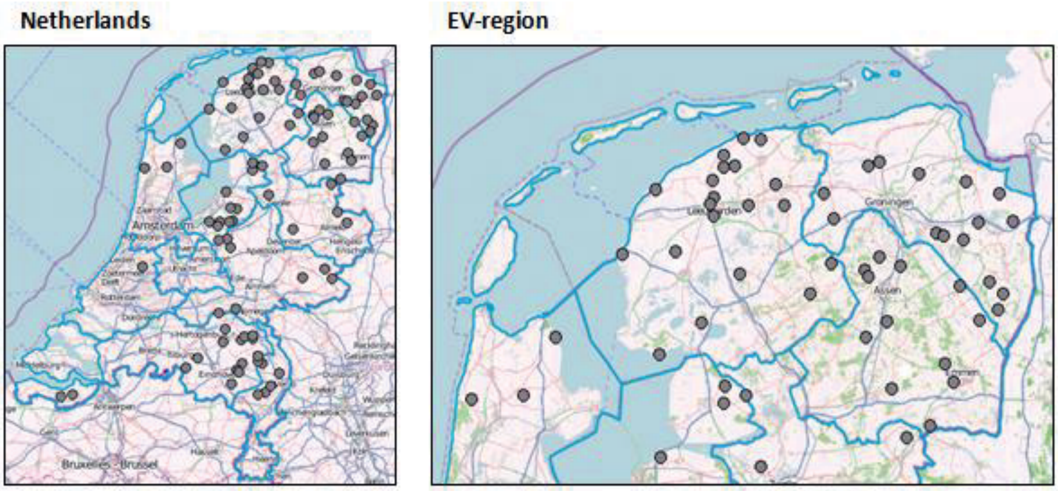


Figure 10 Wind Energy

Source: Agentschap NL / CBS.
***= Size of the red circles corresponds with installed capacity**
****= Between the geographical scales there is a difference in full load hours per production location**

As far as the production of biogas and green gas is concerned, most of this (some 60%) is based on co-digestion of agricultural waste. Some 100 co-digesters are operational in the country (2012), about half of which in the Energy Valley region (see fig. 11) producing well over 3 PJ of energy (again about half of which production is in the Energy Valley region).



	Netherlands	EV-region	Share NL.
Nr. of installations	98 (+5)	52 (+4)	53,0%
Capacity	111,5 MW (+4,3%)	52,9 MW (+5,2%)	47,4%
Energy production	3,21 PJ (+4,3%)	1,52 PJ (+5,2%)	47,4%

Figure 11 Bio-energy: biogas from co-digesters

Source: Agentschap NL.

Although most of the biogas production used to be transformed into power, currently turning the biogas into green gas is increasingly economically interesting given the various subsidy support schemes introduced recently. This explains why, especially in case of serious industrial biogas production capacities, biogas is upgraded and compressed such that it can enter the distribution network (labelled green gas). The number of installations generating green gas is now (2013) some 20, generating some 70 mln cm green gas per annum (2012), about half of which is generated in the Energy valley region (see fig. 12). According to government policy green gas production volumes are scheduled to further increase towards some 1 bcm by 2020.

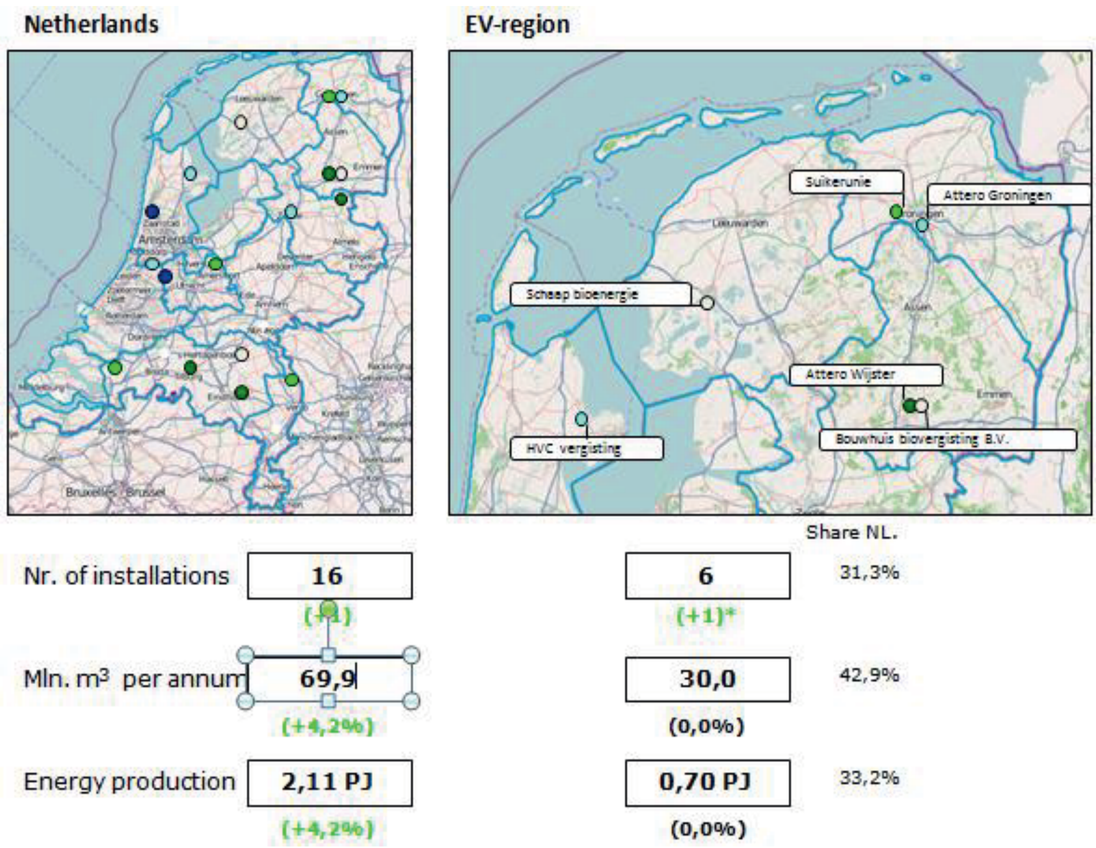


Figure 12 Bio-energy: green gas

Source: Agentschap NL.

Green gas can be used for various purposes, either provided physically or through certificates. Currently there is a strong tendency to introduce green gas into mobility, especially personal cars, busses, etc. In actual practice it is quite complex to rapidly expand such green mobility because of the ‘chicken-egg’ problem: without green gas vehicles little investment in green gas infrastructure, and without green gas infrastructure little investment in green gas vehicles. Still meanwhile over 100 (green) gas (CNG) fuel stations are now operational in the country, some quarter of which in the Energy Valley region (see fig. 13).

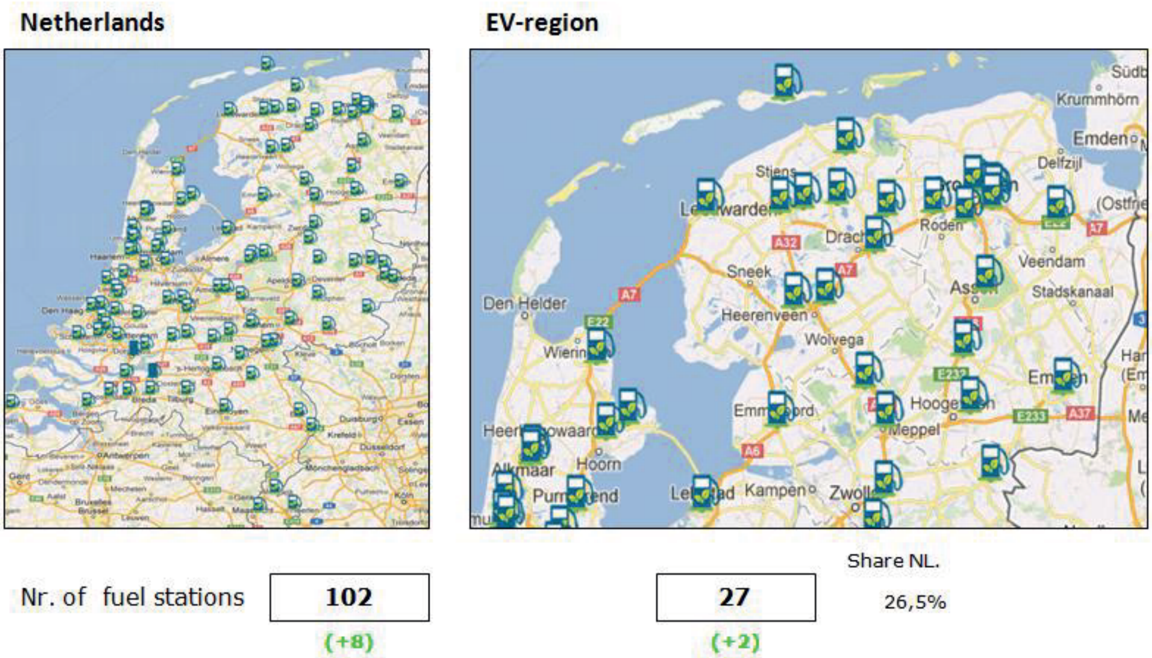


Figure 13 Fuel stations green-gas (2012)

Source: Groengasmobiel.

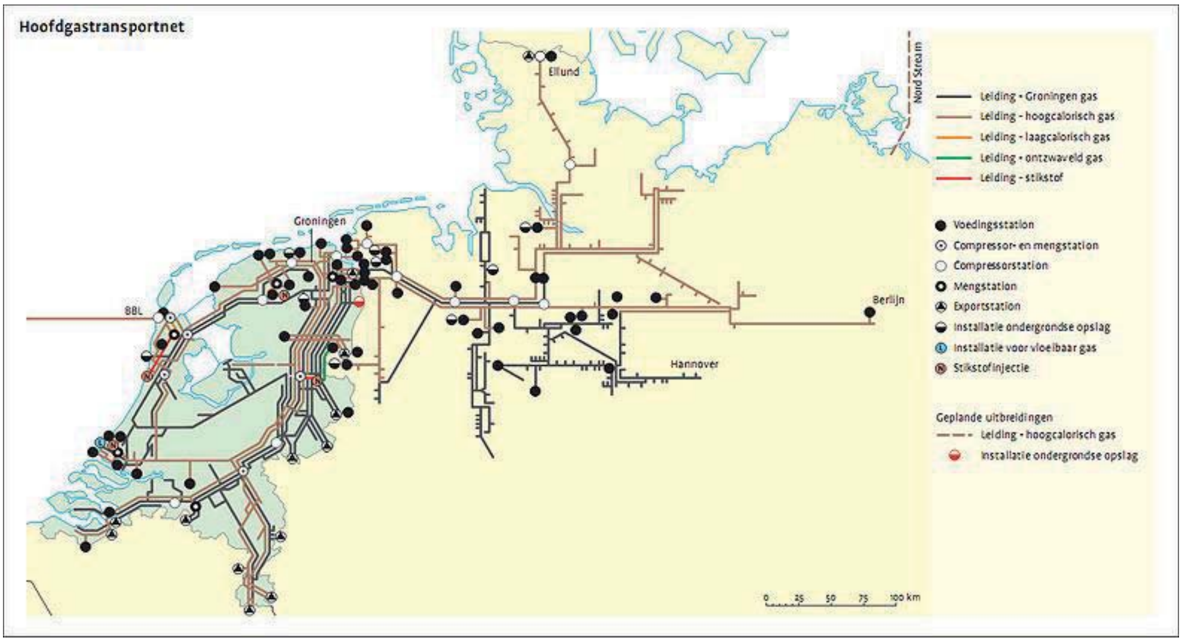


Figure 14 Transmission infrastructure gas grid

Source: kennislink, http://www.kennislink.nl/publicaties/bosatlas-over-nederlandse-ondergrond-uit

As far as the gas infrastructure is concerned, it stands to reason that Groningen and the Groningen field area are the heart of a considerable North-West European pipeline system that allows the natural gas to be transported to various destinations within the country, but also towards destinations elsewhere, notably Germany, Belgium, France and Italy. About half of the

Netherlands' gas production is traditionally exported to the countries mentioned. In 2007 the national TSO, Gasunie GTS, acquired for some €2.2 bn a part of the German gas grid, which made Gasunie GTS one of the first European TSO's with an international network (see fig. 14). Obviously the Gasunie grid (completely state-owned) is linked to the European wider gas infrastructure system, which also explains why the Netherlands gas grid operates as a gas roundabout for the surrounding region, transporting and storing gas from Norway, Russia, own production and based on LNG to various destinations. As was mentioned already the headquarters of Gasunie GTS is located in Groningen, which explains why also much of the knowledge base and surrounding services activities are also concentrated in the Energy Valley region.

Although most of the Netherlands gas production is still from the Groningen field, for some decades now the government policy has been to give priority to exploration from the so-called small fields, both onshore but mainly offshore, in order to leave the unique Groningen source (a.o. in terms of flexibility and balancing capacity) intact as long as possible. This coincided with considerable offshore gas production activity, not only on the Netherlands' territory of the North Sea area, but also on that of the various other North Sea countries. Quite often gas and oil production go hand in hand. Meanwhile some 500 to 600 platforms for oil and gas production have been set up in the North Sea region. Because many of the North Sea oil and gas fields enter the end of their exploration life times during the next few decades, most of those installations are scheduled to be decommissioned accordingly (see also fig. 15).

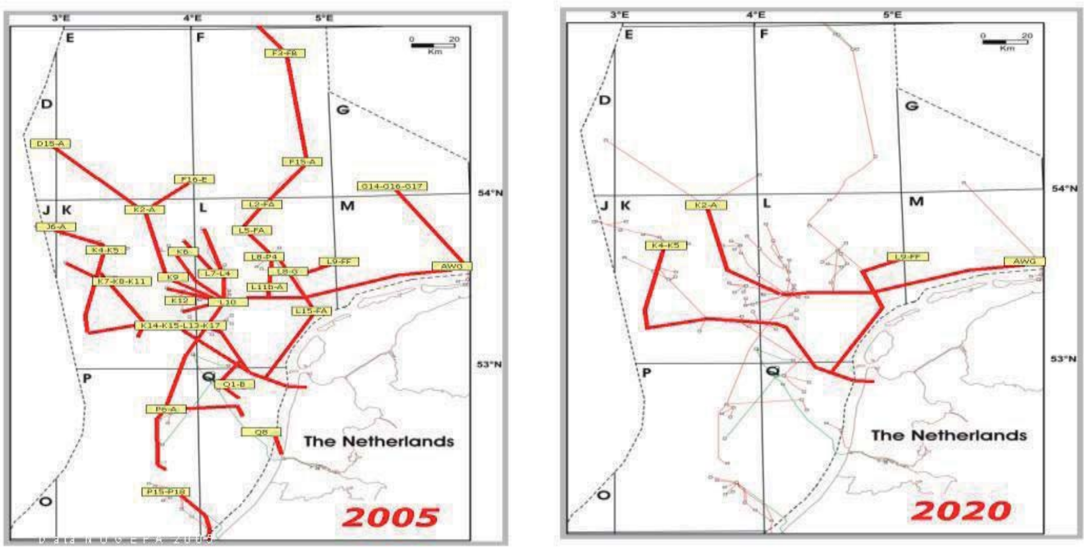


Figure 15 Grid for offshore installations and decommissioning

Source: EBN (2010).

One of the main challenges of the rapidly growing renewable capacity is due to its intermittency: not only is usually some 60-80% non-intermittent back-up capacity required to enable reliable power supply patterns able to satisfy demand, but also network capacity must be sufficient to transport the power towards its destinations. Moreover network balancing can be a major challenge, obviously depending on the different time profiles of power supply and demand, and on transport capacity. Currently much of the challenges related to power transport capacity, especially high voltage, are related to the rapid extension of wind capacity. Although projections for the North Sea area vary widely depending on the underlying scenario and assumptions, under all scenarios the expansion of North Sea region wind capacity for the next few decades will be considerable. This poses a new and formidable challenges for infrastructure investment, as is, for instance, illustrated in fig. 16 where not only current but also possible future offshore grid connections are projected.

One striking fact emerging from the same figure is that the Energy Valley region is likely to play a central role in the North Sea power infrastructure system. One reason is that considerable power supply is scheduled to come onshore from the North Sea into the region. Another reason is that the Energy Valley region is and will increasingly be connected with the power production from Norway (mainly hydro-based) through the 700 MW transport capacity NorNed cable (entering Eemshaven since 2008; the extension to another high-voltage cable connection with Norway is currently considered), and from Denmark via the so-called COBRAcable of some 700-1,000 MW transport capacity (final investment decision expected by 2014). It looks like in the foreseeable future the Energy Valley region, next to acting as a gas roundabout, may play a similar role as 'power roundabout'. Obviously other areas around the North Sea may develop a similar role. The figure also illustrates that offshore interconnecting power transport capacity of some 7,300 MW, capacity will have to be expanded considerably during the next 20 years or so to at least twice the current figure, and probably even more than that. This will require considerable additional investment, not only to transport wind power, but also to collect it from the various individual wind turbines.

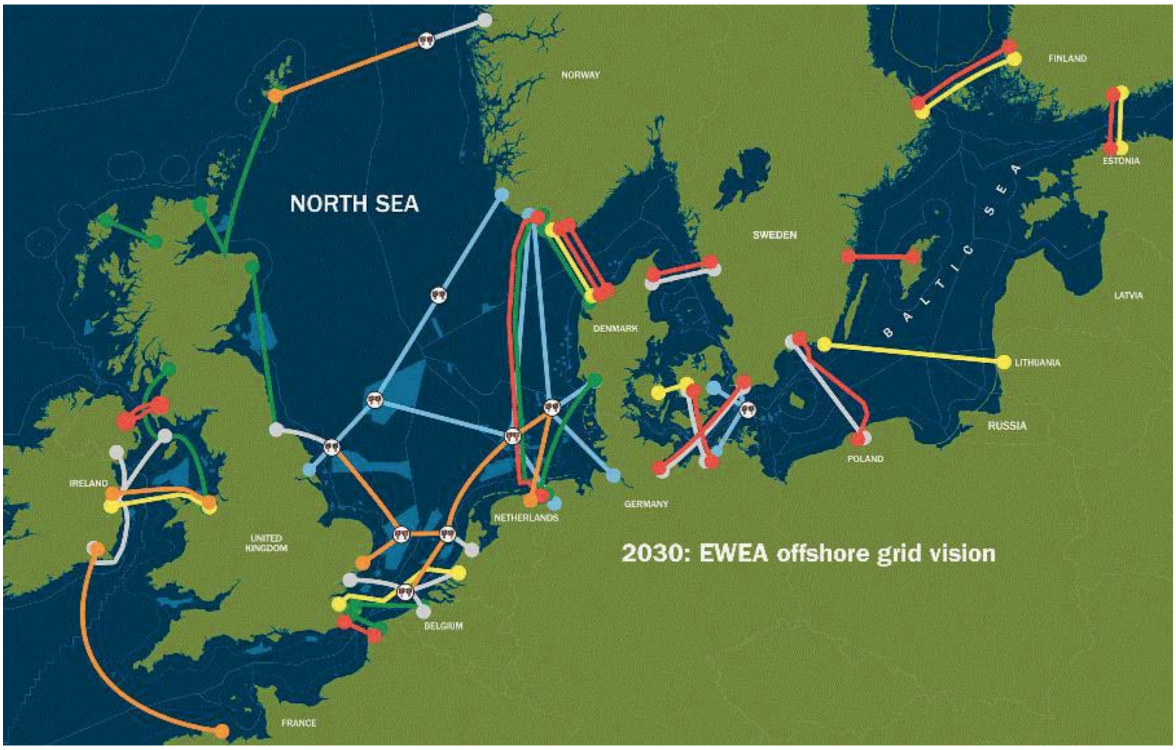


Figure 16 Current and possible future grid connections

Source: EWEA.

3 Description of Innovation and Collaboration

3.1 Smart Specialisation and Cluster Strategies

As outlined in section 5, the Energy Valley region plays a key role in the Netherlands' energy system. Obviously it therefore also plays a serious initiating, coordinating and stimulating role towards not only energy production but also and particularly the introduction of renewable energy and the enhancement of energy efficiency.With regard to the national energy policy and strategies, it is, however, obviously the national government that is playing the leading role, often backed-up by EU energy policy initiatives , rules and regulations.

The current Netherlands' cabinet recently decided to invite the main national stakeholders – the employers' and employees' organisations, the energy sector organisations and the main environmental groups – to reach a national energy accord, which initiative turned out to be successful. The basic elements of the agreement that followed (6 September 2013) at the national level were: to close down five coal-fired power plants by 2016-17; to restrict co-firing of biomass in conventional power plants to 25 PJ; to extend offshore wind capacity by some additional 700 MW capacity planned for 2015-16; and to set up, among others, a revolving fund of about €600 mln for supporting energy efficiency measures in the built environment.

Still a considerable part of the coordination and support activity for new energy initiatives within the Energy Valley region is taken up by a number of regional and local stakeholders and stakeholder organisations, the most important of which are the provincial and municipal bodies, employers' organisations, research groups, and first and foremost the triple-helix organisation Energy Valley. Obviously one of the challenges is to further coordinate all the energy transition initiatives taken by the various individuals, groups, stakeholder organisations and authorities.

The Energy Valley organisation has been set up in 2003 by the Northern provinces together with the principal private, public and research/educational energy players in the region, and has grown since then to become the leading player in pushing for sustainable energy activity in the region and branding the region as thé Energy Valley. The Energy Valley organisation has about 200 contributing members who meet each other regularly through numerous workshops, seminars, events etc. organized by Energy Valley and others, and has an annual budget of somewhat less than €2 mln.

The prime goal of the Energy Valley organisation is to enhance the transition of the region towards a leading sustainable energy economy through a strong interaction between traditional and new energy options. By doing so it hopes to combine energy and climate aims with regional economic progress. Obviously Energy Valley tries to build on the emerging comparative energy strengths, which explains why currently its prime focus is on the:

- (green) gas roundabout
- power production and balancing
- bio-based energy
- decentralised energy systems
- knowledge, research and internationalization.

Some of the main targets of Energy Valley are helping:

- to create more than 9,000 'new energy' jobs;
- to settle 25 start-ups and a similar number of new companies;
- to extend electricity generation capacity by 3,500 MW;
- to increase green gas production to annual production volumes of some 0.5 bcm;

- to strengthen the offshore wind activity position of the region; and
- to support the development of the Energy Academy Europe, and to strengthen transnational cooperation with the neighbouring regions and the North Sea regions in particular.

  To that end concrete actions are concentrated around: the development of new on- and offshore wind parks, green gas hubs, second generation bio-fuel production, smart energy districts, innovative decentralized power generation, re-use of waste heat in the newly built environment, co-siting activity in energy transition parks, etcetera.

3.2 Some detailed data on energy companies

The economic activity on energy in the Energy Valley region can be derived from the orbis[1] databases describing which companies are active in the field of energy in a particular region. The same data source also provides information about the companies' turnover and employment in the region considered. Analysis of this data revealed for the last available year (mostly 2012) that in the Energy Valley region altogether some 4,000 private companies and organisations carry out most of the energy related work. [Note that through its application method our database derived from orbis does not include public authorities, research and educational organisations in the public domain (e.g. universities and schools) or parastatals (e.g. Energy Valley foundation itself, organisations of employers, chambers of commerce, etc.). Actual employment or economic activity in the energy area therefore will be larger than projected below (for some estimates of additional employment see also next under the heading 'knowledge generation').]

The orbis database first of all revealed that the current overall employment in the Energy Valley region of the 4,000 energy and energy-related companies amounts to 29,160 jobs. This compares well with the 32,500 jobs mentioned earlier, based on the 'Energy Valley Monitor', although some superficial estimates of the number of non-private jobs in the energy sector would suggest that the 'Monitor' 32,500 overall (= private + public) number probably is at the low side of the spectrum. Again it should be emphasized also with regard to the orbis numbers that the usual labour market multiplier of anywhere between 2 and 4 is not implemented here. If that would be taken into account overall energy related employment obviously would be much higher (ranging anywhere between 65,000 and 120,000).

A second observation that can be derived from the orbis database is that very large companies in the Energy Valley region only play a relatively limited role in the employment figure: overall only some 6,000 jobs in just 10 very large companies (see also table 1). The remaining about 23,000 jobs in the Energy Valley region energy sector are generated in about 33 large companies (some 6,000 jobs); some 290 medium-sized companies (some 9,200 jobs), or the considerable number of some 3,670 small enterprises (some 7,800 jobs). In other words, some 40% of the energy employment is generated by very large or large energy companies against the remaining 60% in small and medium sized enterprises, that is enterprises with on average 2 and 30 employees, respectively.

[1] https://orbis.bvdinfo.com/version-2013108/home.serv?product=orbisneo

	Company name	Operating revenue (Turnover) th EUR Last avail. yr	Number of employees Last avail. yr	Category of the company
1.	**GASTERRA B.V.**	23.381.400	189	Very large company
2.	**NEDERLANDSE GASUNIE NV**	1.725.800	1.683	Very large company
3.	**GULF OIL NEDERLAND B.V.**	828.126	163	Very large company
4.	**SBI (SEA BUNKERING INTERNATIONAL) B.V.**	383.043	12	Very large company
5.	**DELESTO B.V.**	264.071	83	Very large company
6.	**EXPRO NORTH SEA LIMITED**	206.375	1.129	Very large company
8.	**BOHA OLIEMAATSCHAPPIJ B.V.**	101.867	44	Very large company
11.	**STICHTING DE HUISMEESTERS**	49.481	115	Very large company
1382.	**ESSENT NETWERK NOORD BV**	n.a.	1.370	Very large company
1755.	**NEDERLANDSE AARDOLIE MAATSCHAPPIJ B.V.**	n.a.	1.200	Very large company
			5988	

Table 1 Overview of the very large companies' energy economic activities in the EV-region

Source: Orbis.

A third observation from the database is that the headquarters of almost all small and medium sized energy companies from the sample are located in the Energy Valley region itself. Of the very large and large companies this share is about half.

Finally in analyzing the specializations of the 43 very large and large companies from the sample it became clear that virtually all of those companies have their prime activity in traditional gas and power production, and related infrastructure and installation/maintenance services including trading and sales, and very little in renewable energy. Apparently such activity is concentrated in the smaller companies. The overall picture emerging from the larger private industry specialization therefore is a relatively strong focus on gas and oil.

3.3 Knowledge generation

Knowledge generation regarding the energy sector is developing rapidly in the Energy Valley. This is an important driver for the profile of the region as thé Energy Valley. A recent initiative to enhance synergies is to try to integrate energy innovation, R&D and training into the Energy Academy Europe and the Energy College as much as possible. Relevant companies are closely involved in this initiative. The region has a large number of testing facilities and energy research institutes. Besides this, several large national and international research programmes have been initiated relating to different energy themes.

Also in the area of education and training activity is growing, especially by the University of Groningen and the various universities of applied sciences and colleges in the region, all offering an increasing number of energy courses at various levels. The estimated number of applied universities' students in energy in the region is about 650 (see fig. 17), and in the various colleges another about 4,000 (the number of university students in energy is hard to determine, because the University of Groningen does not provide energy related curricula, only courses). During 2007-11 the energy student numbers in the region increased by some 11% against a nationwide 3% decrease.

	Locations	Number of students in energy related education	Total number of students	Percentage of total number of students
Hanzehogeschool Groningen	Groningen	322	25.306	1,3%
Noordelijke Hogeschool	Leeuwarden	99	10.562	0,9%
Hogeschool Van Hall Larenstein	Leeuwarden	113	2.106	5,4%
Stenden hogeschool	Emmen	0	10.019	0,0%
inholland hogeschool	Alkmaar	111	3.629	3,4%
	Total EV region:	**645**	**51.262**	**1,3%**
	Total Netherlands:	**5.589**	**423.126**	**1,3%**

Figure 17 Energy related education in universities of applied sciences (2011)

Source: Dienst Uitvoering Onderwijs (DUO).

As far as energy research is concerned, such activity is mainly concentrated in the various universities, the industry, and in a number of specialized research institutes. At the University of Groningen for instance, some 30 professors focus on various aspects of energy. Although a precise estimate of the related staff (including PhD's and postdocs) is not available, a reasonable guestimate would be in the order of 350. The number of energy related professors at the universities of applied sciences is estimated about 15, and related staff about 150. Overall the research has a strong focus on gas and smart systems, as well as on the economic, business, legal and societal aspects of energy activity.

Little is known about the overall size of R&D activity within the energy related industry located in the Energy Valley region. The same applies to the various consultancy and advisory bureaus centred around the energy activity in the region. Based on scattered information from interviews and various other sources, it is, however, fair to assume that the number of public and private consultants, advisors and analysts active in the area of energy and sustainability will be at least in the order of 1,500 - 2,000.

A number of specialized energy research institutes are located, or have a subsidiary in the Energy Valley region, the most well-known of which are: Energy Research Center Netherlands (ECN) with some 500 researchers; a subsidiary of DNV KEMA partly covering since 2008 the former research laboratory of the Gasunie Engineering and Technology; the Energy Delta Institute (EDI) withsome 35 employees, the Royal Netherlands Institute of Sea Research with some 370 employees. In addition the Energy Valley region hosts a number of testing facilities and living labs such as RenQi, ECN Windturbine Testpark at Wieringermeer, EnTranCe, Knowledge Centre WMC, Wetsalt, Tidal Testing Centre Den Oever, Dairy Campus, PowerMatching City, Milena Gasifier, Repower Windfarm, Biogas line North East Fryslân. Together these testing facilities are guestimated to provide a few hundred research jobs. Finally a number of research projects is carried out in and/or coordinated from the Energy Valley region such as: EDGaR, Flexigas, Flexiheat, Flexines, Flexinet, I-Balance, INTERREG Green gas, NEN-D, ENSEA, North Sea Sustainable Energy Planning, Energy Vision North Sea Region (EVNSR), MariTIM, Hans Energy Corridor (HEC), etc., covering an overall research budget of nearly €100 mln or some 1,000 man years of research work.Overall the energy research capacity can be guestimated in the order of 4,000 – 5,000 jobs.

It is impossible to provide an exhaustive list of all players in the region in the area of research and innovation. In the tables below therefore only the key players have been listed, i.e. all universities in the region, that is to say next to the university of Groningen the various universities of applied sciences in the region as well as the main energy research centres (table 2); all major research projects and programs with a prime focus in the region (table 3); and the main testing facilities and living labs located in the region (table 4).

University/Research Institute	**Description and main activities**
University of Groningen	Next to healthy ageing and sustainable society, energy is one of the three research priorities of the University of Groningen. It is centred within the Groningen Sustainability Program (GESP) which is an interface between researchers and partners from industry, government and community organisations. It is consolidated through three research centres: Energy and Sustainability Research Institute Groningen (ESRIG), Groningen Centre of Energy Law (GCEL) and Energy and Sustainability Centre (ESC). Different research groups concentrate on certain aspects of the energy system: energy markets and regulation; energy transition; gas, innovation and smart systems; renewable energy; and social dynamics of sustainability.
Hanze University of Applied Sciences	All research relating to energy within the Hanze University is concentrated within the 'Energie Kennis Centrum' (EKC). There are five lectureships directly concerned with energy: sustainable energy; energy applications; life sciences; net integration; and energy transition. Three other lectureships are indirectly related to the EKC: new business development in energy and healthy ageing; smart mobility; and new business and ICT.
Noordelijk Hogeschool Leeuwarden	At the Noordelijk Hogeschool Leeuwarden two lectureships are concerned with energy related research: wind energy; and solar power and transport.
Van Hall Larenstein	At Van Hall Larenstein one lectureship is concerned with energy related research: bio based economy. The university takes on the roll of a Centre for Bio based Economy (CEBE). In collaboration with the Wageningen University (as a centre of excellence), HAS Den Bosch, CAH Dronten and InHolland Delft.
InHolland Hogeschool	InHolland Hogeschool in Alkmaar has one lectureship concerned with energy related research: sustainable design of the built environment.
Stenden University of Applied Sciences	At the Stenden University of Applied Sciences there is one lectureship indirectly concerned with energy related research: sustainable plastics and synthetic materials. One of the current research projects is a study regarding the reduction of energy in plastics production processes.
Energieonderzoek Centrum Nederland	Research activities at ECN are directed towards efficient use of energy and infrastructure, deployment of renewable energy sources, clean conversion of fossil

(ECN)	fuels and development of energy analyses and policies. ECN concentrates its activities at six different themes: solar energy; wind energy; biomass; energy efficiency; policy studies; and environmental and energy engineering.
DNV KEMA	A subsidiary of DNV KEMA is located in the Energy Valley region in Groningen. Since 2008 it covers in part the former research laboratory of the Gasunie Engineering and Technology department. The laboratory in Groningen has state-of-the-art facilities for performing combustion research, flow research and calibrations at medium/high pressures, gas analysis, for investigating, developing and improving industrial processes and innovative energy utilization systems.
Energy Delta Institute (EDI)	The Energy Delta Institute (EDI) is an international business school with a primary focus on natural gas and the role of gas in the energy transition. The institute was founded in 2002 by Gasunie N.V., Gasterra B.V., OAO Gazprom, and the University of Groningen. It was later joined by Shell, Dong, Eneco, EBN, Taqa, Tebodin, A. Hak and Denys. The main objective of the Energy Delta Institute is to contribute to the professional development of current and future energy managers. EDI develops and organizes training programmes and network events with a focus on the economic, management, legal and geopolitical aspects of the Energy business.
Royal Netherlands Institute for Sea Research (NIOZ)	NIOZ is the national oceanographic institution for the Netherlands. Their mission is to gain and communicate scientific knowledge on seas and oceans for the understanding and sustainability of our planet. It facilitates and supports fundamental as well as applied marine research and education in the Netherlands and Europe. The emphasis is on innovative, multidisciplinary, and independent fundamental research in shallow coastal seas and in open oceans. The institute also carries out frontier applied research based on societal questions when this merges well with its fundamental work.

Table 2 Overview of universities and research institutes in the EV-region

Project	Budget	Period	Description
EDGaR	€44 mln	2010 - 2015	Dutch research consortium of ten enterprises and research institutes, coordinates the realization of scientific, applied and technological researches on gas and sustainability. Three themes: from mono to multi gas; the future of energy systems; and changing gas markets. Within all three themes there are multiple projects concerning different aspects of the energy system. The main focus is on research relating to the gas grid and gas conversion.
Flexigas	€6.3 mln	2010 -2014	Collaborative project in which knowledge and the market about the entire biogas chain is involved: biomass-biogas production-conversion-logistics-end users.
Flexines	€3.6 mln	2008 -2012	Development of intelligent energy-infrastructure for the commercial market.
Flexiheat	€2.3 mln	2012 - 2016	Project is concerned with the control, metering and pricing of thermal networks.
I-Balance	€1.2 mln	2012 - 2015	Research in the way supply and demand of electricity or natural gas can be balanced when decentralized renewables are integrated.

1000 Smart households	€ -	2011 - 2014	Deployment of smart meters within 1000 households to save energy.
INTERREG Green Gas	€9.9 mln	2011 - 2014	INTERREG IV A project. In the coming years 63 partners from business (SMEs), research institutes and governments will work together in 18 subprojects to solve the bottlenecks in the value chain of green gas. (e.g. upgrading biogas to green gas, legal aspects, infrastructural chances and bottlenecks, innovation regarding application possibilities of green gas as fuel for transportation)
NEN-D	€7.5 mln	2010 - 2014	Initiative of collaborating German and Dutch governments. Strengthen the position of the regions regarding sustainable energy.
North Sea Sustainable Energy Planning	€5.2 mln	2009 - 2012	Stimulating application of sustainable energy and energy savings in several European countries through public-private collaboration. The idea of the projects is to focus on the specific problems municipalities and countries faced in the field of renewable energy and energy efficiency.
ENSEA	€3.1 mln	2012 -2015	The European North Sea Energy Alliance (ENSEA) aims to increase the competitiveness of EU regional energy clusters through better coordination and exploitation of energy research.
Energy Vision North Sea Region (EVNSR)	€0.5 mln	2012 - 2013	Drawing on strengths and results of existing and completed INTERREG IVB NSR energy projects, EVNSR is formulating and projecting a vision for the accelerated transition to renewable energy within the North Sea region, beyond EU 20-20-20 targets.
MariTIM	€8.8 mln	2011 - 2015	Focus on innovative ship propulsion systems. Three types of projects: LNG passenger vessel, ECO2 Inland vessel, Wind Hybrid Coaster.
Hansa Energy Corridor (HEC)	€1.2 mln	2010 - 2013	Setup of a transnational region of excellence in the energy field in collaboration with German and Dutch actors from science, industry and politics regarding various energy-related topics.

Table 3 Overview of energy related projects in the EV-region

Testing facility / Living lab	Description
RenQi	Innovation centre for sustainable energy infrastructures. RenQi consists of teams of professionals and student working together in applied research projects. At the test lab facility circuits are available for natural gas and electricity. Produced heat is dissipated by a water cooling system. The circuits are connected to the grids and can be disconnected if necessary. Multiple connections are possible. The lab contains a gas mixing street to enable the production, for experimental purposes, of any conceivable gas quality. New energy conversion technologies can be tested individually or in larger series (approx. 50 max.).
ECN Windturbine Testpark Wieringermeer	The test site at Wieringermeer is a combination of a wind farm and prototype test locations. The wind farm consists of five Nordex N80 wind turbines and enables ECN to perform wind farm specific research and development programs. There are also four prototype locations for manufacturers to test, optimize, and certify prototypes together with ECN. Supporting facilities are three meteo towers, a 36 MVA grid connection, data collection equipment and a test site control centre. The site has a favourable wind climate: the average wind speed at 100 m height is 8,3 m/s.
Power Matching City	A living lab demonstration of the future energy system, located in Hoogkerk near Groningen in the Netherlands. In Power Matching City the connected households have smart appliances that match their energy use in real time, depending on the available (renewable) generation. Purpose is to demonstrate the energy system of the future.
EnTranCe	An important part of the Energy Academy Europe will be the testing facility for applied research: the Energy Transition Centre (EnTranCe). Business, entrepreneurs and knowledge institutions work together to accommodate the energy supply of the future. Innovation, product development, training, and entrepreneurship in the area of energy are combined. EnTranCe is building on the research conducted within RenQi.
Knowledge Centre WMC	WMC is a research institute for materials and structures. One of the main activities are fundamental and applied research on Fibre Reinforced Plastics (FRP) and wind turbine structures.
Wetsalt	A demonstration site that can be used for testing and scaling up of innovative technologies for desalination and Blue Energy. The site has civilly been prepared to enable containerised pilot plant testing. Companies can literally plug and play at Wetsalt.
Tidal Testing Center Den Oever	The Dutch Tidal Testing Centre (TTC) located in the North of Holland at Den Oever provides opportunities for tidal stream testing at intermediate scale. It offers testing in a ducted channel, open water tow tests with a barge and in the near future testing will also be possible at a dedicated offshore floating site.
Milena Gasifier	The MILENA gasifier is developed by ECN and is a patented gasification technology that produces good quality gas that can be used to generate power, heat, Substitute Natural Gas (SNG), or chemicals. The MILENA-gasifier consists of two integrated reactors, producing an essentially N2-free producer gas. The MILENA gasification process converts biomass into a combustible product gas with high efficiency. After cleaning, this gas can be used to generate power with gas engines, gas turbines or fuel cells.
Repower Windmills	At the Eemshaven in Groningen two Repower 6M wind turbines are installed onshore. The two wind turbines each have a rated power of 6.15 MW and a

	hub height of 114 meters. The turbines are installed onshore as a testing case and operated by RWE innogy. The Repower 6M turbines installed onshore are meant for gaining insight for employment on the high seas in the project Nordsee Ost.
Biogas Line North East Fryslân	The project Biogas line east Friesland (BioNoF) concerns a pipeline between Dokkum and Leeuwarden. It can be connected to agricultural production plants from their (co)-manure installations which provide crude biogas. The crude biogas is then transported to a collection point over this pipeline. The gathering point is called a Green Gas Hub where the biogas is upgraded to natural gas quality and through the network the green gas is passed to the user.

Table 4 Overview of testing facilities and living labs

4 SWOT analysis

Based on the data outlined above a SWOT-analysis has been carried out, mainly with the national situation as a benchmark. The intention is to bring the SWOT-analysis somewhat further in a next stage by introducing the situation in the surrounding North Sea regions as a benchmark.

Strengths

- An overall strength of the Energy Valley region is the Groningen gas field and all economic and research activity based on that in the areas of exploration, transport/storage, trading and application, together forming the so called North West European gas roundabout. In all parts of the gas value chain innovative activity is taking place, such as new exploration technology, transport of gases of different compositions, storage technology, organising and modelling trading hubs and gas market behaviour, introduction of (green) CNG and LNG e.g. into mobility, establishing green gas hubs, (reversible) fuel cell development, etc. A serious number of research clusters/programs and projects related to gas are established in the Energy Valley region.
- A related strength is that the key players in the gas industry, NAM, Gasunie GTS, and Gasterra, all have their headquarters in the Energy Valley region, as well as a serious number of related servicing and consultancy units. Together with the public research and training activities on gas this forms a strong cluster.
- Another strength is the heavy concentration of power production capacity in the region, which will most likely rise between now and 2020 from currently some 20% of the national capacity, towards some 40% or even more. Related innovation activity mainly deals with flexible power production and co-firing (e.g. torrefaction).
- Another factor is the position of the Energy Valley region in the interconnecting power grid, notably the connection with the cables from the North Sea and Norway to be further extended also to Denmark. Because much of that power is getting onshore at the deep sea harbour Eemshaven, serious data storing activity is emerging at that port area and innovative activity related to balancing and grid development.
- The main national energy research centre, ECN, is located in the region; moreover the University of Groningen and most of the universities of applied science in the region (total some 80,000 students) increasingly strengthen their focus in research and education on energy; a recent initiative is to try to bundle that (post-) academic and applied research and training activity into one organisation, the Energy Academy Europe (EAE).
- The region hosts the second chemical cluster of the country (some 25% of total), which – in part in collaboration with the strong agro- en food industry in the region - increasingly leads to innovative activity in the spirit of bio based economy and green chemical and food industry activity.
- A strong triple helix organisation set up by the provincial governments in collaboration with industry and research community, Energy Valley foundation, now exists for almost a decade supporting and branding overall energy and sustainability activity in the region, and increasingly stretching its activities abroad by collaborating with similar initiatives around the North Sea and with Lower Saxony in particular. The Energy Valley region was also the first to establish a national agreement with the government on energy and sustainability.

Weaknesses

- The Energy Valley region is located relatively far away from the central decision making centre and the population and industry centre of the Netherlands. As a result public attention for the region is relatively hard to organize. Also the area, covering some 30% of the national land area, only covers slightly more than about 10% of the overall economic activity and population. This also contributes to the same limited public attention.

- Given the above limitations lobbying and branding activity both in the Hague and Brussels on the regions' strong points is still relatively weak.
- The region has difficulty in agreeing about which strong focus points should be central in branding the region; collaboration between provinces is sometimes difficult to reach, which is partly due to the fact that much of the large-scale energy activity is concentrated in the areas of Groningen and North Holland.
- The region lacks a strong facility, supported by the universities and others, to set up new innovative starting companies emerging from research activity at the universities and industry, nor is there a strong entrepreneurial tradition to that end. Specialized curricula on energy/sustainability are slow to develop; collaboration between universities and industry is also developing but still weak.
- The region traditionally had a strong agricultural, training (universities) and servicing (hospitals, etc.) focus; medium-sized industry with a technical focus is therefore relatively less represented.
- The public at large increasingly organises resistance against new energy initiatives, such as the new coal-fired power plant, CCS, gas storage, new wind farms, biomass digesters, and even traditional (since the 1960s) gas exploration due to the increasing earthquake activity (both in terms of size and frequency) in the north of the province of Groningen. More generally an overall sense of pride on developing into a leading European energy region seems to be missing.
- Given the urgent need in the energy system for the gas sector to increasingly line up with the (renewable) energy sector, such collaboration has remained rather limited so far in actual practice.

Opportunities

- Given the strong gas sector representation in the Energy Valley region on the one hand, and the rapidly increasing power production and transport functions on the other hand, the region has an almost ideal position to become a frontrunner area for gas and power system integration.
- This potential is further reinforced by the location of the region at the shore of the North Sea and disposing of a number of well located harbours for servicing all kinds of offshore activity.
- Also supportive is the geographical situation of the underground offering a huge potential for further exploration and storage of gases.
- Much of the energy related research activity is already taking place in and/or initiated from the region; energy training is rapidly expanding, which creates a fruitful base for all kinds of innovative starters centred around the various energy activities.
- The region covers a broad base of all kinds of new energy activities, ranging from traditional gas and power to wind energy, biomass application, decentralized cogeneration, smart grids and smart metering, small scale (green) LNG, etc. This offers great opportunities for energy system optimization experiments and related research and training.
- Because the area is relatively sparsely populated and therefore offering services and spatial opportunities less available in other parts of the country, the region could grow into an area for all kinds of innovative energy experiments both in terms of technology and engineering, as well as of policy and social acceptance.
- The region is neighbouring Lower Saxony with similar strong and mainly complementary energy development, which offers a promising scope for collaboration on energy innovation, research and training. A number of projects to that end (HEC, various INTERREG programs, ENSEA) have recently been set up.

Threats

- Natural gas production is scheduled to decline the coming decades to significantly smaller volumes to come to a standstill in about forty years. This may reduce all gas activity as well as the scope and size of its main players. Gas innovation and research may also slow down in the slipstream of declining production.

- Public resistance may grow into an ever stronger issue such that much of the energy innovation, notably wind and biomass related, will be slowed down not only for reasons of NIMBY, but also because people object against the long lasting subsidy programs for renewables. The region may gradually turn against much of the renewables.
- Comparable public resistance, absent so far towards most of the gas- and oil-related activity in the region, may also turn against these traditional activities because they are increasingly seen as fossil and therefore polluting, risky, creating little employment for the local population, and dominated by big industry interests. Also major power production capacity may fall victim to similar sentiments, so that the concept of establishing a strong energy region is undermined.
- The projected increasing risks of serious earth quakes convincingly due to gas exploration may become such a threat for serious numbers of people in the area, that hostility against any further use of the underground may get even out of control. This risk may be reinforced to the extent that the national government and main production companies (notably Shell and Exxon) insufficiently respect those concerns and are prepared to take serious action on that.
- The energy research and innovative capacity in the region develops too slowly, and remains too fragmented and too national and local to generate the critical mass and quality in time, so that effectively the major energy research and training activity develops elsewhere. The current triple-helix concept on energy therefore would fail.
- International and national policies regarding climate issues, renewables, energy system integration, and efficiency develop slowly and in a stop-go fashion, such that incentives become unpredictable and not convincing. As a result the energy transition slows down and the overall region fails to innovate the energy system by turning it from a mainly fossil towards a mainly renewable driven system.
- The switch towards renewables develops much faster in the surrounding areas (Germany, Scandinavia, UK) than in the Energy Valley region. The traditionally strong fossil production base in the region therefore remains dominant, and in fact the region takes advantage from cheap renewable power from the neighbouring countries. Together this slows down the tendency to innovate towards renewable in the Energy Valley region, i.e. the initiative is largely left with the surrounding triple-helix organisations. Overall energy innovative activity in the region then slows down.

4.1 Triple-helix Matrix

Obviously innovation activity, as most would agree, has the best chances of developing successfully if developed in the framework of a triple-helix collaboration. That is: only if research in the public domain is well coordinated with the interests of private investors and supported to the extent necessary by public authorities does it have the potential to enhance economic success. Against that background the underlying matrix has been constructed to reflect for the various key research challenges in an integrating future energy system to what extent activities across the helix players converge (table 5).

Themes	Academic	Government	Company base	Alignment for region
Supply flexibility	15 +	Flexigas, Flexiheat, Flexines Edgar ++	Primarily large scale e-sector players +	No strong link between research and industry; growing +
Storage	6		A few very big players ++	Massive activity; little research +
Demand flexibility	4	Power Matching City, 1000 smart households +		Some experiments only
Grid / Infrastructure	4		Primarily large companies ++	Not much innovative research
Integration Methods	15 +	Edgar, I-balance, Entrance +	Mainly ICT +	Primarily research driven. Development promising +
Boundary Conditions	25, mainly ECN RuG ++	Edgar, policy, law, economics, acceptance, coordination ++	Mainly small scale consultancy +	Large and growing variety of activity ++
Renewable generation	50, mainly ECN ++	INTERREG Green Gas, Solar/Biomass/Wind ECN, testing facilities ++	Mainly small and medium scale biomass and wind. ++	Strong public-private collaboration ++

Table 5 Energy Valley triple-helix specializations

The table is based on relatively weak data from various sources and therefore partly based on impressions from all the different bits and pieces of information coming together in this study. Keeping this in mind however a few points come to mind.

First, in the Energy Valley region the triple-helix formula seems to work best in the areas of renewable generation and boundary conditions. In those areas the research community is not only the most active, but also supported most by public funding and by small-scale industry. Much weaker is the triple-helix structure with regard to demand flexibility and grid/infrastructure. Some experiments are initiated by the leading companies recently, but without yet a strong link with academic work or public support. A clear divide between large-scale industry activity on the one hand, but little connection with the research community on the other hand can also be seen in the area of storage.

An intermediate position seems to exist in the areas of supply flexibility and integration methods. As far as supply flexibility is concerned the research attention is still primarily on gas, but recently the integration of gas and power supply and balancing is gaining ground. The same applies for integration methods: research, both more fundamental and applied, is still relatively modest but is expected to grow significantly in view of the upcoming energy challenges.

All in all, research hotspots can primarily be found at ECN, the University of Groningen, the Hanze University of applied sciences and DNV Kema (partly covering the former Gasunie research unit). There is still a strong focus on gas, gas quality, gas application and gas markets and green gas production. Research on the role of gas in an integrating energy system is still modest but rapidly growing. A number of testing programs at RuG and Hanze university is supporting this.

Another hotspot in innovative research is related to the various ECN research activities on renewable energy production based on solar energy, wind energy and biomass. This research is mainly based on testing facilities and the analyses based on that.

A final hotspot can primarily be found at RuG and in a large number of generally small consultancy units in the Energy Valley region dealing with the boundary conditions of the energy transition. The main focus is on desk research dealing with the business and economic aspects of new energy investment, policy analysis, the role of law, regulations, the impact of various incentives, the functioning of markets, the behaviour of stakeholders and collaboration and optimization issues. Also data collection, storage and analysis, and ICT plays a serious role in this cluster as well as training, communication and branding.

A number of prestigious research projects/programs and testing facilities have been set up to support the energy transition in the Energy Valley. In budgetary terms, the most sizeable of the project/programs being: EDGaR €44 mln, INTERREG Green Gas €9.9 mln, NEN-D €7.5 mln, North Sea Sustainable Energy Planning €5.2 mln, Flexigas €6.3 mln, Flexines €3.6 mln, Flexiheat €2.3 mln, EDIaal some €2 mln, NaMaRo €1.4 mln, HEC €1.2 mln, I-Balance €1.2 mln.

Important new testing facilities and living labs are: RenQi, ECN Windturbine Testpark at Wieringermeer, EnTranCe, Knowledge Centre WMC, Wetsalt, Tidal Testing Centre Den Oever, Dairy Campus, PowerMatching City, Milena Gasifier, Repower Windfarm, Biogas line North East Fryslân.

5 Summary and conclusions

The Energy Valley region is rapidly developing into a major energy region within North western Europe. This is partly based on the Groningen gas field and all economic activity related to its exploration and the subsequent gas value chain activities, but more recently and increasingly so on a wide variety of new energy initiatives still mostly linked with traditional fossil energy production and use, but also focusing on renewable production and energy system integration. Overall energy investment in the region, estimated some €25 bn. is large by almost any standard; triple-helix collaboration is rapidly growing.

The strengths of the region is still strongly based on gas – its exploration, transport, use and application – but also power production is rapidly increasing as well as North Sea and other power grid connections. Research activity and its coordination can hardly keep pace with the formidable investment activity in the region, but the energy focus in the research community is growing as well as collaboration with the industry and focus. The need for energy system integration, i.e. optimizing the energy system by combining the information on all various elements of the energy system, provides a major challenge for which the region seems well equipped for playing a leading role.

This requires, however, a common view and strong collaboration between the various energy stakeholders both in the private and public sector. Although the Energy Valley foundation as triple-helix organisation plays an important role in this respect, the clear research focus has not yet fully developed in the region to generate sufficient critical mass. Also consensus on what the most promising research challenges are and on what the strong and weak points are has not been reached yet to the full extent. This, together with the region being located relatively far away from the national decision centres may act as a weakness for reaching energy innovation excellence.

Opportunities and potential for the region to play a major role in North Sea area energy development seem abundant. Also the current strong triple-helix tradition in energy, the increasing concentration of energy activity in the North Sea and along the Energy Valley coast and harbours, and the already strong energy research base, are all promising signs for the region to be able to position itself as a region of energy excellence.

This, however, will not be achieved overnight, nor easy. Public scepticism, stop-go policy, lack of fruitful collaboration and research focus may all slow down what now seems to be an extremely promising trend.

One of the views that came across fairly clearly from the various sources of information for this study was that, whatever future scenario one would take, triple-helix energy innovation success will only be achieved if based on good international collaboration with likeminded, neighbouring and nearby regions going through similar large scale energy transition processes. If public private sector collaboration is further intensified in the spirit of good international collaboration in the North Sea region, in the end all can benefit to develop the North Sea region as the nucleus of European energy innovation.

Regional Report of Wachstumsregion Ems-Achse e.V.

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1 Wachstumsregion Ems-Achse e.V. at a glance

The Ems-Achse stands for a joint economic region to advance economic growth and increase employment. This is achieved through development and implementation of different projects and the advancement of communication between the companies to gain and amplify knowledge. The economic region Ems-Achse, founded in 2006, profits from the close and faithful collaboration between companies, local authorities and academic institutions. One year after the founding, the Wachstumsregion Ems-Achse consisted of 43 Members (37 companies and 6 municipalities). In the following 4 years (2007-2011) the number increased drastically: today there are more than 400 members. This can be ascribed to successful projects like the completion of the Autobahn A 31 (13 years earlier than planned) which leads from the north to the south of the region and the harbour "EurohafenEmsland" (in 2007). Both projects have been and are very important for the infrastructure of the whole region and have shown what can be achieved if the members of the Ems-Achse are joining forces. All together there are 429 members[2].

SMEs:	**326**
Large Companies:	**39**
R&D:	**2**
Universities/Universities of applied sciences:	**3**
Local Authorities:	**59**

The Ems-Achse stands for promotion of economic growth and is at the forefront of providing new jobs: From 2005 to 2010 the average peak of job-increase has been 14,3% for the Ems-Achse-region, whereas the average peak of Lower-Saxony has been 6,5%.[3]

Six working groups, chaired by the administrative districts, have been formed, addressing and advancing the main topics of the regional economy. Many renowned projects have been realized which are strengthening the transnational collaboration and the different industries. All cluster-members can take part in these groups which are meeting on a regular basis, hosting workshops and networking events to increase the exchange of information and collaboration. Within this structure the Landkreis Aurich is responsible for the theme "Energy".

[2]Dated March 2013.
[3]Kröcher, Uwe, Beschäftigungsboom im Nordwesten – vor und während der Krise, Regio Report, Oldenburg, Juni 2011

1.1 Geography

The Wachstumsregion Ems-Achse is located in the most north-western part of Germany. In the North it borders on the North Sea, in the West is the Dutch-German border and in the South North Rhine-Westphalia. The municipalities forming the region are: Landkreis Aurich, Landkreis Wittmund, Landkreis Leer, Landkreis Grafschaft Bentheim, Landkreis Emsland and the city of Emden.

All together this is an area of 7003 km² with a population of911.354 inhabitants.

County	Population	Size km²
Landkreis Aurich	188.267	1287
Landkreis Emsland	314.765	2882
Landkreis Graftschaft Bentheim	135.022	980
Landkreis Leer	165.168	1086
Landkreis Wittmund	56.784	656
Stadt Emden	51.348	112

Figure 1:Counties of Ems-Achse

From 6 East Frisian Islands in the very North to small foothills of a low mountain range (90m) in the very south – the landscape of the region is quite diverse.

The districts Aurich and Wittmund have been shaped by the direct access to the Sea. Tourism and fishery are important parts of local economy. Seaports gave distinction to the city of Emden and district of Leer. The county of Emsland is the biggest district in the region and builds together with the district Grafschaft Bentheim the southern part of Ems-Achse, where one can find all kinds of different landscapes: from open fields to forest and moor. Also first small hills give a different touch to the area in contrast to the North. What unifies the different landscapes is the river Ems which flows right through the region and gave his name to the Wachstumsregion.

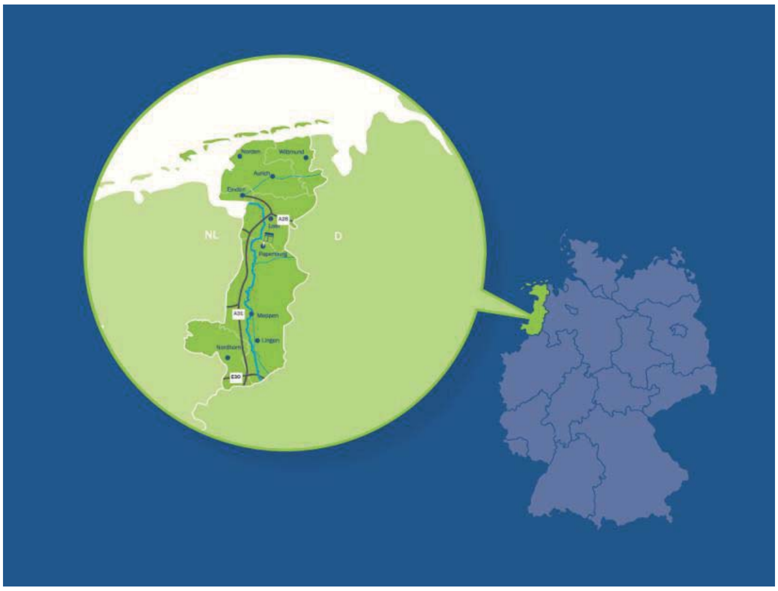

Figure 2: Location Ems-Achse

The whole region always relied on agriculture. The land is fertile and the population rate is relatively low. After drying up the moor, in the more southern parts, the first peat was cut and a new source of income was developed. Around 1800 turf production was commercialized and one can say that this was the beginning of a long history in the energy sector.

In the 1940s natural gas and oil fields have been developed - Pumping stations, pipelines, oil fuel units, residential centers of the petroleum industry, new shops and numerous industrial enterprises are besides highly mechanized turf factories features of this era.

Of originally 11 oilfields in the district Emsland 7 are producing oil up to now. Peak oil was reached in 1968 already and nowadays the oil produced in Germany covers the demands of the country to 2,5-3%. But even if Germany never had a history of an oil producing country, the landscape in the southern parts of the Ems-Achse is characterized by grasshopper pumps.

Another geographical attribute of the northern parts of Ems-Achse contributes to the reputation as “region of energy”:
Some of the largest German salt deposits were found in East Frisia which can be used to store oil and gas. These salt deposits were formed around 250 million years ago due to the drying out of seas with a high salt concentration. The pressure of very thick and heavier overlying sediments, which have then squeezed up the salt, formed salt domes with very large volumes.

The German federal government decided to build a federal crude oil reserve in Etzel since the particular conditions met the demands:
„The local salt dome [in Etzel] extends over a length of 17 kilometres and a width of 5 kilometres and upward from a depth of more than 4000 metres to within 750 metres of the earth’s surface. Few locations in Germany or indeed in Europe compare to Etzel’s favourable conditions for the

construction of caverns. The location was also ideal in terms of its proximity to the North Sea and the Niedersachsenbrücke jetty just 25 kilometres away in Wilhelmshaven."[4]
After the construction of pipelines and pumps, leaching started in 1973. One of the biggest German natural gas reserves was recently put into operation in Jemgum.
Both sites, Etzel and Jemgum are still being expanded and when construction is done there will be 33 caverns with a storage volume of approximately 700.000 m^3 – 750.000 m^3 each in Jemgum[5] and 144 caverns in Etzel. Up to now 62 caverns have been build in Etzel with a storage volume of approximately 38.000.000 m^3.[6]

Other economic possibilities arose from the boom of renewable energy.
Conditions have been proven to be very fruitful for the formation of "windparks", with wide and windy plains especially in the northern parts. With biogas and renewable resources one could settle on the long tradition of farming. Farmers in the Ems-Achse region are not only producing agricultural products, today they also produce electricity and heat. Some even establishes local heating systems which deliver thermal heat for whole villages.

1.2 Economy

Within the Ems-Achse region all kinds of industries and branches are located. Nonetheless there are 6 economic focal points which can be attributed to the region. Although all sectors are spread over the whole region, one can see certain concentrations in the different districts. Therefore every county takes responsibility of an economic field which has a prominent status in their district.
As a result, six working groups have been formed, as already mentioned before in chapter 3:

Energy (Aurich)
Logistics(Emden)
Maritime Collective Economy (Leer)
Mechatronics (Emsland)
Synthetics (Grafschaft Bentheim)
Tourism (Wittmund)

Besides the connection of all fields via numerous supply chains the topics themselves overlap. This overlap is especially significant within "Energy" - very obvious in mechatronics, and more unapparent in, for example, matters of tourism[7].

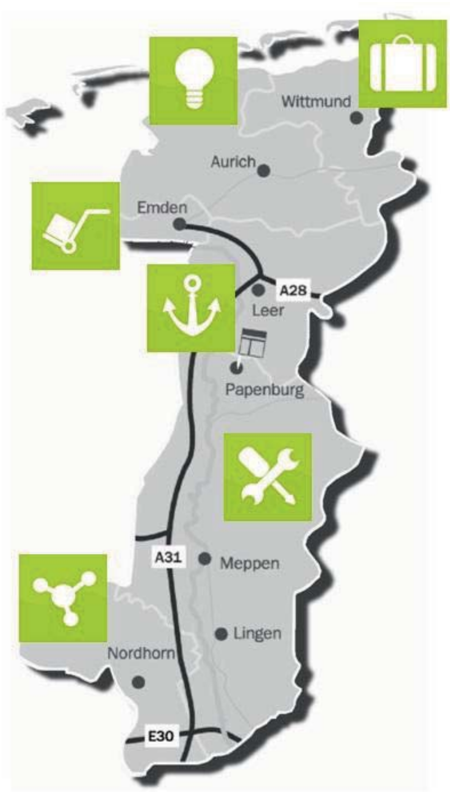

Figure 3: Working Groups Ems-Achse

[4] IVG Caverns GmbH, Kavernenspeicher Etzel – Versorgungssicherheit für Erdgas und Erdöl, Friedeburg, Juni 2011
[5] Astora gmbh& Co. Kg, http://www.speicher-jemgum.de/Projekt/, as of September 2013
[6] IVG Caverns GmbH, http://www.ivg.de/investment/caverns/kavernen-informationszentrum-etzel/, as of September 2013
[7] For example, there is a wind energy plant with an observation deck which can be visited and the city of Aurich is building the "Energie-Erlebnis-Zentrum-EEZ" (Energy Adventure and Experience Center) right now. When new plants and facilities are planned, matters of tourism have to be taken into account as well.

The energy industry is an important economic factor for the Ems-Achse and the region relies on its economic power. “The manufacturers of plant and equipment for renewable energy units and their suppliers dominate the sector […] Alongside the core business of energy supply the region is also the location for cable manufacturing and pipeline construction companies as well as a wide range of associated service industries.“[8] The region is characterized by a diverse mix of industries with many highly specialized small and medium sized companies, but also large companies, international market leader among them, which are located all over the Ems-Achse.

Also other sectors profit from the generation of energy from renewables: Many farmes count on wind energy, solar power and biogas. Some even run large district heating networks with their biogas plants, distributing heat for whole villages.

Another aspect of the energy industry is logistics. With the third largest and most western German North Sea Port in Emden the Ems-Achse has to offer a harbor with many years of experience in offshore and onshore wind. “The port is used for several wind farms in the German bay as a base for the pre-assembly, transportation and maintenance of the off-shore wind turbines.”[9] The other important traffic routes are the Autobahn 31, the rail track Ruhrgebiet-Emden, the Dortmund-Ems-canal and in the south the intersection of Autobahn 30 to Amsterdam, Hannover and Berlin.

The success of the energy sector as an economic key area of the region is also mirrored in the employment figures of the region: Whereas in the eastern parts of Lower Saxony employment reduction was the case in the energy sector during the years 2000 and 2009, the western region was able to increase employment. In the LandkreisAurich, for example, more than 1000 jobs have been created during this period[10]. To make sure that the trend continues upwards the Ems-Achse values international collaboration and its advantages like economic growth, international impact and increasing competitiveness.

Sustainable energy supply is a core challenge faced by all European regions.
Theoretically huge parts of the Ems-Achse are able to supply themselves with sustainable energy only. Some municipalities are even producing more than they would need (LandkreisWittmund 133%, Stadt Emden 119%, LandkreisAurich 100%[11]). But to guarantee a stable supply with renewable energy, we are in the need of solutions especially depending grid stability. In the face of the intended German nuclear power phase-out in 2022 this issue becomes even more important. With projects like hec and NEND and the Energy Efficiency Resolution (signed by all municipalities in April 2008) the Ems-Achse is preparing for the upcoming challenges.
Furthermore, with the caverns in Jemgum and Etzel, the region is a very important part of federal security of energy supplies.

1.3 Education/Research

Measured against the size of the area there are not that many universities and research institutes as elsewhere. Nevertheless or probably because of that Ems-Achse maintains good contacts to research organisations and universities outside the regional scope. Despite these other contacts and cooperations, the view should be maintained on the cluster and its members and the region

[8] Kröcher et al, Potenzialstudie Energieregion Nord-West, Oldenburg/Hannover, Mai 2013, S. 10.
[9] Stadt Emden, http://www.emden.de/de/wirtschaft/homeport/main.htm
[10] Brand, Harms, Rietzler, Energieland Niedersachsen, Eine Studie der Nord/LB Regionalwirtschaft im Auftrag des Institutes der Norddeutschen Wirtschaft e.V., Dezember 2010
[11] Deutsche Gesellschaft für Sonnenenergie, Energymap, Regierungsbezirk Weser-Ems, URL: http://www.energymap.info/energieregionen/116/178.html, as of October 2013

itself in the following passages. To begin with, an overview of the German education system is given.

1.3.1 German Education System

„All pupils in Germany enter the Grundschule which in almost all Länder covers grades 1 to 4. Following the primary school stage, secondary education in the Länder is characterised by division into the various educational paths with their respective leaving certificates and qualifications for which different school types are responsible. Once pupils have completed compulsory schooling they move into upper secondary education. The range of courses on offer includes full-time general education and vocational schools, as well as vocational training within the *duales System* (dual system). The tertiary sector encompasses institutions of higher education and other establishments that offer study courses qualifying for entry into a profession to students who have completed the upper secondary level and obtained a higher education entrance qualification. As part of lifelong learning, continuing education is assuming greater importance and is increasingly becoming a field of education in its own right. In response to the vast range of demands made on continuing education, a differentiated structure has been developed.“[12]

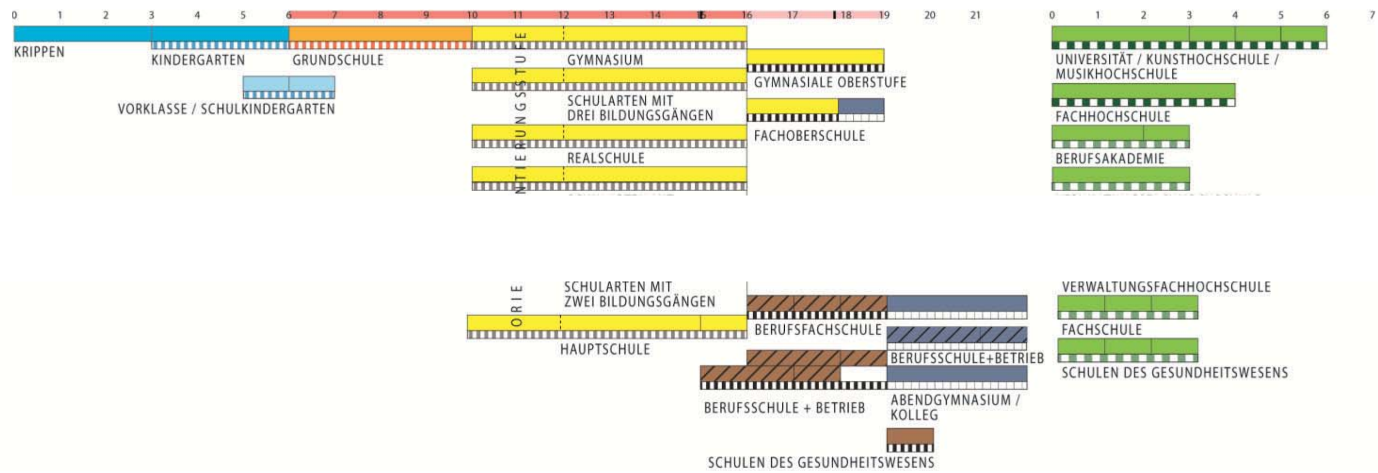

Figure 4: German education system[13]

1.3.2 Energie-Forschungszentrum Niedersachsen – EFZN

The "Energie-Forschungszentrum Niedersachsen" (Energy Research Centre of Niedersachsen) located in the German Lower-Saxon city of Goslar, or in its short version the "EFZN", is a scientific institution of the "Technische Universität Clausthal" (in short the "TU Clausthal" or in English the "Clausthal University of Technology") in cooperation with the universities of Braunschweig, Göttingen, Hannover and Oldenburg. The focus of EFZN lies on issues pertaining to the entire energy-generation and energy-utilisation chain from the raw-material source to disposal. An average of 80 researchers from the fields of natural science, engineering science, law as well as

[12] Eurypedia, European Encyclopedia on National Education Systems, https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Germany:Overview, as of October 2013
[13] Eurydice, Education Structures, http://eacea.ec.europa.eu/education/eurydice/documents/facts_and_figures/education_structures_EN.pdf, as of August 2013

the social and economic sciences works together under the same roof, thus facilitating an interdisciplinary approach to energy research.

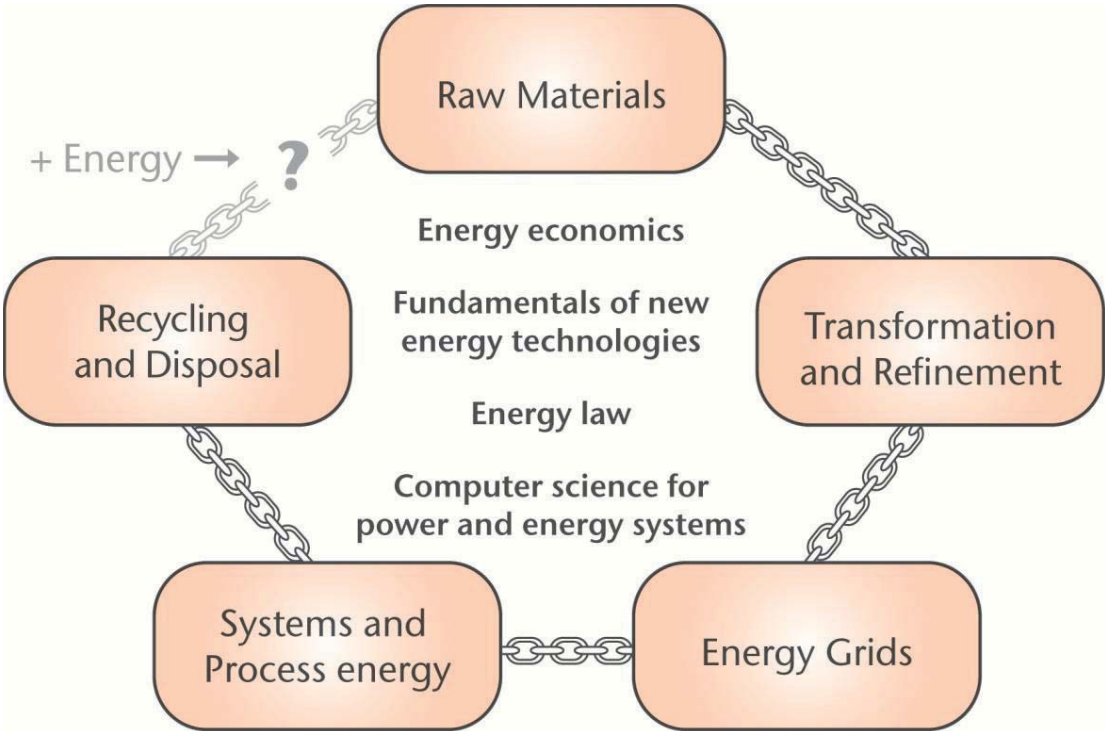

Figure 5: Energy Chain, EFZN[14]

The EFZN joined the Ems-Achse in July 2011 to strengthen the competence in energy-research, since the EFZN combines energy research in Lower Saxony and ensures representation of all the universities of Lower Saxony, who are involved with energy research.

1.3.3 Universities of applied sciences

There are two universities of applied sciences located in the Ems-Achse region:

Hochschule Emden/Leer

The university consists of two different sites in the cities Emden and Leer.

The college in Leer is renowned for nautical sciences and shipping management. These fields of education are closely related to the energy industry in the way that mostly the whole logistic and supply for offshore windparks is carried out by maritime economy. The Hochschule Emden/Leer

[14] Energie-Forschungszentrum Niedersachsen, Energy Chain

is also involved in two research projects: *MariTIM*, which deals with maritime technologies and innovation and *North Sea Supply Connect* which aimed at connecting (among others) SME suppliers and manufacturers of energy production, distribution, consumption and energy efficiency technologies along the North East Corridor of the North Sea.

In Emden the students can get their degree in various fields of engineering, for example a bachelor/master of engineering in *environmental technology*, *energy efficiency, electrical engineering, computer science* or *machine construction and design*. The focal points of research in the field of engineering are on industrial computer science and sustainable technologies but there are also socio-scientific and pedagogic research topics[15].

Hochschule Osnabrück – Campus Lingen
The Hochschule Osnabrück runs a campus in Lingen – the faculty for management, culture and technology. Students can choose for example between business and management studies, machine construction or industrial engineering and operations research. In different laboratories students can transfer the gained knowledge into practice. The teachers work closely with companies in the region and together projects in different disciplines are realized, for example renewable energy, technical product development, software development or logistics.

1.3.4 Institutions & Networks

Probably due to the spatial distances to the universities, a lot of institutions and networks have been founded and are located in the region. They are very well known and enjoy a good reputation.

Some of those networks are integrated in the Ems-Achse cluster. The ones dealing with energy in a narrower and also broader sense are for example:

3N Kompetenzzentrum - Niedersachsen Netzwerk Nachwachsende Rohstoffe e.V.
3N is the lower saxonian competence center for regrowing resources and bioenergy, located in Werlte. As a non profit organisation it supports the lower saxony network of renewable energy and resources. More than 32 enterprises, local authorities and institutions are members of this platform. 3N functions as contact point and source of information for economy, agriculture, forestry, science and citizens. Furthermore 3N participates in regional, national and European projects, prepares studies on different topics and is also active promoting the advantages of regrowing resources with exhibitions and workshops.

3N is also responsible for the Klimacenter Werlte, next to the office. The Klimacenter illustrates what regrowing materials have to offer: the building functions as a reference object to the use of

- Bioenergy (wood pellet heating, firewood heating, energy efficiency)
- Building materials (insultaing materials, flooring, paint and lacquer)
- New materials (biodegradable plastics, natural fibre composites, bionics)

[15] Hochschule Emden-Leer, Forschungskerne der Hochschule, http://www.hs-emden-leer.de/forschung-transfer/forschung/forschungskerne.html, as of September 2013

Craftsmen can use the Klimacenter as an exhibition and demonstration object, companies are able to present their products and customers can take a close look at different techniques. It is also possible to rent laboratories and meeting facilities.

CCN – Climate Center North
In 2010 the county of Aurich founded the Climate Center North to promote the topic of energy efficiency within the Ems-Achse.

The CCN sees itself as a hub for manufacturing companies and technology providers in the field of energy efficiency and aims to support the development and application of new technological solutions in this area. This can save resources, CO_2 and costs. Furthermore competitiveness and innovation capacity of enterprises and institutions will be increased.

Some activities of the Climate Center North are for example:

- Prepare overview of energy and CO_2 consumption for the region
- Introduction of energy management systems for SMEs
- Implementation of a course for Energy Representatives

Mariko
The Mariko is the maritime competence center of the region. It is headquartered in Leer and interlinks the maritime expertise of the region. The Mariko supports its national and international partners in matters of education and training, qualification and research, but also marketing.
The relation to energy stems from the offshore wind industry and green shipping technologies.

Energieeffizienzagentur Landkreis Emsland e.V.
Since 2011 this “Agency for Energy efficiency” is working with companies in the administrative district Emsland and illustrates measures for saving energy and efficient usage. Assistance is also offered when it comes to questions of funding opportunities.

1.3.5 Innovative SMEs and industry

Innovative SMEs are important for technological progress. Besides the competences universities and other research institutions have to offer, companies and municipalities work together closely to benefit from each other’s knowledge or facilities. One example is the project “KalteFernwärme” (Cold district heating) in Aurich:

- The dairy Rücker in Aurich uses their 30 °C warm waste water to heat the huge multipurpose hall of the city. Up to one million litre sewage daily can be used for environmental-friendly heating. In 2011 the project was honoured by the initiative „Deutschland – Land der Ideen“.

Besides SMEs also industry has got headquarters in the Ems-Achse region, amongst others:

- Enercon, GE Energy, BARD Offshore, Volkswagen, Meyer Werft

Needless to say, large companies usually have their own research departments but just to name a few activities:

- Right now Enercon is building an innovation centre in Aurich which could accommodate about 700 research and development engineers on an area of 30.000 m^2.
- The Volkswagen factory in Emden is trying to become a "Blue Factory" – a label for CO_2 neutral production. Numerous projects related to environmental protection and sustainability have been already initiated.
- The Meyer Werft is very active in projects dealing with new drive systems and components for their ships.

The Ems-Achse region also often functions as a testing location for innovation and technology for companies and research institutes from outside the borders of the member districts:

- The German car company Audi invested 20 Million Euro in a facility in Werlte which uses electricity to convert Water and carbon dioxide in methane on an industrial scale (6 MW). It is the first facility in the world which can produce these amounts. The basic idea is to produce gas with spare electricity from wind energy which can be stored and used to fuel cars.
- Haren was part of a testing region in the project "Smart Country". Goal of the project was the realization and evaluation of innovative concepts of distribution networks. It was funded by the Federal ministry of Economics and Technology, project partners are energy supplier RWE, TU Dortmund together with ABB AG and Consentec.

1.3.6 Interreg

The Ems-Achse or rather the member institutions and counties are frequently taking part in Interreg IVa and b projects. The majority of these projects deal with energy, resource efficiency and sustainability.
For example:

Groen Gas
The most recent project with a total volume of 10 million Euro, funded by the Dutch Ministry of Economic Affairs, Agriculture and Innovation, provinces Drenthe, Groningen, Friesland, Overijssel and Gelderland as well as the German federal states of Lower-Saxony and North Rhine-Westfalia. A total of 63 project partner from all parts of the triple helix work together in 17 sub-projects to remove bottlenecks along the whole value chain of biogas. Topics are: Processing of biogas, law and regulations, infrastructure, green gas as fuel etc.

Nachhaltige Energien Niederlande Deutschland - NEND
NENDis a cooperation of local authorities in the northern Netherlands and north western Germany. The aim of NEND is to strengthen the position of the region in the field of production and use of renewable energy. Based on different aspects of the region both sides of the border, NEND deals with four themes:
Energy efficiency, sustainable building, biomass, solar energy

Hansa Energy Corridor - HEC

- The Hansa Energy Corridor was a collaboration between 9 partners located in Northern Netherlands and Northwest Germany:
- Rijksuniversiteit Groningen
- Hanze University Groningen
- Provincie Groningen

- Stichting Energy Valley
- Landkreis Aurich/Wachstumsregion Ems-Achsee.V.
- Energie-Forschungszentrum Niedersachsen
- Oldenburger Energiecluster OLEC
- Carl von Ossietzky Universität Oldenburg
- Jacobs University

To develop the energy transition eight key areas were addressed within the starting phase of the platform. All of these themes shared that they are addressing key challenges within the European energy system based on an interdisciplinary approach, which covered technological, social, economic as well as regulative and legal issues.

Energy-Gateway

The homepage www.energy-gateway.eu derived from the Hansa Energy Corridor. It strengthens the region by displaying the different scientific, economic and political competencies and also public and private commitment. The internet platform is divided in larger regional projects which are described in detail on single subpages and three interactive maps on which municipal projects, locations of companies and universities are linked.

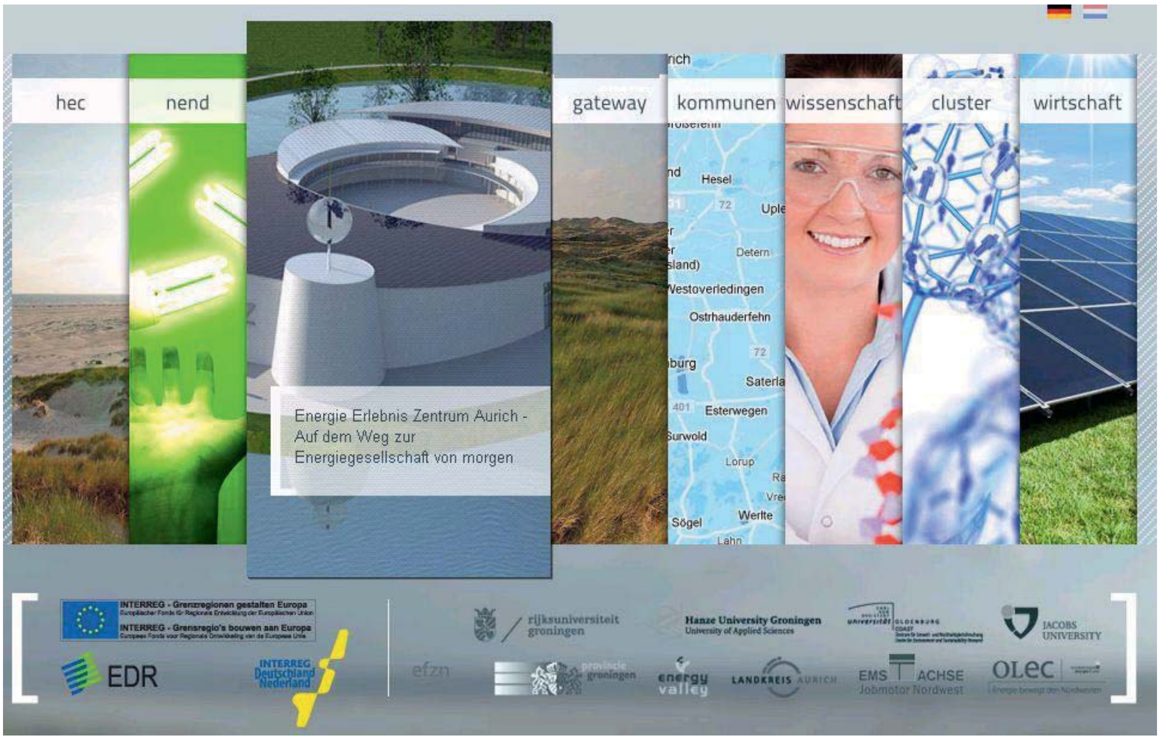

Figure 6: Screenshot of http://www.energy-gateway.eu/

2 Description of the regional energy system

The chapter on description of the regional energy system has the aim to explain the meaning and impact of the Energiewende in Germany and also gives an insight into the national and regional energy system. Concerning the Energiewende the "Erneuerbare Energien Gesetz" (Renewable Energy Law) plays a major role in Germany. Many profound changes in the way of energy generation have been accelerated and enabled by this law.

2.1 Summary of the national and regional energy system

This sub-chapter delivers concrete figures and data concerning energy consumption, gross electricity generation, the gas and electricity supply both in Germany (national level) and in Lower Saxony (regional level).

2.1.1 Prologue: Energiewende[16](energy transition)

Germany has drawn a lot of international attention for its aim to switch to a renewable energy economy and leave nuclear and fossil energy behind. Hence, in the aftermath of the nuclear reactor core meltdowns in Fukushima, Japan in March 2011, the German Government presented a set of decisions known as the Energiewende (energy transition) in June 2011. It refers to a fundamental transition to a decarbonized energy system based mainly on variable renewable energy (RE), e.g. wind and solar power, with the emphasis on increasing energy efficiency without the use of nuclear energy. The Energiewende is based on an earlier 'Energy Concept' that was agreed on by the same coalition government of Christian Democrats and Free Democrats in September 2010, which has already laid out a long-term perspective until 2050 for the transition towards a RE-based energy system.

2.1.2 Energy consumption[17]

The energy consumption is divided into primary energy consumption and final energy consumption. In the following, numbers and figures on the German and Lower Saxony energy consumption are given.

Primary energy consumption (PEC)

The PEC indicates how much energy is used in an economy in order to deliver all energy services (such as production, heating, moving, telecommunications, computer lighting etc.).

Final energy consumption (FEC)

FEC refers to what the energy is actually consumed by final consumer. The consumption applies to both primary fuels (oil, natural gas, hard coal, brown coal, nuclear energy and renewable energy) and secondary energy carriers (refined by conversion of primary energy sources such as electricity and petroleum products).

[16] The German energy transition; Finnish Institute of International Affairs Briefing paper 128; May 2013, p3

[17] 2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

Primary energy consumption (PEC) in Germany (2012)

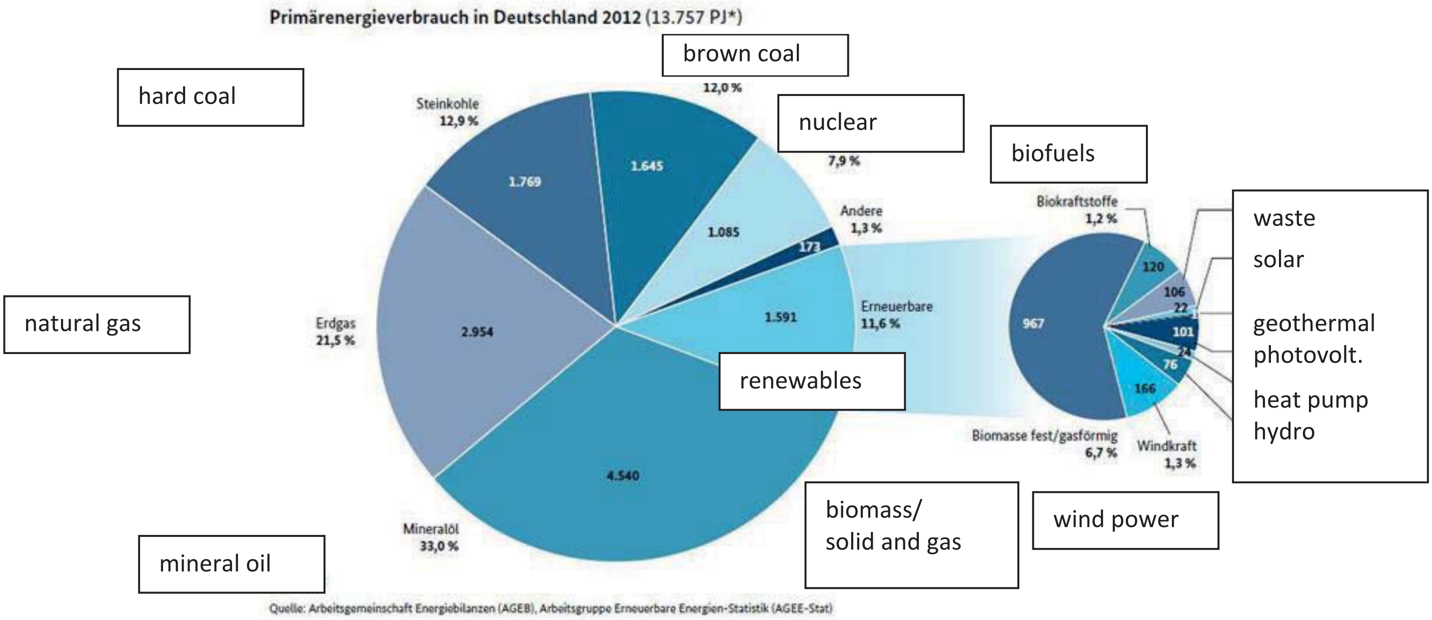

Figure 7: PEC in Germany 2012[19]

Primary energy consumption in Lower Saxony[20]

In 2010, primary energy consumption of Lower Saxony amounted to 1,480 petajoules. The share of renewable energy in primary energy consumption reached 12.3 percent in 2010 (2008: 10.3%).

The final energy consumption (FEC) in Lower Saxony has remained almost constant in recent years. Due to economic fluctuations, FEC has declined in 2009 towards 904 petajoules (PJ). However, in 2010, final energy consumption with 948 PJ returned back to the level of the previous year 2008 (946 PJ) and 2006 (953 PJ). In 2002, the FEC was still at 961 PJ and, hence, slightly decreased since then.

[18] 2013 Bundesministerium für Wirtschaft und Technologie www.bmwi.de; http://www.bmwi.de/DE/Service/suche,did=540366.html

[19] http://www.bmwi.de/BMWi/Redaktion/PDF/E/energiestatistiken-energiegewinnung-energieverbrauch,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf. p1; Arbeitsgemeinschaft Energiebilanzen, Arbeitsgruppe Erneuerbare Energien Statistik

[20] 2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

2.1.3 Gross electricity generation

Table 2 shows the gross electricity generation in Germany (2011). In the following the focus is held on the gross electricity generation in Lower Saxony.

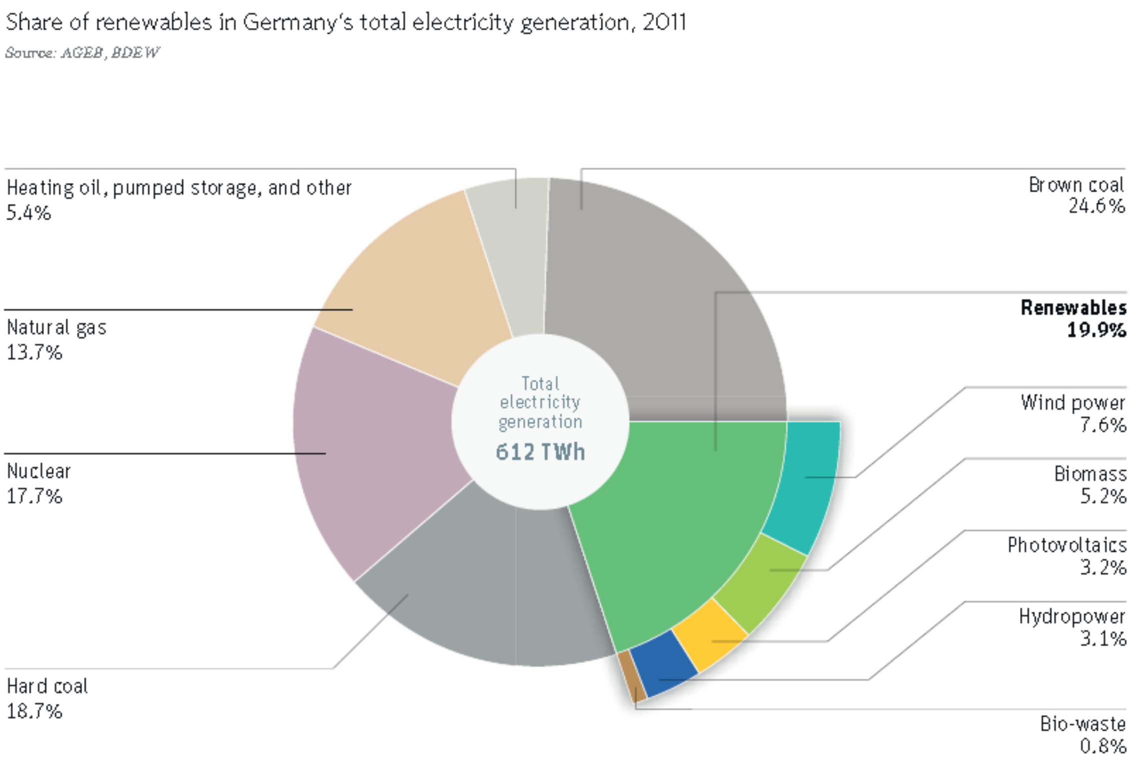

Figure 8: Share of renewables in Germany's total electricity generation[21]

Gross electricity generation in Lower Saxony[22]

The gross electricity generation in Lower Saxony in 2010 was based on almost 46 percent nuclear energy, to approx. 19 percent on hard coal and brown coal, 10.5 percent to oil and gas, and almost 22 percent renewable energy. As for electricity production from renewable energy sources, wind power dominates, followed by biogas and biomass. The proportion of solid biomass and biogas has become firmly established in electricity production from renewable energy sources.

As for house heating in Lower Saxony, natural gas - more than 50 percent of households heat with natural gas -is used primarily, followed by fuel oil, district heating and electricity. Coal is used only to a small extent

[21] 2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

[22] 2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

2.1.4 The German electricity and gas grid[23]

The German electricity grid

The German electricity grid, across all voltage levels, has a length of nearly 1.6 million kilometres. More than 900 local and regional energy companies organize the distribution of electricity in their network areas.
The electricity flows at different voltage levels through power lines from the power plants to the customers. Low-voltage systems connect small local power consumers such as individual households. At the regional level, electricity is distributed via medium voltage networks. The range of customers includes major consumers such as businesses.

The backbone of the energy infrastructure are the transmission networks. They are the "power highways" of the Republic. These highways transport on the high voltage level of 220 and 380 kilovolts large amounts of electricity over long distances directly from power plants to the distribution networks in the regions. In addition, the transmission networks connect the German electricity grid with that of neighbouring countries and, thus, enable the cross-border exchange of energy in Europe. The four transmission system operators (TSOs) 50 Hertz, Amprion, TenneT and EnBW are responsible for the modernization and expansion of high and very high voltage networks in Germany.

Operators and their regulation zones

The transmission network in Germany is historically divided into four regions, so-called regulation zones. The TSOs are responsible for the high voltage networks in their areas. 50 Hertz operates the high voltage grid in northern and eastern Germany. The net area of Amprion is mainly in the west and southwest. EnBW is responsible for most of the high voltage network in Baden-Württemberg. The network of TenneT pervades throughout Germany, ranging from the Danish border in the north to the Alps in the south. Overall, the transmission network has a length of more than 35,000 kilometres supplying power to the 82 million inhabitants in Germany. For Lower Saxony, the TSO TenneT is responsible.

Natural gas

Natural gas plays an important role with a primary energy consumption share of 21.6% in the energy mix of the Federal Republic of Germany.

For the next few decades natural gas will still make a significant contribution to the energy supply in Germany. By far the most important market for natural gas is still the heat market. Gas today is, however, not focused on the heat market, but characterized - in addition to its function as a base material in the chemical industry - as a flexible and diverse energy source in the heating market, the power generation, energy storage and as a future perspective as storage option for electricity from renewables and mobility. Natural gas compared to other fossil fuels is more climate-friendly, as its use is associated with lower CO_2 emissions.
Biogas (Biomethane) can be refined with appropriate treatment techniques to reach natural gas quality and be fed into existing natural gas networks and, thus, can contribute to relief both in the heat, power and fuel markets.
Natural gas power plants can play an important role in balancing power fluctuations from renewable energy sources, as these are subject to considerable fluctuations depending on the weather and season.
Another important and promising application for the German natural gas grid is the use as a giant storage for several billion kilowatt-hours of energy by converting electricity from renewable

[23] www.netzentwicklungsplan.de

sources into hydrogen or methane and feed into the natural gas grid. Promising research and demonstration projects are running currently with the aim to bring this technology to large-scale operation in the next decade.
Finally, natural gas also plays an increasingly important role in mobility as a cost-effective and environment friendly fuel.
Due to the high import dependence, gas supply security instruments play a central role

The German gas industry[24]
The gas industry in Germany is one of the "infrastructure industries". It is privately organized on three stages:

- Production and import
- Transport and transmission
- Final distribution

In 2012[25], more than 35,500 employees worked in the approximately 900 companies in the gas supply industry.
Further in 2012, about 88 percent of the consumed natural gas was imported mainly from Norway, Russia and the Netherlands (2011: around 86 per cent). In 2011, the energy consumption for gas in Germany amounted to approx. 2.230 petajoules (PJ). The largest consumer group in final energy consumption by sector was industry with approx. 920 PJ (41 %), closely followed by households with approx. 870 PJ (39%).

The third internal market package established a planning instrument at European level for the build up and maintenance of the network infrastructure necessary for the requirements of an internal EU market. The national implementation was carried out in the electricity and gas supply Act (Energy Economy Act – EnWG). Since December 2010 the (EU) Regulation No. 994 / 2010 on measures to ensure the security of gas supply the supply security is in force. The German gas market is characterized by a wide variety of privately organized market actors in the areas of gas networks, storage operations and trade.

[24]http://www.netzentwicklungsplan-gas.de
[25]Federal Statistical Office 2012

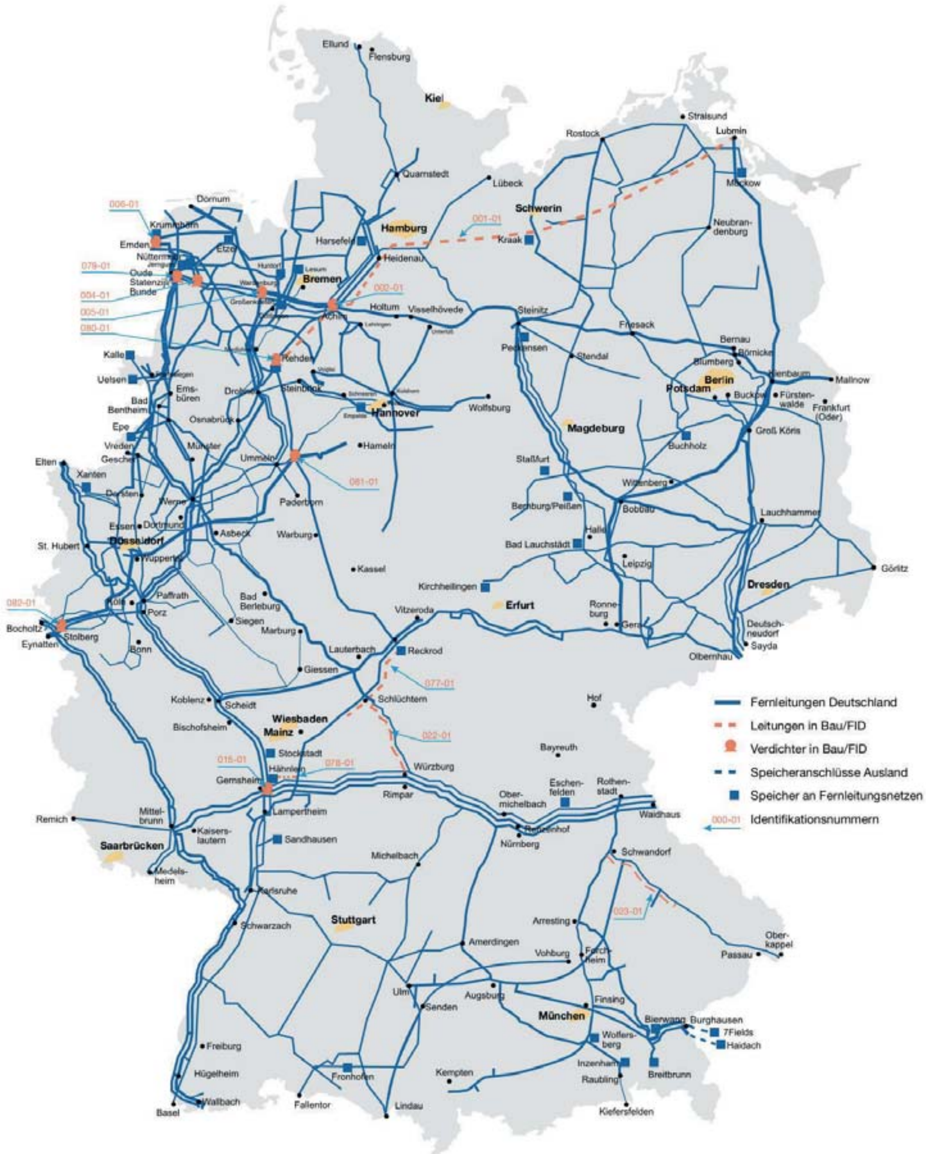

Figure 9: The German gas grid[26]

[26] http://www.netzentwicklungsplan-gas.de; Netzentwicklungsplan Gas 2012 der deutschen Fernleitungsnetzbetreiber; p25

2.2 The Lower Saxony energy system

This sub-chapter delivers a detailed description of Lower Saxony's functional areas in the energy industry and the potential of energy generation and production in Lower Saxony.

2.2.1 Overview of the functional areas in the energy industry[27]

In parts of Lower Saxony the energy industry has gained a significant importance for the regional economy. It is expected that this trend will increase substantially in the coming years, especially in the coastal regions. The structural transformation of the German energy system, the transformation process of energy production from fossil fuels and nuclear energy to energy production from renewable energy sources is becoming a major driver of employment and economic development. In addition to the maritime industry and tourism, the energy industry is on the way to establish itself as a major growth driver especially in the relatively underdeveloped coastal areas.

Within the complex energy industry several functional areas must be distinguished

Supply role for industry and households: Traditionally, municipal utilities and major energy suppliers - in Lower Saxony especially companies such as E.ON and EWE - take over the task of basic supply of electricity, gas and heat. In addition, the manufacturing of machinery and equipment for the electricity supply plays a significant role.

Exploitation and conversion of energy raw materials: A second aspect of the energy industry is the exploitation and conversion of energy raw materials, predominantly mining of stone and brown coal and - to a lesser extent - also the production of oil and natural gas. Lower Saxony plays a leading role throughout Germany in the field of gas and oil production

2.2.2 Regional focal points of energy production in Lower Saxony

The locations of energy utility companies are distributed throughout the entire country (Bundesland). In addition to some 50 municipal utilities, the two major providers E.ON and EWE AG Oldenburg are active on the Lower Saxony market. They supply both industrial and commercial customers as well as households with electricity, gas and heat.

EWE AG is the fifth largest energy provider on the German electricity and gas market, besides the other big providers Vattenfall, RWE, E.ON and EnBW. Furthermore, the municipal utility of Hannover (capital of Lower Saxony) belongs to the larger companies that provide energy. Other municipal public utilities are mainly of regional importance. Some of them dispose of their own power stations to generate electricity or heat and are usually owned by the regional distribution networks for district heating, electricity and gas.

For many providers, the services range has expanded over the last years and went beyond the mere supply of electricity, gas and heat towards e.g. consulting services. With the liberalization of the electricity and gas markets, the municipal utilities no longer have a local monopoly, but are in competition with other trans-regional and national providers. The municipal utilities are focused on maintaining their traditionally close ties with their customers through better and enhanced services.

The territorial focus of power supply is with the large power plants, particularly in the more densely populated regions. These regions are also priority sites of industrial production at the same time. As part of the modernization of power plants complexes, a territorial shift is taking place towards the coastline. The coastal regions are also priorities for electricity production from (onshore and offshore) wind energy as well as for the provision of energy from biogas. By the

[27]Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p20ff

current structure of the establishment of offshore wind fields, the Lower Saxony coast will continue to grow for the provision of important future energy.

The two renewable energy sources wind and biomass are also widely scattered inland. For wind energy, sites with high wind levels are crucial. Both can be characterized by their high degree of decentralization compared to the traditional structure of large power plants. Particularly for the coastal regions new source and sink concepts have to be developed to react on the production sites from wind, biomass and geothermal energy located in North and North West Germany and the high energy consumption that incurs in the South and West of Germany making it necessary to rethink and adapt the transmission systems

Locations and focus regions for energy production in Lower

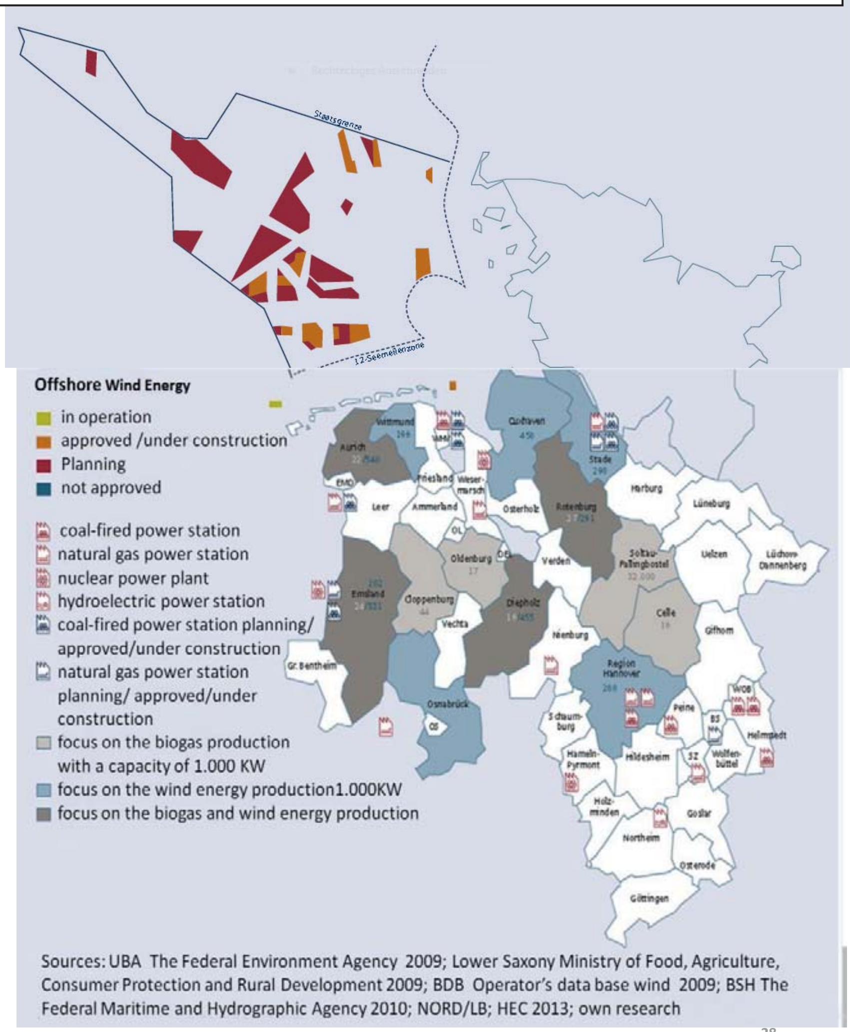

Figure 10: Locations and focus regions for energy production in Lower Saxony[28]

[28]Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p21f

2.2.3 Potential of energy generation and production in Lower Saxony[29]

The structural change in the German energy production in favour of renewable energy is becoming a driver of value added and employment. The energy sector of Lower Saxony has the potential to provide new economic stimulus, particularly in the rather underdeveloped coastal regions, but also in other rural areas.

Responsible for this are two lines of development: Firstly, a continuation of the wind energy boom in offshore installations (offshore wind parks) is expected in the coming years. On the other hand, new and more efficient clean coal power plants will be constructed. They should preferably be built on the coast or on the banks of the river Elbe close to Hamburg. This is mainly due to the high import rate for hard coal, for which a sea accessibility is a favourable cost factor.

2.2.3.1 Fossil fuels[30][31]

Lower Saxony is one of the regions in Germany in which oil and gas exploitation still has a considerable share. In addition, brown coal is mined in the region of Helmstedt (East Lower Saxony). With the exception of brown coal mining, the amounts of fossil fuels exploited in Germany are relatively low compared with the level of consumption. However, in oil and gas production Lower Saxony has a leading position in Germany (95 percent of Germany's total natural gas production). This means for Lower Saxony that more gas is produced than consumed.

In 2008, 16 percent of the demand of natural gas was covered by production within Germany. However, the overall production rates are declining. Natural gas production in 2006 was 3 percent lower than in 2004. Crude oil production decreased by as much as 7 percent in the same period. In Lower Saxony, many oil fields/ oil reservoirs are known to have been exploited by only 20 to 30 percent. Fossil fuels will continue to be of great importance for the energy supply in the near future. Despite the impressive growth of renewables, coal will continue to play a major global as an energy carrier.

In 2008 in Lower Saxony, stone and brown coal covered more than 13 per cent of primary energy consumption (in Germany a total of nearly a quarter). Mineral oil is the second most important energy source with a 26.5 percent share in primary energy consumption, slightly behind natural gas with 27.6 percent. The natural gas consumption was 2010 approx. 88 billion cubic meters in Germany. Domestic production had accounted for 14 percent of which 95 percent came from Lower Saxony. The most important supply country was Russia (32 per cent), followed by Norway (28 percent).

2.2.3.2 Conventional power plants[32]

Traditionally, Lower Saxony is characterized by a strong and powerful industry. Therefore appropriate power plant capacity has been installed to satisfy the energy demand of the established industry. Currently, there are preparations ongoing in Lower Saxony to plan seven new coal-fired power plants of Stade, Wilhelmshaven, Emden and Dörpen (Emsland). Further to these large power plants a number of smaller coal plants (<100 MW) is in operation in Lower Saxony. In addition, some gas-fired power plants are operated. These are used primarily as peak load power plants.

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[29]Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p25ff

[30]2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

[31]Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p25f

[32]Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p25f

Table 1: Existing and planned power plants in Lower Saxony (> 50 MW) in 2012)[33]

Existing and planned power plants in Lower Saxony > 50 MW				
Name/ Location	Operator/ company	Capacity (MW)	Operating mode	Expected runtime
Buschhaus/ Helmstedt	E.ON Kraftwerke GmbH	352	Brown coal	2017
Emden	Statkraft Markets GmbH	430	Natural gas	2013
Emsland/ Lingen	KLE GmbH (RWE/ E.ON)	1329	Nuclear	2021
Emsland/ Lingen (B+C)	RWE Power AG	934	Natural gas	ca. 2024
Emsland/ Lingen (D)	RWE Power AG	876	Natural gas	ca. 2050
Stöcken 1+2 Hannover	GKH (Hannover/ VW/ Continental)	230	Hard coal	ca. 2030
Linden Hannover	Stadtwerke Hannover AG	90	Natural gas	ca. 2050
Grohnde/ Emmerthal	GKHK Grohnde /E.ON/ Stadtwerke Bielefeld)	1360	Nuclear	2021
Hallendorf/ Salzgitter 1	Salzgitter AG	253	Natural gas	2025
Heyden /IV) Petershagen	E.ON Kraftwerke GmbH	875	Hard coal	ca. 2027
Huntdorf	E.ON Kraftwerke GmbH	321	Natural gas	2018
Hannover-Herrenhausen	Stadtwerke Hannover AG	87	Natural gas	2020
Mehrum 3 Hohenhameln	Kraftwerk Mehrum GmbH	690	Hard coal	ca. 2020
Robert Frank/ Landesbergen	Statkraft Markets GmbH	487	Natural gas	2013
Stade	Dow Chemical GmbH	193	Natural gas	2013
Wilhelmshaven	E.ON Kraftwerke GmbH	54	Natural gas	ca. 2013
Wilhelmshaven	E.ON Kraftwerke GmbH	757	Hard coal	2022
Wolfsburg Nord	VW KW GmbH	111	Hard coal/ nat. gas	ca. 2035
Wolfsburg West	VW KW GmbH	281	Hard coal	ca. 2035

Figure 11: Locations and focus regions for energy production in Lower Saxony[34]

2.2.3.3 Nuclear power[35]

In Lower Saxony, the use of nuclear energy for electricity generation began in 1968 with the Lingen nuclear power plant. With the nuclear power plants Stade, Emsland and Grohnde the use of nuclear energy in Lower Saxony was developed in the first instance. At peak times, up to two-thirds of the public electricity supply was ensured in this way. In the nuclear power plants in Lower Saxony uranium and a mixture of uranium and plutonium (mixed oxide - MOX) are used as fuel. The mixed oxide fuel comes from the reprocessing of spent fuel and reduces the consumption of fresh uranium fuel.

Meanwhile, the phase-out of the use of nuclear energy has begun. Currently, two nuclear power plants - Grohnde and Emsland - are operated along with a nominal capacity of 2,830 megawatts. However, they will be shut down within the next decade.

[33] Power plants in Northern Germany. A review commissioned by the Chamber of Commerce North (2012); p3

[34] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010), p21f

[35] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p26

In particular the shut down times are as follows:

- Nuclear power plant Weser (Unterweser) in August2011
- Nuclear power plant Grohnde in December 2021
- And the Emsland nuclear power plant in December 2022

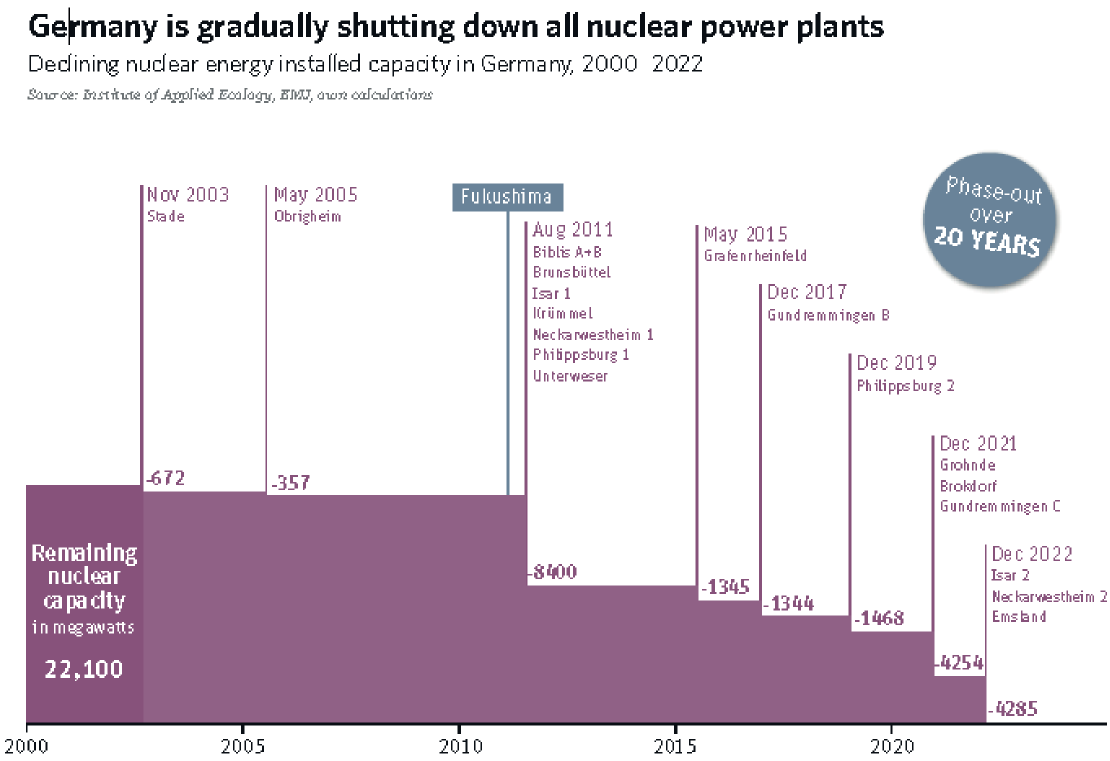

Figure 12: Declining nuclear energy capacity in Germany 2000-2022[36]

2.2.3.4 Wind energy[37]

Wind energy is an essential component of a sustainable energy policy. Therefore, it is essential to further increase the installed wind power capacity in order to reach the target - 100 percent energy supply from renewable energy sources - in Lower Saxony. To achieve growth, older wind turbines are replaced by more modern and more powerful ones (Repowering). Due to the construction of new high performance wind turbines, a larger distance to residential buildings is often required for these installations.

36 Energy Transition - The German Energiewende; Craig Morris & Martin Pehnt; an initiative of the Heinrich Böll Foundation; released on 28 November 2012; www.energytransition.de, p32
37 Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p26

Comparing onshore wind energy by Bundesländer:
By the end of 2011, one quarter of installed power in Germany is located in Lower Saxony (7.039 out of 29.075 MW)

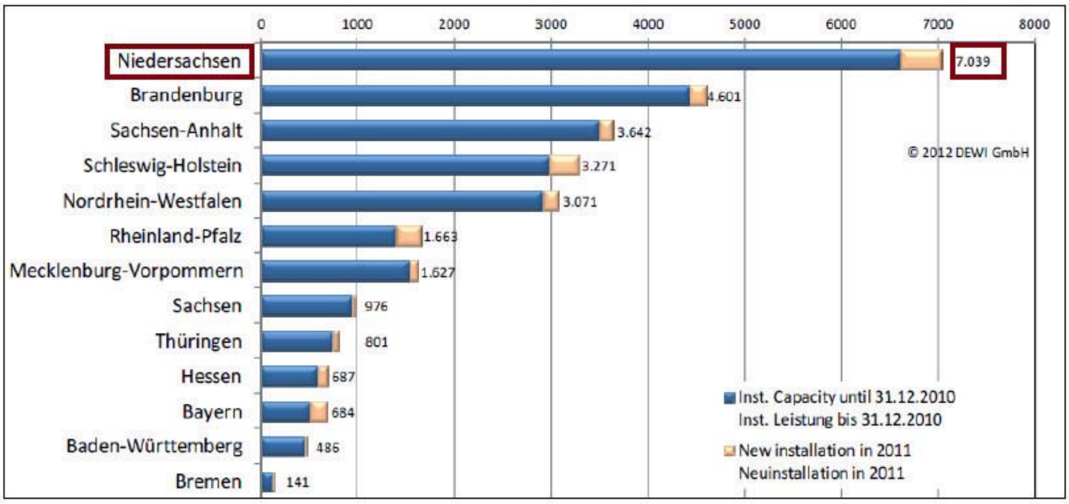

Figure 13: Comparison onshore wind energy by Bundesländer[38]

At the end of the year 2009, 5.268 onshore wind power plants with a total capacity of 6.4 GW of electric power were installed in Lower Saxony. Hence, with 24.9 percent almost a quarter of the total wind power capacity of Germany is currently provided by wind power plants in Lower Saxony. The figure above shows the latest numbers in which this trend continues.

Not only because of the good wind conditions in the North Sea which promise a rich wind energy harvest, the coastal sites are highly interesting when the focus turns to production and installation sites as well as a test field for offshore wind farms. Compared to inland sites, offshore production facilities are especially favoured because of the less complicated transportation of parts and components of wind plant parts. Approved so far are 21 offshore wind fields from the Lower Saxony North Sea coast with 1.571 wind turbines with a maximum capacity of more than 7.4 GWof electric power.
Cuxhaven offers a good example. The city at the mouth of the river Elbe is home port for the offshore expansion. Therefore, many companies have settled here. These include inter alia AMBAU (offshore base elements) , CSC Cuxhaven Steel Construction GmbH (components and assembly for offshore foundation bodies) , BIFAB Germany GmbH (production offshore foundation bodies) , Otto Wulf GmbH & Co KG (diving, towage and salvage company), DEWI OCC - Offshore certification Centre GmbH (research, certification), DEWI (onshore test site for offshore wind turbines)

[38] http://www.tfd.uni-hannover.de/fileadmin/redaktion/Vorlesung_Pruefungen/05_Birkner_Klimaschutz_in_Niedersachsen.pdf; p23

The district of Aurich benefits from the upcoming offshore wind energy boom. Renowned, technologically leading production companies for wind turbines as Enercon, Prokon, Bard and more have their headquarters.

The planned wind farms off the German North Sea coast face unique technology challenges, as the offshore wind farms can only be built in relatively great distance from the coast, different to near-shore facilities, e.g. in Denmark and UK. The solution for technical and infrastructural problems associated with a greater water depth, in particular the logistical requirements for the construction of wind farms and in their operation, may give the businesses involved a significant competitive advantage on the global market. In addition, there is another challenge regarding the offshore wind farms grid connection between plant operators and transmission system operators who are obliged to connect the wind farms to the power grid.

In summer 2009 the first units in the two wind farms "alpha ventus" were built and connected to the electricity grid. For the wind farm "alpha ventus", which is designed as a test site, wind turbines with a total capacity of 60 megawatts (MW) will be installed. In the wind park "BARD Offshore 1", at a water depth of up to 40 meters, a total of 80 wind turbines with an overall capacity of 400 MW were be installed in 2010. The timing for the construction of further wind farms also depend on the options for grid connection of the equipment. By 2015 it is expected that offshore wind farms with a total capacity of approximately 3,000 MW will be installed along the German North Sea coast.

The presently ongoing boom in offshore wind turbines creates new jobs, especially for the Lower Saxony North Sea coast. At the end of 2009, about 2,000 people are directly employed in the offshore wind energy industry in Lower Saxony. In the long term, according to estimates by the government of Lower Saxony, 10.000 permanent jobs can be created by the offshore wind energy. In addition, further employment in other branches of industry is generated, e.g. in skilled crafts, trade and service providers who work in the wind energy industry.

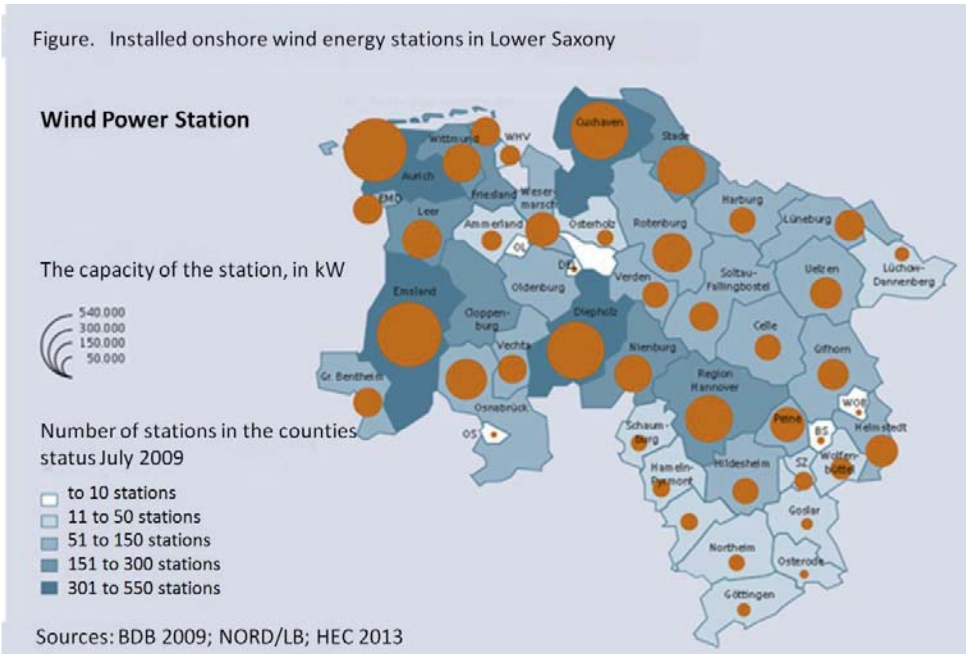

Figure 14: Installed onshore wind energy stations in Lower Saxony[39]

[39]Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p27

2.2.3.5 Biogas and biomass[40]

Further to wind energy, the production of energy from renewable resources such as heat, electricity, gas or fuel, has taken a remarkable upswing in Lower Saxony in recent years. Biogas is currently used mainly in cogeneration/ combined heat and power (CHP) plants for cogeneration of electricity and heat. The feed-in of upgraded biogas into natural gas networks is of increasing importance and further use as fuel is currently discussed. By mid-2008 3.891 bioenergy plants with an installed total capacity of 1.376 MW in Germany were installed. The nationwide capital expenditure in 2008 was at 500 million Euros. For 2009 780 new plants with about 1 billion Euros of investment were estimated in Germany.

For 2008 in Lower Saxony, a total of 710 biogas plants with a capacity of 365 MW were in operation. In that year Lower Saxony generated nearly a third (32 percent) of overall bioenergy in Germany. Since 2004, the energy has grown rapidly by putting into operation biogas plants. Thus, the area for energy crops has increased by nearly 30.000 hectares to over 200.000 hectares in 2007. In that year (2007) 10.6 percent of the arable land was covered by energy crops. Thus, Lower Saxony is below the national average of 14.9 percent. Although there is still growth potential for bioenergy production in Lower Saxony, further expansion will reach limits, mainly because of the cultivation of energy crops in competition with other forms of use such as food production.

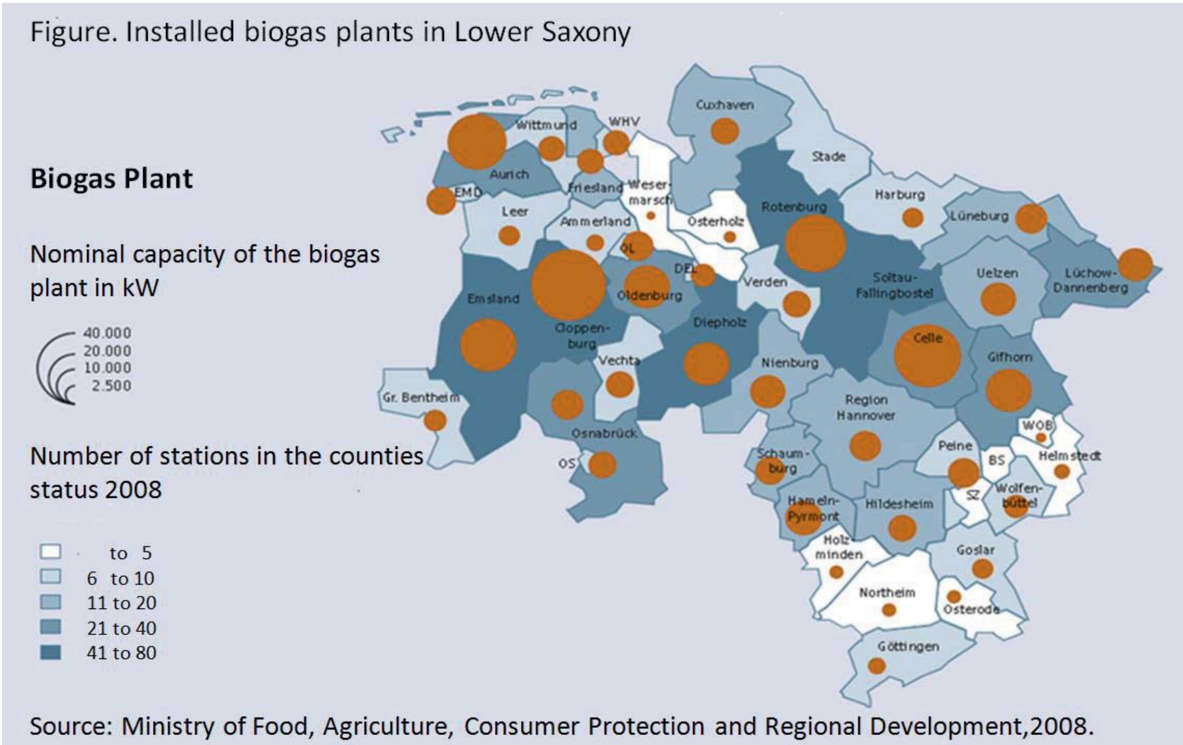

Figure 15: Installed biogas plants in Lower Saxony[41]

[40] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p27

[41] Energieland Niedersachsen: Struktur, Entwicklung und Innovation in der niedersächsischen Energiewirtschaft. Eine Studie im Auftrag des Institutes der Norddeutschen Wirtschaft e.V. (2010); p28

In 2007, 54 percent of the biogas plants in Lower Saxony had an electrical output of more than 500 kW (516 kW average). By 2010, the share of bio-energy in primary energy consumption in Lower Saxony is expected to increase from 6 percent to 8 percent. The territorial focus of biogas plants are located in the counties of Cloppenburg, Rotenburg (Wümme), Diepholz, Emsland and Soltau -Fallingbostel. Nearly three-quarters of the plants are concentrated in 15 of the 46 Lower Saxonian counties.
By investing in biogas plants (estimation in recent years range around 800 million Euros), a strong biogas industry has developed in Lower Saxony. Furthermore, renowned German plant manufacturers and component manufacturers have their headquarters in Lower Saxony and here mostly in rural areas.
In addition to the use of biogas in Lower Saxony, further energy production plants with solid biomass fuels, such as fuel wood, timber from landscape management, wood residues from wood processing, recycling wood, are in operation. Furthermore, biofuels such as biodiesel, rapeseed oil fuel, ethanol and biogas produced from renewable raw materials are generated in Lower Saxony.
An important future field of bioenergy use may also be in the field of auto mobility. Biodiesel is well established in the German market for some time already. Volkswagen, one of the world's largest manufacturer of automobiles, has kicked off a major R&D program in the area of natural gas -powered vehicles (EcoFuel).
The feed-in of biogas into the natural gas network is at the beginning of development. In this respect, the use of bioenergy will continue to gain in importance in the coming years. The production of synthetic fuels from biomass in diesel quality is in development
Reference projects known in Europe such as the bioenergy villages Jühnde and Beuchte which cover their electricity and heat demand almost entirely from bioenergy souces, refer to new forms of decentralized and self-contained local energy supply which may become more important in the upcoming future.

2.2.3.6 Hydropower[42]

Hydropower has a very high annual availability with the highest proportions in the winter at peak demand times may thus contribute to the coverage of base load. In Lower Saxony there are about 250 plants that generate electricity by hydropower. Their installed capacity is about 60 megawatts. In Lower Saxony, about 0.4 percent of electricity is covered by hydropower. However, the generation depends on rainfall and fluctuates from year to year. The potential for energy production from hydropower are largely exploited in Lower Saxony. Other projects such as the use of small hydropower plants are discussed. From there, further options could be developed.

2.2.3.7 Solar Energy[43]

Solar energy is also usable in several respects. However, Lower Saxony is not spoiled by sun. Solar radiation is some 15 percent lower than in Southern Germany, with the consequence that the solar yield is correspondingly smaller and the cost of solar electricity is higher. By the end of 2012, 121,484 photovoltaic systems with a capacity of approximately 3,000 megawatts were installed in Lower Saxony

At suitable locations, eg. single-family homes, 50 to 65 percent of the hot water needed each year can be covered by solar energy. During summer, most of the demand for hot water can be provided via the solar system.

[42]2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html
[43]2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

2.2.3.8 Geothermal energy[44]

Geothermal energy is a sustainable energy source that is climate-friendly, baseload-capable, decentralized, domestically available and virtually inexhaustible. The potential that geothermal energy holds is neither exhausted in Lower Saxony nor in entire Germany.

The use of near-surface geothermal energy (up to 100 m depth) is used with the technology available today to supply only the heat supply and cooling of buildings. Deeper geothermal resources can also be used to generate electricity. However, the investment costs and finding risks are very high. In addition, there are considerable geological risks in the exploitation of geothermal resources.

Currently, geothermal systems have been used in Lower Saxony with about 10 percent of all new buildings. 7,000 near-surface geothermal heat pump systems with an installed capacity of about 70,000 kilowatts are estimated. In addition to solar thermal systems, condensing boilers and plants with combined heat and power, the use of geothermal heat pumps offer a great growth potential in the heating of building in Lower Saxony.

2.3 Energy generation in the Wachstumsregion Ems-Achse

As mentioned before the energy industry has a long tradition in the region. Besides the power generation from renewables there are 4 fossil power plants:

StatkraftMarkets GmbH Gaskraftwerk Emden	Emden	naturalgas/steamturbine	cold reserve, rated power 430 MW
RWE Power AG Kraftwerk Emsland	Lingen	natural gas	rated power 1.696 MW
BP Europa SE Raffineriekraftwerk Lingen	Lingen	fuel oil/natural and refinery gas	rated power 68 MW
RWE Power AG/E.ON Kernkraft GmbH KKW Emsland	Lingen	uranium	rated power 1.329 MW

Figure 16: Power plants in the Wachstumsregion Ems-Achse[45]

Due to favourable natural conditions and efforts of the public authorities and citizens, the number of renewable power plants is very high already but still increasing, whereas solar and wind energy plants predominate.

[44] 2013 Niedersachsen.de; http://www.umwelt.niedersachsen.de/umweltbericht/nutzungsfelder/energie/grundlagen/energie-89115.html

[45] Bundesnetzagentur, Kraftwerkliste 2013, http: http://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Sachgebiete/Energie/Unternehmen_Institutionen/Versorgungssicherheit/Erzeugungskapazitaeten/Kraftwerksliste/Kraftwerksliste_2013.xls?__blob=publicationFile&v=7, as of October 2013

Number of plants (renewables)	Waterpower	Wind	Biomass	Solar	total
Aurich		531	47	3.718	4.296
Emden		76	2	363	441
Emsland		488	212	9.208	9.910
GrafschaftBentheim	1	76	51	1.693	1.821
Leer		139	25	2.757	2.921
Wittmund		241	25	1.383	1.649

Figure 17: Number of renewable power plants in different counties of Wachstumsregion Ems-Achse[46]

	Waterpower		Wind		Biomass		Solar		**total**	
	Installed capacity [MW]	Generated power [GWh]	Installed capacity [MW]	Generated power [GWh]	Installed capacity [MW]	Generated power [GWh]	Installed capacity [MW]	Generated power [GWh]	Installed capacity [MW]	Generated power [GWh]
Aurich			640	1.473	19	115	77	59	**736**	**1.646**
Emden			145	334	20	130	8	6	**173**	**470**
Emsland			662	1.093	97	496	284	198	**1.043**	**1.788**
Grafschaft Bentheim	0,05	0,17	117	171	38	248	47	28	**202**	**448**
Leer			152	273	9	37	52	37	**213**	**347**
Wittmund			231	590	11	68	30	23	**272**	**681**

Figure 18: Installed capacity and generated power[47]

[46] Adopted from: Kröcher et al, Potenzialstudie Energieregion Nordwest, Oldenburg/Hannover May 2013
[47] Adopted from: Kröcher et al, Potenzialstudie Energieregion Nordwest, Oldenburg/Hannover May 2013

3 Policies for research and technological development (RTD)

The following chapter is going to give some insights on the existing strategies for research and technical development - from the Wachstumsregion Ems-Achse itself to actors on a regional and national level. Since different funding measures are often linked to these policies, an overview of some relevant programs will be given. These programs are limited to a national and federal state level.

3.1 Clusterstrategy

The Wachstumsregion Ems-Achse is a model of regional economic growth and development with clearly defined and dynamic growth centers. Since the industrial fields of the region are very divers, working groups consisting of the cluster members deal with the different strategic areas (Energy, maritime collective economy, mechatronics, synthetics, logistics, tourism and skills shortage(cross-disciplinary))[48].
With these working and project groups and the individual bodies of Ems-Achse[49], it is possible to develop specific strategies for each area and to constantly question and adjust those if necessary.

In the field of Energy, the strategic core areas are recorded in the Energy Resolution[50] which was signed by the steering committee in April 2008. In general it states that the members and partners of Ems-Achse recognize the opportunity the energy sector offers for the local economy. At the same time the partners are aware of their environmental responsibility and seek to promote the efficient use of energy and the development of renewable energy. Measures and goals which have been decided on are for example:

- Energy management for commercial and public sector
- Increase of energy efficiency in public and private buildings
- Education and benchmarking – for example the annual "Ems-Achse Energy Efficiency Award"
- The public authorities will ensure the prerequisites for planning of renewable energy plants of any kind - today and in the future (repowering of wind energy plants will play a major role)

The resolution is used as a guideline and cluster strategy the members agreed upon.

3.2 Smart Specialization

The counties and cities of the Weser-Ems region and therefore also the Wachstumsregion Ems-Achse want to contribute to optimal frame-conditions for future-oriented economic activity in the north west of Lower-Saxony and have formulated a regional strategy for smart specialization. The strategy "Wissensvernetzung in Weser-Ems 2020" is based on an intensive consultation process that the counties and cities pursued in Weser-Ems for more than a year with proven top-level representatives from business and science in the region. It is aligned with the initial-principles of "smart specialization", which the EU has defined as a prerequisite for the future regional development.

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[48] Compare 3.2 Economy
[49] Managing board, steering group, advisory board
[50] Official name: "Entschließung zur Energieeffizienz und dem Ausbau regenerativer Energieerzeugung in der Wachstumsregion Ems-Achse"

The three fields of action ("Wissensdrehscheiben") are: Energy, Food Industry and Maritime Economy.[51]
It was possible to already interlink this strategy with ENSEA in a first workshop "Wissensdrehscheibe Energie".

3.3 Internationalization

A good portion of the industry members of Ems-Achse are global players and are active at international markets. Based on their experiences we will try to make these strategies accessible to the other members of the cluster who are interested but not yet involved in international business.

Historically, university cooperation and academic exchange has always been focused on internationalization, e.g. in joint international publications, participation in international conferences and joint international projects between academic partners from different countries and continents.
Along with that, the energy research centre has signed several cooperation and project agreements with European and international partners, such as:

- Rome/ Italy
- Edinburgh/ UK
- Stavanger/ Norway
- Groningen/Netherlands
- Sichuan/ China
- Nigeria

Alike with the energy research centre Lower Saxony, the cooperating universities in Lower Saxony

1) Technical University of Clausthal
2) Leibniz University of Hannover
3) Technical University of Braunschweig
4) Georg-August University of Göttingen
5) Carl-von-Ossietzky University of Oldenburg

have a long history of internationalization, cooperation agreements and strategic alliances.
This entire network from energy research centre Lower Saxony including the 5 universities is complemented by the further roll-out of the ENSEA cluster in the future (associated partners).

[51] Arbeitsgemeinschaft der Landkreise und kreisfreien Städte in Weser-Ems, Wissensvernetzung in Weser-Ems 2020, Westerstede, March 2013

3.4 Actors facilitating research and technological development

There is a broad range of actors dealing with innovation on a national and regional level.

Despite the universities, universities of applied sciences and other research institutes, the chambers of crafts, chambers of commerce, the counties and municipalities are offering counselling to facilitate technological development and to stimulate innovation. They address company founders, innovators and mostly SMEs with specific funding programs or guidance.

To facilitate research the federal government and the different states offer a lot of funding possibilities:

„The funding of research in Germany is as diverse and differentiated as the German research landscape itself. The Federal Government and the federal states (Länder) act independently with regard to the funding and organisation of research, although they coordinate their efforts in joint bodies and sometimes in joint initiatives. They are also joined by private donors and companies that provide a high degree of funding for research and development. Additionally, the European Union provides extensive funding for research through a wide variety of measures.“[52]

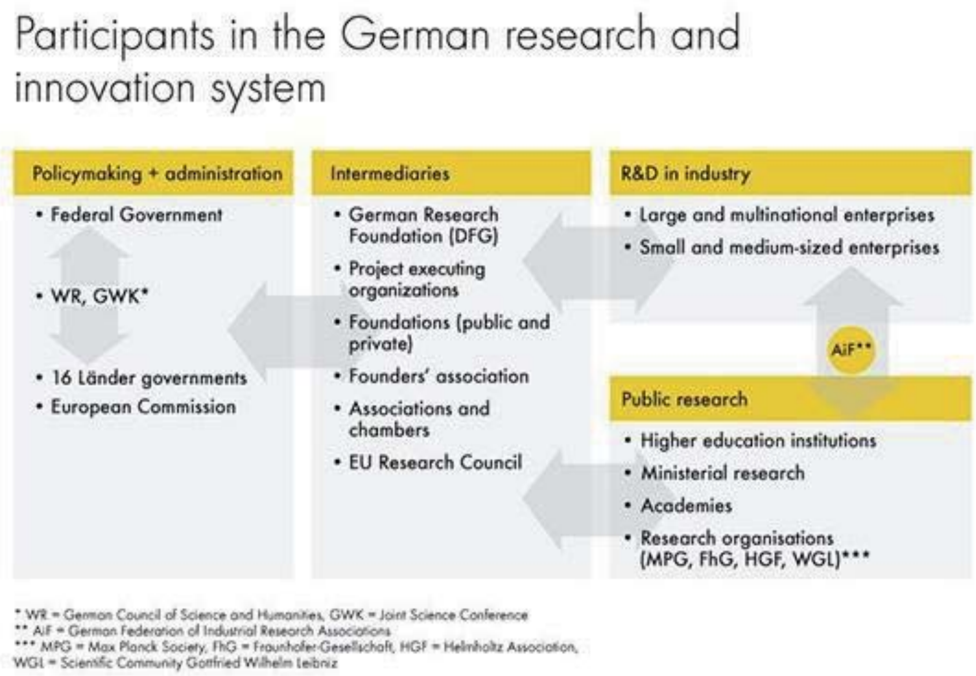

Figure 19: Participants in the German research and innovation system[53]

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[52] Research in Germany, Research Funding System, http://www.research-in-germany.de/dachportal/en/Research-Funding/Research-Funding-System.html, as of October 2013

[53] Federal Ministry of Education and Research, How does government funding work, http://www.research-in-germany.de/dachportal/en/Research-Funding/Research-Funding-System/How-does-government-funding-work.html, as of September 2013

3.5 Relevant policies at national and regional level

In 2006 the German Federal Government launched the so called High-Tech Strategy[54]. After 4 years it was decided to continue as High-Tech Strategy 2020 with the aim to create lead markets, intensify cooperation between science and industry, and continue to improve the general conditions for innovation. Overall there are 17 areas the strategy is focussing on, concerning „Energy“ the most relevant are:

- CO_2-neutral, energy-efficient and climate-adapted cities
- Intelligent restructuring of the energy supply system
- Renewable resources as an alternative to oil

In the governments draft budget for 2014 the funding for projects under the umbrella of the High-Tech Strategy is 2.1 billion Euro, which is 17% more than in 2009.

The administration of Lower Saxony is aiming at promoting innovative advances. "To this end, its Ministry of Economic Affairs, Employment and Transport is launching state-level initiatives in areas of activity that hold particular importance and promise for the federal state's economic development. These initiatives are setup in those fields where a future trend to this effect is discernible, where markets show clear movement in this direction, and where there is existing potential.“[55]
The current initiatives are:

- Adaptronics;
- Fuel cell and battery technology;
- Healthcare management - Life Sciences Niedersachsen;
- Micro system technology;
- Nano-innovations and materials innovations;
- Telematics;
- Satellite navigation (GAUSS);
- Food industry;
- Logistics;
- Aerospace industry, Niedersachsen Aviation

These initiatives persist for usually three years and the state government provides a budget from which innovative projects may be financed.

In the following relevant funding opportunities for research and innovation are described more detailed. The list is not exhaustive but will give an overview of some national and regional programs.

[54]Compare: Federal Government, High-Tech Strategy, http://www.2012.hightech-strategie.de/en/350.php, as of October 2013
[55]LowerSaxony, state-level technological initiatives, http://www.lower-saxony.de/portal/live.php?navigation_id=28550&article_id=99179&_psmand=1016, as of October 2013

3.5.1 National level

On the national level mostly the Federal Ministry of Economics and Technology and the Federal Ministry of Education and Research offer monetary possibilities to facilitate R&D.

Federal Ministry of Economics and Technology:

- **6. Energieforschungsprogramm der Bundesregierung (engl.: 6th Energy-research program of the federal government)**

The program is carried out together with the Federal Ministry of the Environment, Natural Conservation and Nuclear Safety, the Federal Ministry of Food, Agriculture and Consumer Protection and the Federal Ministry of Education and Research.
The strategic focus is on the priority areas renewable energy, energy efficiency, energy storage systems, grid technologies and the integration of renewable energies into the energy system. For the funding period from 2011 to 2014 2.24 billion Euro are/have been available.
Companies, research institutions and universities can apply. Whereas companies have to take 50% of the costs themselves, research partners may get a funding-quota of 100%.[56]

- **BMWI-Innovations gutscheine (go-inno)**

With these „innovation coupons "the ministry is funding external consultancy services to facilitate innovation and increase competitiveness of companies, including skilled crafts and trades. The coupon will compensate for 50% of the costs. The program is divided into two different areas: "innovation management" and "resource- and material efficiency". The funding is not restricted to certain industries or branches but it is only available to SMEs (in exceptional cases companies with less than 1000 employees may apply).[57]

- **High-Tech Gründerfonds**

Together with partners from German industry, the Ministry of Economics and Technology supports entrepreneurs by financing them "on attractive terms and actively supporting their management teams with a strong network and entrepreneurial expertise"[58]. High-Tech Gründerfonds Management GmbH will provide initial financing of up to 500,000 EUR in the form of a subordinated convertible loan, and acquire a 15% nominal share of the company. They will also reserve a further 1,5 million EUR for follow-on financing. The loan will have a term of 7 years. The contribution of the entrepreneur to the financing must be 20% of the investment.

Eligible for funding are companies located in Germany which have been operating for less than one year and are based on a technological innovation which offers strategic competitive advantages.

- **SIGNO**

This initiative aims at helping universities and SMEs to protect their innovations and make use of them commercially. For both the funding quota is 40%. Universities can apply if they want to development strategies to collaborate with economy or improve the application of research results. SMEs find advice and financial help on how to apply for a patent. There is also an internet-platform where innovations and investors are brought together (www.innovationmarket.de).

[56] Bundesministerium für Wirtschaft und Technologie, Förderdatenbank, http://www.foerderdatenbank.de/Foerder-DB/Navigation/Foerderrecherche/inhaltsverzeichnis.html?get=6d69ab0c2543e7448c16c5345c79c40d;views;document&doc=7510
[57] Bundesministerium für Wirtschaft und Technologie , BMWI-Innovationsgutscheine, http://www.bmwi-innovationsgutscheine.de/go-inno/index.php
[58] High-Tech Gründerfonds Management GmbH, http://www.en.high-tech-gruenderfonds.de/

Federal Ministry of Economics and Technology/Aif - Arbeitsgemeinschaft industrieller Forschungsvereinigungen:

- **IGF – Industrielle Gemeinschafts forschung**

The overall goal is to bring together basic research and economic application. The program helps SMEs to solve their common problems through joint research activities, mainly carried out by universities and non-profit research institutes. The participants share their results with everyone involved in the projects because they also share the risks.
Cornet - Collective Research NETworking, transnational projects

Federal Ministry of Education and Research:

- **KMU-innovativ**

KMU-innovativ (engl.: SME-innovative) is a program to help SMEs finance world-class research. SME are very often precursors of technological progress but for most of them the financial risks to undertake necessary research activities are too high.
The program is divided into different topics, the one concerning energy is mostly "Technologies for resource and energy efficiency". Funding is available for high-risk industrial research and pre-competitive development projects which are interdisciplinary and application-oriented. The funding rate may rate up to 50%.

- **Zentrales Innovations programm Mittelstand - ZIM:**

This "Central Innovation Program for SMEs" funds individual projects, cooperation projects and so called cooperation-networks with a funding quota up to 45 %.
There is no restriction to topics. Fundable are R&D projects of SMEs to develop new products, procedures or technological services. Within "cooperation-networks" also the management activities of the network is fundable, since a new network is going to be developed around the project activities.

Kfw – Kreditanstalt für Wiederaufbau:
The Kfw is the business development bank of the German federal government and one of the world's leading development banks. The bank is committed to improving economic, social and ecological living conditions all around the world on behalf of the Federal Republic of Germany and the federal states. "KfW committed EUR 29,2 billion worldwide for climate protection and environmental projects in 2012. KfW is Germany's largest environmental and climate bank. As a promotional bank that seeks to initiate new developments with its loans, it is important for KfW to promote sustainable investments that benefit environmental and economic development equally. This is a central theme that also guides its funding activities. For example, KfW does not finance any projects that are likely to have unacceptable ecological or social impacts. For this reason all KfW bonds are so-called "green bonds", which socially responsible investors (SRI) can purchase with a good conscience."[59]

[59] KFfW Group, 2000 till today, https://www.kfw.de/KfW-Group/About-KfW/Identität/Geschichte-der-KfW/2000-bis-2010/, as of October 2013

Private customers, companies and public institutions can make use of investment credits with favourable conditions if they meet the different requirements. Usually funded are infrastructural measures but there are also programs for, e.g., education, start-ups or international projects of companies to accelerate innovation in German economy.
One of the different programs is executed with the Federal Ministry of the Environment, Natural Conservation and Nuclear Safety:

- **BMU Umwelt innovations programm (UIP)**

Funding is available for large-scale technological processes and combination of different processes which reduce or avoid ecological impacts. The technique has to be new or must be combined with other processes in a new way and has to be used the first time in Germany on a large-scale basis. Eligible applicants are domestic and foreign commercial companies in Germany as well as other natural and legal persons of private law, municipalities, counties, community organisations, municipal associations, corporations and other public institutions as well as companies linked to local authorities. However, applications of SMEs are preferred. In this program funding will be provided as interest subsidy to reduce the cost of an by the KfW refinanced bank loan or as an investment grant.

Besides the KfW there is the Landwirtschaftliche Rentenbank, Germany's development bank exclusively for agricultural economy. "The bank focuses on granting standard promotional loans as well as special promotional loans at particularly favourable interest rates for agribusiness and rural areas."[60] The bank offers funding possibilities for energy projects and innovation in the agricultural energy sector in the form of favourable conditions for loans.

3.5.2 Regional level (Lower Saxony)

Ministry of Economics, Labor and Transport:

- **Zukunft und Innovation Niedersachsen**

Goal of the program is to strengthen the innovation capacities of economy in Lower Saxony. It is divided into 5 different areas

A. Technology-based projects dealing with societal problems
B. Dialog between Science, Economy and Civil Society
C. Technology-Contests
D. Collaboration of Schools, Universities and Economy
E. Support of applications for national and EU-programs

The eligibility requirements and funding opportunities differ from area to area.

Ministry for Environment, Energy and Climate:

The ministry is funding research and development of new technologies in the field of renewable energy, energy conservation and fuel cells. It especially supports small and medium-sized

[60] Landwirtschaftliche Rentenbank, http://www.rentenbank.de/cms/beitrag/10011592/262501/?, as of October 2013

enterprises, which develop products of renewable energy and/or innovative techniques for energy efficiency and energy saving measures. Collaborations with universities are desirable. Emphasis is on the topics:

- Fuel cells
- Energy Saving
- Fuels of the future

For SMEs the funding-quota is 45% or less. The funding itself is processed by the N-bank.

N-Bank:
The Investitions- und Förderbank Niedersachsen, or so called N-Bank, is the business development bank of Lower Saxony.
"All federal subsidy schemes aiming to back the regional economy, labour market and education, as well as grants for housing and urban development, are processed centrally in the N-Bank."[61]
There are specific programs for industry, private individuals and public institutions. Several are dealing with innovation and matters of energy efficiency.[62]

[61] NBank, profile english, http://www.nbank.de/_downloads/Die_NBank/NBank_Profile_englisch.doc.pdf, as of October 2013
[62] Nbank, Übersicht Förderprogramme, http://www.nbank.de/Service/Uebersicht_Foerderprogramme.php, Stand October 2013

4 Description of the methodology

The aim of WP2 is to generate metrics that provide insight into the following areas of interest for comparing the ENSEA research driven regional energy clusters (and their parent countries):

- Research strengths in the sector, public institutions
- Research strengths in the sector, private institutions
- Effectiveness of existing linkages and collaborations
- Skills availability
- Talent attraction
- Capacity for EU and international engagement

Additional information was also collected on:

- Background economic data including public and private spending on R&D, numbers of researchers, size of workforce for each of the ENSEA regions (or for the parent country if regional data was unavailable).
- Comparator metrics for a few leading and newly emerging countries (to include China (and the Sichuan region of China).

The collection methods for the ENSEA SWOT analysis were in general:

- Use of a consultant to collect data for all the ENSEA regional clusters using metrics defined in the European Innovation and Regional Innovation Scoreboard
- Desk-based research to capture analyses of aspects of local energy innovation systems and gather relevant statistical material
- Interviews with key institutions in energy research and innovation in the cluster to collect detailed information that is not available from the desk research
- Regional workshops with local companies or Higher Education Institutes (HEIs) to identify any perceived barriers to increased energy innovation and to help evaluate the effectiveness of current research and policy support
- Social Network Analysis to capture the linkages between stakeholders within and between the ENSEA clusters

Since some of the methods did not apply to all of the partners, some measures had to be left out or supplemented accordingly. For example, the methodological framework of the Innovation Union Scoreboard (IUS) and the Regional Innovation Scoreboard (RIS) do not match with regions of the Ems-Achse. It was possible to provide data for Lower-Saxony but one cannot draw conclusions for the cluster region itself from these figures.
For the German partner Wachstumsregion Ems-Achse an intense desk-based research was conducted. As part of the research in order to easily understand and compare the focus of activities in energy within the clusters a matrix was designed to be filled in as much as possible by each region. The purpose of the matrix is to provide a guide for the SWOT assessment activities by identifying levels of triple helix (research, Government and company) activity being carried out by each region. The original Matrix was later used in a simplified form due to problems collecting relevant data and filling it in.
To get the necessary information recent studies were used and a list of companies in the energy industry within the region was prepared and divided into SMEs and non SMEs. In some cases it

was possible to obtain turnover and number of employees but since these figures were not available for most of the SMEs it was decided not to make use of them. In addition to a regional workshop with about 100 participants held in September, a survey among the identified companies was conducted. The answers were integrated into the different thematic SWOTs. To get an overview of the research activities of the scientific partners of Ems-Achse, the Energie-Forschungszentrum Niedersachsen also conducted desk-based research and a survey to collect regional data “research strength in the sector”.
Therefore, following the WP2 Matrix agreed among the ENSEA consortium, economic data on public spending was collected and evaluated. The Federal Government in Berlin offers a huge data portal (www.foerderportal.de) in which all funded projects in Germany are listed.
Hence, within the framework of a Boolean search, the project database was analyzed to find out the number of research projects and the amount of funding in each of the Matrix categories. In order to collect respective data the Boolean search was conducted as follows:

- Terms "energy" AND "biomass" for renewable energy and biomass
- Terms "energy" AND "geothermal" for renewable energy and geothermal
- Terms "energy" AND "hydropower" for renewable energy and hydropower
- Terms "energy" AND "offshore wind" for renewable energy and offshore wind
- Terms "energy" AND "onshore wind" for renewable energy and onshore wind
- Terms "energy" AND "solar" for renewable energy and solar
- Terms "energy" AND "marine power" for renewable energy and marine power

The same methodology was applied for all other the categories power plants, grids, etc. including their respective sub-categories, e.g. coal-fired plants, gas and steam plants, biomass plants in the category power plants.

The output was a comprehensive set of data describing amongst others the following items:

- The Ministry Department that enabled the research project, e.g. Federal Ministry of the Environment, Federal Ministry of Economics, Federal Ministry of Finance, Federal Ministry of Agriculture etc.
- The beneficiary including the Bundesland and city where the beneficiary is based
- The executing institution including the Bundesland and city where the executing institution is based
- The topic of the research project
- A short description of the research project in clear text
- The lifespan of the project , i.e. start date and end date (only projects from 2008 onwards were evaluated, those projects that ended before 2008 were taken out of further data processing)
- Total amount (€) that was spent on the research project
- Additional information on the project's profile

In a second step, the data set was further analyzed and processed. Two filter streams were opened in order to be able to describe the overall situation in the Federal Republic of Germany (16 Bundeslaender) as well as to describe the situation in the Bundesland at focus, i.e. Lower Saxony.

In order to complement the study, the following 5 major universities and technical universities based in Lower Saxony and with their respective Departments that are aligned with energy topics and being part of the structure of the Energy Research Centre of Lower Saxony were surveyed both by direct contact and interviews:

1. Technical University of Clausthal
2. Leibniz University of Hannover
3. Technical University Carolo-Wilhelmina of Braunschweig
4. Georg-August University of Göttingen
5. Carl-von-Ossietzky University of Oldenburg

The data feedback from the university survey together with the Federal Government database analysis was then merged and summarized. From there, the data was transferred to the simplified regional matrix describing the role of research in terms of number of projects in the respective field of research as well as the round figure of money spent on the research(quantitative data).

The figures provided give an overview of the number of research projects concerning energy, the research topics and the round figure of funding.
All results were used to prepare the following SWOT-analyses.

5 SWOT Analysis

For the Wachstumsregion Ems-Achse different SWOT analyses have been created – the first reflects the cluster in the context of the German energy transition and further SWOTs cover the different economic focus points of the energy sector in the region. This was regarded necessary because the region covers various types of renewable energy generation which are basically different in technical aspects and also have different requirements.

5.1 Ems-Achse overall

Strengths	Weaknesses
▪ Dynamic economic development, headquarter of large companies ▪ Good interregional transport connection ▪ Moderate location-related costs for companies ▪ High quality of life in the region, partially tourist region ▪ existence of various industry networks, also in the area of energy efficiency and energy in general ▪ highly developed corporate structure concerning renewable energy; emphasis on: - Wind energy - Bio energy - Solar energy - Energy storage – underground - Technology providers in the field of energy supply/infrastructure - Energy hub for fossil energy ▪ Implementation of large energy projects (in a regional and international context)	▪ Low density of universities and research institutions (in Ems-Achse region) ▪ Partially significant demographic change with stagnation of population number

Opportunities	Threats
▪ Interdisciplinary and cross-sectoral approaches may increase competitiveness in the region ▪ Further development of networking and cooperation promotes capacity for innovation and the region's profile ▪ Target-oriented training and education of employees ▪ Increase of technology transfer to SMEs ▪ Internationalization offers new opportunities for growth and new markets for economy ▪ Development of a clear profiling strategy	▪ Demographic change and growing qualification requirements of the economy increase the competition for skilled employees ▪ International competition requires a clearly defined profiling strategy of the regions ▪ Increasing cost pressure in the area of production ▪ Developments on the energy market ▪ Developments on the financial market – availability of investment funds

5.2 Wind Energy

Strengths	Weaknesses
▪ Wind energy is a central element of the German „Energiewende" ▪ Important location for wind power generation ▪ location of important technology providers with a high level of vertical manufacturing and worldwide sales and distribution[63] ▪ Corporate structure with a high proportion of SMEs in project planning and construction ▪ Offshore wind energy under development ▪ Location of ports with expertise in the offshore industry and logistics ▪ Innovation capability of companies ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ <u>Research activities:</u> FORWind Centre for wind energy research Offshore: - Modeling of wind fields - Wind performance forecast systems based on energy meteorology (interface between renewable energies and atmospheric physics) Onshore: - Cross-linked multi-phase transport techniques (sub sea, off-/ onshore) - Onshore wind atlas for Germany	▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated ▪ Increasing use of repowering possibilities ▪ Due to a lack of storage technologies wind power cannot be used as base load ▪ Offshore technology is very capital-intensive

[63] Kröcher et al., Potenzialstudie Energieregion Nordwest, Oldenburg/Hannover Mai 2013, p. 74.

Opportunities	Threats
▪ Growth spurt from offshore; ▪ New priorities of funding strategies ▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach ▪ Development of suitable storage methods ▪ Power to Gas	▪ Strongly dependent on regulations ▪ Uncertainties concerning connection to the grid (offshore) ▪ High costs and risks in the offshore-sector ▪ Developments on the energy market ▪ Spatial concentration of production of plants ▪ Slow network expansion (grid) ▪ Other legal restrictions ▪ Complex approval and licensing procedures ▪ Access to investment funds - financial markets ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ location of onshore-wind energy plants, authorization process ▪ Amendements of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel ▪ Need, requirement of land and competition for areas ▪ Power generation varies considerably with wind regime

5.3 Bio Energy

Strengths	Weaknesses
▪ The region is a leading generation site as well as a location of technology providers[64] ▪ Innovation capability of companies ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ Research activities: - Bionics: Implementation of natural fermentation of input materials into technical solutions - Genetics: Genetic increasing of the carbon content in the power plant - Optimization of process control of biogas plants - 2nd generation biofuels (BtL) - Sustainability assessment	▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated ▪ Corporate structures characterized by small and medium-sized businesses - problem for internationalization strategies[65] ▪ Increasing risk because of shortage in raw material supply ▪ Declining profitability of investments/cost effectiveness of plants depending on the legal framework (EEG-German Renewable Energy Law)
Opportunities	**Threats**
▪ New perspective: direct marketing[66] ▪ Provider of balancing energy ▪ Important role in ensuring the base load in regional virtual power plants ▪ Economical implementation of existing research to applicable technologies ▪ integration of waste management in energy supply offers great potential ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach	▪ Non acceptance of local residents ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Other legal restrictions ▪ Complex approval and licensing procedures ▪ Access to investment funds - financial markets ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ Amendements of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel ▪ Emergence of overcapacities – a significant expansion of capacities is not expected ▪ Conflicting uses of input materials for biogas plants with comestible goods and land usage ▪ Reasonable utilization of digestates

5.4 Solar Energy

Strengths	Weaknesses
▪ It is possible to integrate solar panels in already existing structures (for example roof areas). There are no conflicts with other kinds of utilization ▪ Very large numbers of diverse companies in the region ▪ Strong user- and service-orientation of enterprises ▪ Innovation capability of companies ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ Research activities: - Sun house concept (vessel-solar-combination, small-scale storage) - Next generation silicon wafer cells	▪ Lack of open area (large-scale) plants ▪ Large numbers of small photovoltaic units ▪ Trend to overcapacities of products, but technology providers are rare ▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated ▪ Declining profitability of investments/cost effectiveness of plants depending on the legal framework (EEG-German Renewable Energy Law) ▪ Significant power fluctuations depending on the weather
Opportunities	**Threats**
▪ Economical implementation of existing research to applicable technologies ▪ Development of system solutions in the field of PV combined with storage options for the user ▪ Increase of efficiency ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach Development of suitable storage methods	▪ Local conditions rather disadvantageous (sunshine duration) ▪ Particularly dependent on national policy of subsidies ▪ High risk due to storm damage (for example hail) ▪ Costs of electricity are high compared to other technologies ▪ Increasing number of trade rivals worldwide ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Other legal restrictions ▪ Complex approval and licensing procedures ▪ Access to investment funds - financial markets ▪ Continuation of German „Energiewende" ▪ Political uncertainties ▪ Amendements of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel

5.5 Geothermal Energy

Strengths	Weaknesses
▪ Favourable natural conditions[67] ▪ Geothermal energy is available at any time - base load provision is possible ▪ Research activities: - Energy atlas CCS vs. deep ground geothermal energy - Research alliance on geothermal energy and high performance drilling (GEBO) - Drilling Simulator Celle	▪ As generation site as well as a location of technology providers of minor importance ▪ Exploration is expensive

Opportunities	Threats
▪ Development potential for energy production (capabilities for base load) ▪ Part of the concept for the German "Energiewende" ▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach	▪ Local acceptance issues of large-scale applications (Uncertainty of geophysical reactions) ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Other legal restrictions ▪ Complex approval and licensing procedures ▪ Access to investment funds - financial markets ▪ Continuation of German „Energiewende" ▪ Political uncertainties ▪ Amendements of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel

[67] Accordingto: Geodatenzentrum Hannover, Nibis-Kartenserver, http://nibis.lbeg.de/cardomap3/?TH=545.314, asof September 2013.

5.6 Marine Power

Strengths	Weaknesses
	▪ Little potential ▪ Particularly strong competition with other uses
Opportunities	**Threats**
▪ Long-term perspectives ▪ Synergies between energy and maritime economy	▪ Growing acceptance issues concerning large-scale projects

5.7 Hydro Power

Strengths	Weaknesses
▪ Pump storage power plants can be run highly flexible ▪ High efficiency, up to 95% ▪ Low costs of operation ▪ Longevity ▪ Research activities: - Mini-hydropower stations	▪ Little development potential in Lower Saxony due to topography
Opportunities	**Threats**
▪ European cooperation in the area of hydro power	▪ Growing acceptance issues concerning large-scale projects

5.8 Fossil Energy

Strengths	Weaknesses
▪ Region is important location for conventional power plants ▪ National importance in converting – region as energy hub[68] ▪ Innovation capability of companies – development of new business areas ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ Research activities: - Post-combustion CO_2 separation - Efficient transformation of fossil energy carriers in power plants - power plant simulation	▪ Finite energy source in the long run ▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated
Opportunities	**Threats**
▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach	▪ Growing number of coal-fired power stations is not likely ▪ Declining acceptance concerning winning and production ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ Lack of qualified personnel

[68] Kröcher et al., p. 27.

5.9 Energy Storage

Strengths	Weaknesses
▪ Region is leading in underground storage ▪ Favourable geological conditions for underground storage[69] ▪ Innovation capability of companies – development of new business areas ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ Research activities: - Battery test centre for electro mobility and energy storage - POWER TO GAS and other energy storage schemes to store and utilize renewable energy - Underground pumped storage stations - Compressed air storage	▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated
Opportunities	**Threats**
▪ Growing need for storage technologies ▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach ▪ Power to Gas ▪ Further development of hydrogen technology, storage of hydrogen in caverns[70]	▪ Growing acceptance problems ▪ Developments on the energy market ▪ Slow network expansion (grid) ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ Amendements of the Erneuerbare Energien Gesetz (EEG) ▪ Lack of qualified personnel

[69]Accordingto Landesamt für Bergbau, Energie und Geologie, Salzlagerstätten, http://www.lbeg.niedersachsen.de/portal/live.php?navigation_id=665&article_id=555&_psmand=4, asof September 2013.
[70]Crotogino, Hamelmann, Wasserstoff-Speicherung in Salzkavernen zur Glättung des Windstromangebots, http://www.ipp.mpg.de/ippcms/ep/ausgaben/ep200802/bilder/wasserstoff_speicher.pdf, asof August 2013

5.10 Energy Supply/Infrastructure

Strengths	Weaknesses
▪ A large share of the distribution networks belongs to regional/local actors ▪ Leading technology providers (cable manufacturing, computer science for power and energy systems)[71] ▪ Central »hot spot« in the international distribution system, especially for Norway/ Scandinavia ▪ Innovation capability of companies – development of new business areas ▪ Regional production conditions ▪ High regional involvement of companies ▪ Strong reliable industry networks ▪ Research activities: - Sustainable planning of low voltage utility grids (e-home) - ICT infrastructure for reliable electricity supply along with decentralized power generation (Smart Nord)	▪ Complex and diverse business areas demand high standards from the qualification of employees – a huge demand for highly specialized and interdisciplinary skilled workers is generated ▪ Load management relatively inflexible in base load operation so far
Opportunities	**Threats**
▪ Internationalization of the power grid infrastructure ▪ Smart Grids ▪ Gas network essential for the German “Energiewende” ▪ Power to Gas - Technology ▪ Decentralized power generation by gas-fired plants ▪ Economical implementation of existing research to applicable technologies ▪ Development of qualification strategies, if possible already during first education (training on the job, university, apprenticeship etc) ▪ Strengthening and further cooperation of industry networks and cluster ▪ Support of the Triple Helix-approach	▪ Growing acceptance problems concerning network expansion ▪ Guarantee of network security ▪ Slow network expansion (grid) ▪ Continuation of German „Energiewende“ ▪ Political uncertainties ▪ Lack of qualified personnel

[71] Kröcher et al., p. 136.

5.11 Triple-Helix Matrix

Based on the data of the different SWOTs and the background studies which were used the following preliminary findings have been drawn about the relative strengths of Wachstumsregion Ems-Achse and Science represented in Lower-Saxony[72]. The focus is on thematic areas identified as being of interest for the ENSEA-partnership as a whole.

Explanatory notes:

- In the column "Science Lower Saxony" the number of projects and the overall amount of funding are listed, both for Lower-Saxony and for Germany in brackets underneath.
- The "Government" column is describing the responsibilities and tasks of the local authorities.
- The company column shows the number of SMEs and non-SMEs working in that field in the Ems-Achse region.

The colours express
Green: Expertise for further development
Amber: Basis for further development
Red: Limitations or relevant only to a limited extent
Grey: Not applicable

[72] As described in chapter

Themes	Science Lower Saxony	Government	Company base Ems-Achse	Overall for region
Supply flexibility	19 projects/ 10.7M€ (D: 292/ D: 193.4M€)	Municipal energy providers covering renewable and conventional energy production	Non-SMEs 17 SMEs 15	
Storage	126 projects/39.9M€ (D: 603/ D: 474.2M€)	Authorization processes Public hearings/concerns of the public Realization of Interreg IVa project NEND-Nachhaltige Energie Niederlande Deutschland (8 M€)	Non-SMEs 6 SMEs 1	
Carbon Capture & Storage		Moratorium until 2015 (in Lower Saxony)		
Demand flexibility	n.a.	Climate Center North- energy efficiency cluster for SMEs Emsländische Energieeffizienz agentur energy efficieny regulations for public buildings Ems-Achse Energy Efficiency Resolution Realization of Interreg IVa project NEND-Nachhaltige Energie Niederlande Deutschland and HEC-Hansa Energy Corridor (1.2 M€)	Non-SMEs 3 SMEs 5	
Grid / Infrastructure	6 projects/ 1.2M€ (D: 39/ D: 15.2M€)	Authorization processes, but limited by Federal Net Agency Public hearings/concerns of the public	Non-SMEs 12 SMEs 13	Dependent on speed of grid/system expansion
Integration Methods	23 projects/n.a.	growing importance		Currently only academic focus
Boundary Conditions	all faculties are involved in the topic, very broad range	development and implementation of regional funding programs Execution of region, national and European funding programs Counselling for start ups and SMEs Municipal climate protection programs EEG-German Renewable Energy Law (Federal)	Not applicable	

Renewable generation	180 projects/ 129.1M€ (D: 1.758/ D: 1.004M€)	Authorization processes Public hearings/concerns of the public Realization of InterregIVa project Hansa Energy Corridor	Non-SMEs 23 SMEs 243	
In Detail				
Wind onshore	10 projects/ 5 M€ (D: 25/ 11,9 M€)	Realization of InterregIVa project HEC-Hansa Energy Corridor (1.2 M€)	Non-SMEs 6 SMEs 25 Windparks 19	
Wind offshore	50 projects/ 60,5M€ (D:244/ 179,4 M€)	Realization of InterregIVa project HEC-Hansa Energy Corridor (1.2 M€)	Non-SMEs 5 SMEs 15	
Solar	75 projects/ 43,6 M€ D: 1.070/ D:627 M€	RealizationofInterregIVaproject NEND-Nachhaltige Energie Niederlande Deutschland (8 M€)	Non-SMEs 4 SMEs 91	
Geothermal	12 projects/12,4 M€ D: 62/ D:45,1 M€		Non-SMEs 1 SMEs 1	
Biomass	33 projects/ 7,5 M€ D: 342/ D: 134,5 M€	Realization of Interreg IVa project NEND-Nachhaltige Energie Niederlande Deutschland (8 M€) GroenGas(8 M€)	Non-SMEs 5 SMEs 37	
Hydro	D:12/ D: 4,1 M€			
Marine Power	D:3/ D: 0,9 M€			
Engineers, consultants etc.			Non-SMEs 2 SMEs 55	

6 Summary & Conclusion

The Wachstumsregion Ems-Achse, with its diverse activities and competencies in the energy sector, has emerged as a location of renewable energy in a relatively short period of time. Through the cooperation with the EFZN the scientific know-how could be expanded for the region in addition to the existing scientific institutions and universities.

The research for WP2 has shown that companies in the Ems-Achse region have a good innovation development and are widely linked within the industrial sector. Furthermore, it can be stated that the special situation in Germany with enacting the “Erneuerbare Energien Gesetz” (Renewable Energy Law) has brought a positive stimulus to the development of innovation in the field of renewable energy.

At the same time, funding and support programs in the field of energy have been provided – in the scientific as well as in the scope of federal and state governments. Within the Wachstumsregion Ems-Achse energy projects involving the complete triple helix, business, science and politics/administration were consistently implemented successfully. This has also significantly contributed to the apparent good performance of the Ems-Achse region.

However, a successful energy transition in Germany requires even greater efforts of system integration or balancing of our energy system than today. Also, the system expansion should be pursued to the required extent. Grid stability and system security and the promotion of the development and testing of suitable storage methods have to play a central role in our efforts.

The set of SWOT analyses shows very vividly the strengths and weaknesses, but also the opportunities and risks of the Wachstumsregion Ems-Achse. It is essential to benefit from these strengths and opportunities at a local level and to extend and develop them further in an international context together with our partners in the ENSEA-region. Likewise, common solutions are developed to diminish risks and provide expertise as required from the stakeholders in the region. This step takes place in the creation of a so-called Joint Actions Plan.

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European North Sea Energy Alliance

Regional Report of Rogaland

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1 Introduction

The European Union faces some serious challenges as a result of policy objectives like ensuring a competitive, sustainable energy supply by 2020 (Europe 2020 strategy) and achieving a resource efficient and low carbon economy by 2050 (Resource efficient Europe2). Currently, policy trajectories focusing on energy innovations through knowledge exchange are thought to face three important objectives.

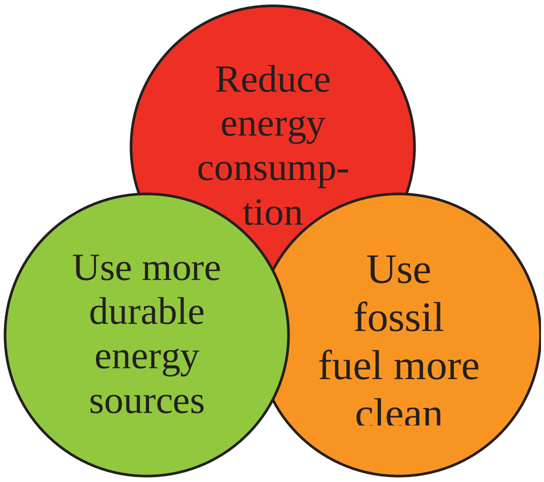


Figure 1: Policy trajectory focusing on three important objectives

The use of renewable energy sources will play a key role in achieving CO2 reduction targets. Renewable electricity generation will need to double between now and 2020 to meet the EU's 2020 targets. Up to 60% of this new capacity is expected to come from offshore renewables, with much of this being installed in the North Sea Region.

Operating a power network with a high share of intermittent renewables will be very different from the way these networks operate at present. Their presence will create significant challenges to maintain quality and security of supply, mainly because of the variability (or intermittency) of their output. The diagram below (*figure 2*) shows the impact of this variability on an energy system in 2025, with a high level of wind power. By 2025 output from wind turbines will sometimes dominate the system and at other times play a much smaller part in meeting demand. Successfully operating such a system will most likely require a combination of flexible technologies that can offset this variability. This diagram shows the increased role of gas as a buffer to stabilize the system, however, there could be a variety of solutions including making energy consumption more flexible (demand side management), more use of energy storage, more flexible generation and more interconnection between networks.

Assessing the contributions of each of the options will help guide near-term investments in infrastructure, generation capacity and innovation. This is a critical area in which understanding needs to be improved.

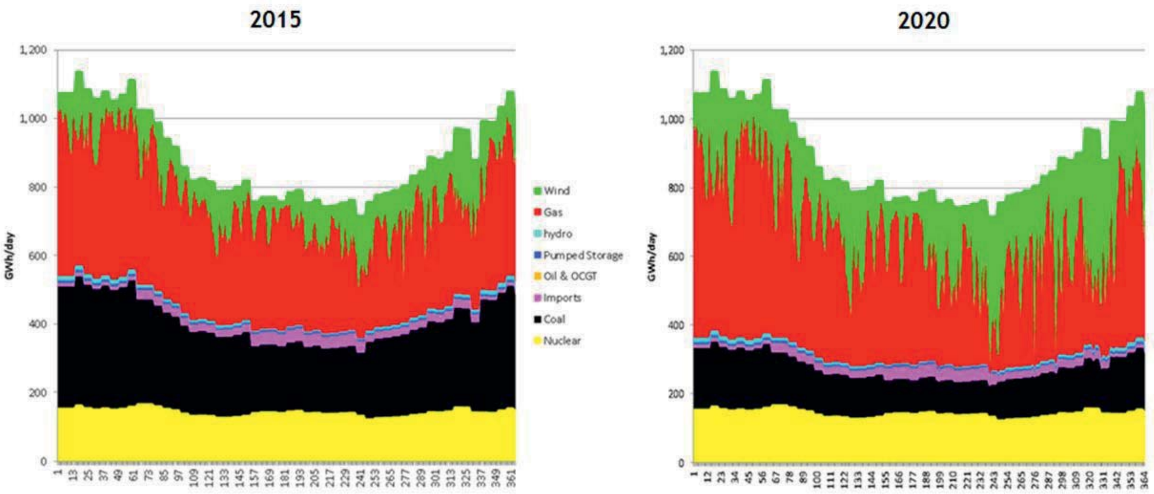


Figure 2: Prediction of energy production and demand in 2015 (left) versus 2020 (right).

Source: The impact of import dependency and wind generation on UK gas demand and security of supply to 2025, Oxford Institute for Energy Studies 2011)

The European North Sea Energy Alliance (ENSEA) aims to increase the competitiveness of research driven energy clusters through better coordination and exploitation of research. To deliver the "20-20-20" climate and energy goals as well as sustainable growth, the European energy system has to change rapidly to accommodate more renewable energy.

ENSEA proposes a holistic focus on the energy system that will generate innovative solutions to meet the challenges and market needs of a resource efficient Europe. Successful exploitation of these innovations will provide new business opportunities and boost the competitiveness regional clusters and the European economy in general.

A key driver for cluster policy definition in ENSEA will be the adoption of an energy system approach by all four partner regions, focusing on how to handle the rising share of renewable energy production in the existing energy system. ENSEA regions capitalize on the current successful collaboration between the Northern Netherlands and North Western Germany (Hansa Energy Corridor) extending this approach to Scotland and Norway.

Through regional analyses, followed by the creation and implementation of Joint Action Plans facilitated by the generation of “competence pools”, partners will identify exchange and implement “good practice” policy measures for stimulating research and technology transfer. Partners will leverage funding sources at regional, national and European level. Best practice will be identified from within the regions, other successful European and international clusters, and established Key Driving Forces and Economic Performance Indicators.

Target areas for policy measures include:

Better coordination of research, exchange of knowledge and staff through the development of joint demand driven research programs between the regional Energy Academies

Strengthening basic and applied Research and Technology Development (RTD) by facilitating collaborations and valorisation of results between different actors in the cluster to secure the right focus in research and to ensure implementation of results

Strengthening RTD collaboration by facility sharing measures to improve access to RTD facilities both within and between the clusters facilitating more cost-effective energy research

Supporting technology transfer by bringing entrepreneurs and researchers together through social networking, facilitating financing opportunities and improving support infrastructure for SME's

Capitalizing on international links, including existing collaborations with the Sichuan Region in China, through the development of a joint internationalization strategy

This report provides regional overview of the energy related topics of interest for the ENSEA project for the Rogaland region.

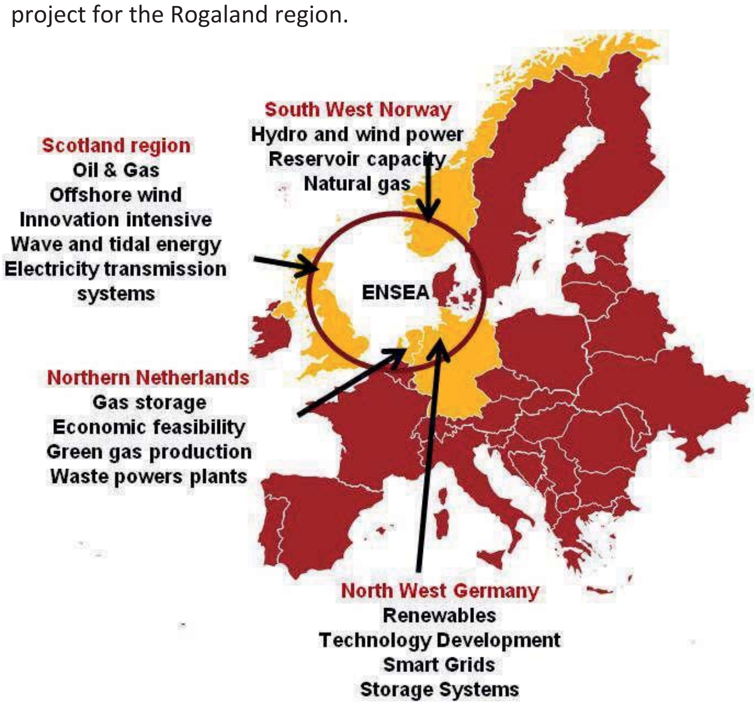


Figure 3: The ENSEA partners and their main competences

2 Objectives

The main objective of this report is to provide information about the current status of the energy related topics in Rogaland as a base for the regional SWOT analysis that will be done in ENSEA project. This information contains:

- On-going energy related activities within energy clusters
- Regional research capacity at academia and research centres
- Fact and figures for regional energy production and use

This report also provides an up to date summary of currently on-going national/EU/international projects that the Rogaland region is collaborating with. Given the fact that at the time of writing this report there is no single document summarizing the energy related activities in the Rogaland region, the secondary objective of the report is to create a valuable all-in one document, which can be of interest for e.g. students, energy utilities, researchers and other interested national and international parties.

3 Rogaland region in a glance

3.1 Geography and Demography

Rogaland is located in the south-western corner of Norway, adjacent to the North Sea. Proximity to the petroleum fields made Rogaland the petroleum capital of Norway in the early 1970s. Rogaland has a natural advantage when it comes to hydro power production, with rivers, high height of fall and great reservoir capacity. The region has long and strong hydro power traditions, with a production of approximately 12 TWh each year. Most of the potential is already developed, but there are possibilities related to energy efficiency and smaller scale hydro power. Six percent of Rogaland's area is agricultural land, making Rogaland an important agricultural producer in a Norwegian context. Manure from the agricultural sector is an important feed stock to bio energy production. However, its potential has not been utilized yet, but it provides the region with strong future biogas production capability.

Figure 4: Map over Rogaland County

Rogaland has a population of 436 087 (2011 numbers). This is about 9percent of Norwegian total. Rogaland has seen a population growth of 15.2 percent over the last 10 years. The comparable number for Norway total is 9.3 percent. The population growth has two main explanations. One is the birth surplus, which have been steady for a number of years. The other explanation is the net immigration to the county, which has been historically high since 2006. Increased work immigration from EU countries is an important factor.

3.2 Higher Education and Research

Rogaland has 5 percent of the country's total R&D activity; the percentage is slightly higher for businesses with 6percent of the country's total R & D in the business sector, while they are lower for the other sectors. The Industry's R&D is spread across a number of areas like fish farming, oil industry and related services, as well as various industry segments with both high technology and low technology industries. Three quarters of business R&D activity is found in the Stavanger /Sandnes area. From 2001 to2011 there was an increase in total R&D activity in the county at 26 percent, slightly below the growth of Norway in total .This growth has mainly come within the university and college sector that has had more than tripled its R&D activity. In 2012 Rogaland received 3.6 percent of funding from the research council, while over 10 percent of the country's tax deduction projects (see SkatteFUNN in Table 3:Research council's national programs) was happening in the county. The county's share of any allocations from Innovation Norway was respectively 5.5 and 6.8 percent of the gross and net commitments. Innovation activity in the business sector is slightly below the national average, while R&D intensity in the business sector is below average.[73]

Higher education, in the field of energy, in the Rogaland region consists mainly of the University of Stavanger, Haugesund/Stord University College and the Norwegian business school. Research work supported by national funding as well as private funds is carried out both at the University of Stavanger (UiS) and at the International Research Institute of Stavanger (IRIS), where the main part of the results are made available via publications. However, there is a strong industry cluster in the region pursuing their own R&D work, where the results are most of the time kept internally in the company, because of strong competition in the market.

Petroleum and petroleum related topics, such as risk analysis/management, economy, utilization, transport, enhanced oil/gas recovery, drilling, offshore technology as well as energy efficiency and sustainable energy solutions are among energy related research areas in focus of R&D activities in the region. In an attempt to focus the R&D efforts in the region on sustainable energy solutions and generate necessary critical mass, a centre (cenSE) was established in 2009. Knowledge transfer between oil and gas industry and clean energy sector is a major focus in the region aiming at utilizing synergetic effects between e.g. offshore technology and offshore wind, drilling technology and geothermal energy, etc.

Moreover, the Rogaland region is collaborating on carrying out energy related research projects with the other Norwegian universities and research institutes such as University of Bergen / CMR, Agder University, University college of Telemark, NTNU and SINTEF.

3.3 Conditions for sustainable economic growth

Petroleum industry and the related businesses are a major driving force for economic development of Rogaland County. Existence of international oil companies as well as service companies in the region with all their investment and human resources is pushing the functional limits of Rogaland’s societal and environmental systems. The economic growth of the Rogaland region is mainly depending on the total stock of wealth, man-made physical and human capital, which is in direct interaction with natural (resources and environmental) capital. The Norwegian social/institutional systems or “Social Capital” has a rather extensive public policy in management of its natural capital. An important issue in Rogaland is to maintain proper conditions for keeping a sustainable balance between various forms of capital. In other words, it is important for the Rogaland region to keep up with its rapid economic growth while protecting its natural capital. Some of the major steps taken include:

- Adaptation of regional and local energy plans
- Development of renewable energy resources and increasing their share in the regions energy basket
- Following up and maintaining the international and national environmental policies

However, the final decision concerning execution of the ambitious regional goals listed above has to be adjusted to the national energy and climate plans.

[73] Regional comparison of R & D and innovation

4 Policy and support mechanisms

4.1 Policy

Through the EEA agreement of 1994, Norway is a part of the EU internal market in most areas. This means that all EEA relevant EU legislation is implemented in Norway. Energy policy is almost exclusively EEA relevant.

4.1.1 National level

The Renewable Energy Directive (2009/28/EC) requires member states to submit national renewable energy action plans. This is also applicable for Norway. The Norwegian government submitted the action plan to EEA for approval in 2012. It was underlined that Norway already has an extensive renewable energy production from hydro power. In 2011, Norway produced 124 TWh electricity from renewable sources. New hydro power projects are in progress, and also licenses to produce electricity from other sources, such as wind power. The increased production must be seen in the light of the green certificate agreement between Norway and Sweden, which presupposes an increased (new) renewable electricity production of 26,4 TWh by 2020. The goal is technology neutral, which means that the most profitable sources will be preferred. Increased renewable energy production is supported by a strong R&D effort. A number of R& D programmes concerning stationary use of energy, transport and bio energy have been established.

Table 1: R&D programmes

Energi21	Energi21 is the national strategy for research, development and commercialization of new climate friendly energy technology. Energi21 is developed based on mandate from The ministry of Petroleum and Energy. The Energi21 strategy sets out the desired course for research, development and demonstration of new technology for the 21st century. The strategy identifies six priority focus areas: • Solar cells • Offshore wind power • Utilisation of resources using balance power • Flexible energy systems – smart grids • Conversion of low-temperature heat into electricity • Carbon capture and storage (CCS)
OG21	OG21 is a Task Force established to help the petroleum industry to formulate a national technology strategy for added value and competitive advantage in the oil and gas industry. The objective is to develop a more co-ordinated and focused approach to research and development throughout the oil and gas industry. The initiative has received strong support from the industry.

•

4.1.2 Regional level

Rogaland County Council (RCC) is by law the regional planning authority, with a superior responsibility of developing and implementing regional plans. RCC has developed three relevant plans within the areas of energy and research; namely Regional plan for energy and climate, Regional plan for business development and Strategy for Research and Development.

Regional plan for energy and climate

The Norwegian Parliament has decided that Norway should fulfill its international obligations to reduce greenhouse gas emissions, and established quantitative goals to reach it. Municipalities and county councils have been requested to develop plans regarding local and regional contribution. The Norwegian county councils have the superior responsibility for regional planning, and RCC initiated the work with the Regional plan for Energy and Climate in 2007. The regional plan aims to facilitate increased renewable energy production, while at the same time reduce greenhouse gas emissions. Superior goals in the Regional plan for energy and climate are as follows:

- 4TWH increased renewable energy production in Rogaland by 2020
- 20% reduction in energy consumption in Rogaland by 2020 (comparison with 2005 numbers)
- Reduction of 750 000 CO_2 equivalents in Rogaland by 2020, excluding large industry

The plan was passed by Rogaland County Council in 2010.

Regional plan for business development

The regional plan is a long term tool for economic development in Rogaland. The plan was developed in a broad regional dialogue, with triple helix input. The plan indicates five fundamental target areas which are believed to trigger economic development:

- Innovation and innovation structure
- Competence and recruitment
- Internationalisation
- Natural resources
- Infrastructure

The plan was passed by Rogaland County Council in 2011.

Strategy for Research and Development

The Research and Development strategy stimulates increased research based innovation and use of R&D in companies connected to the energy sector. The strategy emphasises the importance of developing schemes for competence transfer from traditional oil & gas research to renewable energy production, especially regarding offshore wind power (offshore installations and infrastructure), geothermal energy (drilling competence) and biogas (see chapter 5 for details). The strategy gives the following themes a priority for research:

- Renewable energy production: offshore wind power and marine energy, geothermal energy, biogas and hydro energy.
- Offshore constructions – operation and maintenance: integrated operations
- Gas – processing and transport: pipeline operation , maintenance and technology development, processing unit operation, maintenance and technology development, and capacity and quality improvement

Action plan 2012/2013

The three plans are followed up by a common action plan, covering the period 2012-2013. The action plan will be updated on an annual basis. This program decides what the county council will focus on when it comes to business development in the next two years. This includes strategy for energy and biogas production:

Table 2: Action plan strategies

Strategy 1.7: Make the conditions favourable for Rogaland's future position within renewable offshore energy production.	• Give priority to R&D and innovation concerning wind power technology, including offshore • Work for better frame conditions / support scheme for development of new commercial technology and new concepts in offshore wind power • Support further development of a test centre for offshore wind
Strategy 1.8: Support initiatives in development of biogas production	• Make the conditions favourable for development of a biogas cluster in the county • Give priority to R&D and innovation concerning biogas technology and upgrading of the gas for natural gas pipeline grid • Work for better frame conditions / support scheme for development of new commercial technology and new concepts in biogas
Strategy 2.9: Become a leading region regarding renewable energy and energy efficiency competence.	• RCC will work for and make the conditions favourable so that Rogaland can become a spear point when it comes to skill training in renewable energy and energy efficiency
Strategy 4.8: Increased development of bio fuel from wood	• Secure markets for bio chips by allowing use of bio energy more often in new big construction projects • Increased use of bio energy in public buildings

4.2 Support mechanisms – R&D and innovation programmes

Most of the public funding for research in Norway is provided by the Norwegian Research Council. However during the last few years they have been focussing on regional programs to ensure participation with focus on further strengthening of regional expertise.

4.2.1 National level

The Research Council of Norway

The Research Council of Norway is a national strategic and funding agency for research activities, and a main source of advice on and input into research policy for the Norwegian Government, the central government administration and the overall research community.

An important objective is to ensure that Norway adequately invests in research and development (R&D) activity. To secure this there are several national programs within the research council:

Table 3: Research -council's National Programmes

Demo 2000	The "Demo 2000" program is an initiative supported by the Ministry of Petroleum and Energy (MPE) in order to ensure long term competitiveness in the oil and gas business and continued profitable development of the petroleum resources of the Norwegian Continental Shelf. The program also aims to develop innovative Norwegian industrial products, systems and processes for the global offshore market. The steering group for the program consists of representatives from oil companies, service industry and research institutes.
Petromaks 2	The "Petromaks 2" programme will promote knowledge creation and industrial development to enhance value creation for society by ensuring the development and optimal management of Norwegian petroleum resources within an environmentally sustainable framework
EnergiX	The "EnergiX" programme provides funding for research on renewable energy, efficient use of energy, energy systems and energy policy. The programme is a key

	instrument in the implementation of Norway's national RD&D strategy, Energi21, as well as for achieving other energy policy objectives
MAROFF	The Innovation Programme "MAROFF" supports research and knowledge-building that will contribute to innovation and environmental value creation in the maritime industries in Norway
GASSMAKS	The "GASSMAKS" programme is intended to help ensure that more Norwegian natural gas is refined and used in Norway. The programme's paramount objective is: Maximising value creation in the natural gas chain
SkatteFUNN	Under the SkatteFUNN scheme, business enterprises engaged in research and development activity on their own or in collaboration with others may apply for a tax deduction. The scheme is legal-right based and regulated in the statutory framework, and is open to all branches of industry and all types of companies - regardless of size. To be eligible for a tax deduction, business enterprises must be subject to taxation in Norway, although they do not have to be currently liable for taxation
BIA	BIA funds industry-oriented research and has no thematic restrictions. This broad-based programme supports high-quality R&D projects with good business and socio-economic potential. Established in 2006, BIA is targeted at industry and has a budget for 2011 of approximately NOK 355 million
Centres for Environment-friendly Energy Research (FME)	The objective of the scheme for Centres for Environment-friendly Energy Research (FME) is to establish time-limited research centres which conduct concentrated, focused and long-term research of high international calibre in order to solve specific challenges in the field
Centres for Research-based Innovation (SFI)	The purpose of the Centres for Research-based Innovation (SFI) is to build up and strengthen Norwegian research groups that work in close collaboration with partners from innovative industry and innovative public enterprises
The Research Council of Norway´s Business phd	Under the Industrial Ph.D. scheme companies may apply for support for a three-year period for an employee seeking to pursue an ordinary doctoral degree. The doctoral candidate must be employed by the company and the doctoral research project must be of clear relevance to the company's activities.

Innovation Norway

Innovation Norway is the Norwegian Government's most important instrument for innovation and development of Norwegian enterprises and industry. They support companies in developing their competitive advantage and to enhance innovation via funding and supporting clusters as well as other targeted programs. Rogaland county council owns 49% of Innovation Norway

Innovation Norway's cluster programs

The Arena program is aimed at the regional groupings of companies and knowledge institutions that see opportunities for a concerted effort to improve both the industry and the individual company. The program offers financial and technical support to the long term development of regional clusters. The purpose is to stimulate innovation based on interaction and cooperation between companies, research and education stakeholders and public development agencies. The projects lasts from 3 to 5 years. Arena projects connected to the energy industry in Rogaland are Arena Integrated Operations (2007-2010), Arena Norwegian Offshore Wind (2010-2014) and Arena Maritime Cleantech West (2012-2014). Relevant arenas in other regions: Arena Smart grid Services (mid Norway), Arena Wind Energy (mid Norway).

The NCE (Norwegian Center of Expertise) program enhances innovation in the most expansive and internationally oriented industrial clusters in Norway. Companies get a better basis for initiating and conducting intensive innovation processes, based on collaboration with relevant business partners and knowledge operators. It provides better conditions for new businesses, through commercialization of new business ideas and through establishment of external companies in the cluster. The program offers clusters technical and financial support for development of up to ten years. Today, 12 clusters are supported by the NCE program. Two clusters can be relevant for the ENSEA project: NCE Subsea (west Norway) and NCE Smart Energy Markets (east Norway).

Other Innovation Norway funding programs

Environmental friendly technology programme	The "Environmental friendly technology programme" supports projects concerning cleaning technology, more environmental friendly products and production processes, more efficient resource handling and technological systems for reducing impact on the environment.
Bio energy programme	The "Bio energy programme" offers investment support for sites built for heat production, farm heating plants, greenhouses and biogas. Support to initiatives concerning studies and competence can be given to consultant assistance connected to preliminary studies, preparation projects and detailed statement investigations, as well as competence and information initiatives

Enova

Enova is a public enterprise owned by the Norwegian Ministry for Petroleum and Energy. Enova is responsible for financing projects that will promote a more renewable and energy efficient Norway.

Introduction of new technology to market	Through the programme "Introduction of new technology to market" Enova wishes to contribute to new solutions in renewable energy production and energy efficiency are demonstrated and marketed. The support is meant for demonstration of energy technology under real operation conditions.

4.2.1. Regional level

Regional Research Funds

The Regional research funds support R&D projects initiated by companies, public enterprises, universities, university colleges and independent research institutes. The funds are designed to support the priority focus areas within each individual region. The energy and maritime sector is one of five priority areas for the regional research fund Western Norway (which includes Rogaland and two other counties). On a yearly basis, the Regional research fund grants 30 million NOK (approximately 4 million EUR) for research on west Norwegian topics, many of them focusing on energy.

VRI (Policy Instruments for Regional R&D and Innovation)

VRI is the Norwegian Research Council's main support mechanism for research and innovation in Norway's regions. The primary goal for VRI is to encourage innovation, knowledge development, and added value through regional cooperation and a strengthened research and development effort within and for the regions. The VRI programme seeks to generate knowledge about innovation processes in the regions, enhance cooperation on innovation among regional players and promote research-based innovation in Norwegian trade and industry. In Rogaland, energy is one of the main priorities for the VRI program. The program is led by Rogaland County Council (RCC). We therefore have an excellent starting point for working with other regions around the North Sea. VRI energy has a special focus on projects within offshore wind (marine installations and infrastructure), geothermal energy (drilling competence) and biogas (research and infrastructure). This programme also finances several 'knowledge brokers' which is an important link between companies and research organizations and is important in mobilizing applications to the Regional research fund and other programmes. A VRI knowledge broker will be playing a role in the ENSEA project when it comes to connecting companies to initiatives aiming for Horizon 2020.

The VRI programme has many instruments. Some of them are designed to support knowledge transfer. The instrument called "Technology transfer" offers companies support for cooperating with an R&D institution to verify use of known technology in a new industry area. Another instrument is "Dialogue conferences" where representatives from industry, R&D and public support system meet in a triple helix dialogue. The aim is to discuss common issues for the industry and through dialogue try to identify R&D projects to solve common challenges in cooperation. VRI also has an instrument called "people mobility". This is an exchange of people between industry and research institutions / universities, for instance industry based employees are engaged by a university or a university college to teach in a course where the university doesn´t have lecturers with the necessary skills. This form of exchange secures that education is practical and answers the industry´s needs. Through "Student mobility" VRI supports companies that offer students to work in the company while writing their master thesis. The thesis should be a part of a development project in the company – and the student will help solving a problem for the company.

4.3. Commercialisation

Prekubator TTO

Rogaland has its strength in the operative approach to research that is to implement the research in commercial contexts. Prekubator TTO is the region´s technology transfer office for research based innovation from the university and the university colleges, the university hospital and the institutes. Prekubator is also responsible for The Research Council of Norway´s programme for commercialisation of R&D results – FORNY – and they also offer technology verifications.

Incubator

The Ipark (Innovation Park) incubator assists in bringing up new business ideas and helps them to the point of profitable activity. The incubator offers support both in early phase and in the further development of the company. Companies can also get counselling concerning capital, finding the first client, finding joint venture partners and alliances to develop the potential of the company.

5 Regional energy sector

5.1 Energy system from the national perspective

According to the provisions of the Energy Act, the planning process of the power system in Norway is divided into one overall national elucidation of the transmission grid (300-420 kV) which is performed by the national TSO Statnett, and 17 connected regional planning responsible parties (50-145 kV) . Lyse Elnett is the responsible party for regional energy planning in the southern and middle part of Rogaland, appointed by the Norwegian Energy Regulator (NVE). At municipal level, Lyse Elnett is also according to law, responsible for local energy elucidation at municipal level in the region where development of all stationary energy sources and carriers are evaluated (i.e. waste, hydro, wind, gas, biomass, heat pumps etc., and carriers like electricity, gas, and water (district heating/cooling)). The output from local energy elucidations serves as input in the regional planning process. The planning and establishing of interconnectors to the continent and UK and power from shore to offshore installations in the North Sea are thus undertaken by Statnett as TSO and the regional/local parties are not foreseen to have any responsibility or role.

5.2 Electricity Production

5.2.1 Fossil fuel based (Rogaland: Gas & Oil)

The level of fossil fuel-based generated electrical energy in Rogaland as well as in Norway is very limited, as can be seen in the figures below, which are representing the statistics from 1993 – 2012 on a 3 months basis. The figure below is representing the total energy production in MWh. The nearly perfect match of the curve for total power production and that one for electricity produced by hydro power shows that other sources play a minor role. This is also supported by the figure showing the split of power production according sources. It should be noted that, to make the curves for thermal power and wind power visible, a logarithmic scale was chosen.

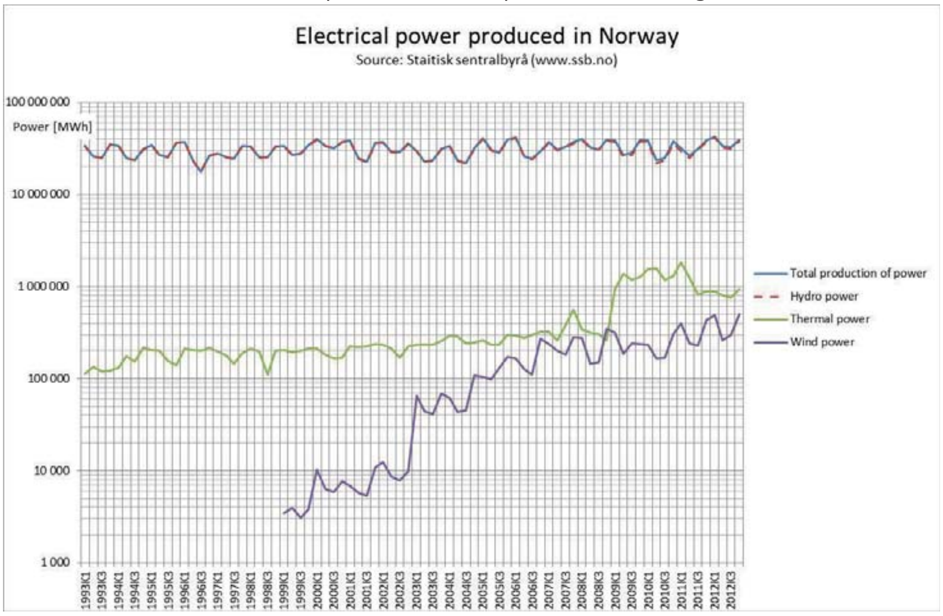


Figure 5: Electrical power produced in Norway

Power generation technology based on fossil fuel as a source is, in Rogaland, used on oil platforms and in a natural gas fuelled combined cycle plant (GTCC) at Kårstø. Besides there are also some applications in greenhouse heating & lightning.

5.2.2 Renewable (Rogaland: Hydro, Biogas/Biomass, wind)

5.2.2.1 Natural gas/Biogas – regional value creation and grid

Given the fact that both natural gas and biogas require a distribution network that can be used simultaneously of both when processed and upgraded to similar qualities, this section covers both natural gas and biogas, starting with natural gas.

Norway is the world's second largest exporter of natural gas after Russia and ranks fourth in world natural gas production (eia[74], 2012). Norwegian natural gas covers 20 percent of Europe's gas use. Rogaland is the national gas hub in Norway. The region hosts the major Norwegian gas processing plant (Kårstø) and the national operator for gas infrastructure (Gassco). A rather comprehensive transmission grid for natural gas (upstream gas pipes) has been developed over the years in the North Sea. The first processing plant onshore in Norway was built by Statoil at Kårstø in Rogaland in 1985.The strong position within the gas sector relates to proximity to the North Sea gas fields and a strong petroleum cluster.

Norway exports about 99 % of its produced natural gas to the international market, almost exclusively to Europe. Only about 1 % is used domestically. The Norwegian government wants to facilitate for increased industrial use of gas in industrial activities in Norway. There are significant oil and gas resources on the Norwegian continental shelf, and most of this gas is brought to land for processing prior to export. Therefore, there are large volumes of gas available for petrochemical activities in Norway. Gassco, the national gas operator, emphasizes the potential of industrial activities around existing processing plants. Kårstø is the major processing plant in Norway. There are unused areas planned for industrial parks located in proximity to Kårstø, thus providing a potential for increased domestic use of gas in industrial activities.

The gas pipes and the landing of the North Sea natural gas at Kårstø gave an opportunity to establish a regional low pressure natural gas distribution grid in Rogaland, firstly by GasNor in 1993/94 in the northern part of Rogaland and later by Lyse (2002) in the southern and middle part of Rogaland. In total 725 km of gas distribution grids have been established in Rogaland. GasNor has two smaller scale LNG plants (2003), while Lyse through the Skangass group has built a big LNG plant (2011) which is expected to produce 4, 3 TWh in 2013.

The total amount of gas sales (both natural gas and LNG) in the area is 6-7 TWh, most of it exported out of the region as LNG, while the low pressure distribution of natural gas amounts to 1.2-1.5 TWh. The existing gas distribution network is also offering an opportunity for distribution of upgraded biogas (i.e. bio-methane). The southern part of Rogaland has the best and the biggest biogas resources in Norway and the utilization is now in progress with biogas produced from sewage, sludge, biological waste and from previous landfill. The biogas production is and will mostly be used in the transportation sector. The biogas is expected to replace the natural gas gradually in the future in order to obtain sustainability. As mentioned earlier, one of Rogaland County Council's responsibilities is regional planning. For biogas, regional production goals can be found in regional plans both for energy & climate and for agriculture. Rogaland County Council has an ambitious goal of 0.35 TWh of production by 2020.

In a Norwegian context, Rogaland has an outstanding biogas potential. The production potential is mainly due to the extensive amounts of feed stock from the agriculture sector. Rogaland's biogas potential is confirmed in a 2008 report from Enova.

[74] U:S: Energy Information Administration www.eia.gov

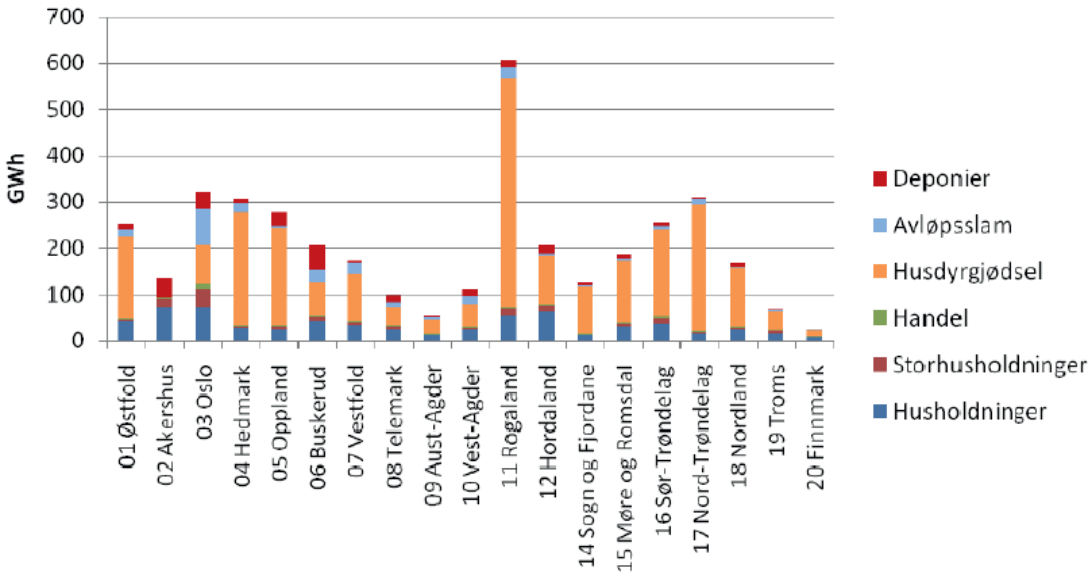


Figure 6: Regional biogas potential in Norway

The existing gas infrastructure is an advantage for Rogaland. Smaller scale production units, such as farms, also have the possibility to feed in (upgraded) biogas on the grid. The cost will thus be related both to investment aid to build the biogas plant and the cost to upgrade the biogas. This solution is not profitable with the current constraint and low electricity price.
Another option is to produce biogas for own or industrial use. One option with high potential is biogas production for use in greenhouses. The vast majority of Norway's greenhouses are located in Rogaland. The heating demand in a greenhouse is extensive with strong seasonal variations, and could be met by locally produced biogas from agriculture waste and manure. An extra effect is the opportunity to separate the CO2 which is needed in the greenhouses. The greenhouses are stable and big consumers of energy. However, the seasonal variation of the energy demand, both heat and light, requires a holistic solution balancing continues production with changing demand.

5.2.2.2 Electricity – hydro power & storage

The electricity produced in Norway is almost exclusively from renewable hydro power (ca. 98%). Power is generated either from runoff river plants with unregulated generation or from conventional hydroelectric plants with dams/reservoirs where generation can be adjusted in line with actual needs. Norway has almost 50% of the total storage capacity in Europe, as the storage capacity of the exciting reservoirs is approximately 80 TWh. The two biggest reservoirs and the biggest power plants in Norway are located in the Rogaland-region and partly owned by Lyse (Svartevann, Sira-Kvina and Blåsjø, Ulla-Førre). The above mentioned dams are designed for multi-seasonal storage and provided with pumps. The operation of these pumps is however quite different from conventional pumped storage hydroelectric plants which mostly operate on a day to day base (pumping to storage when demand and prices are low, and generation when demand and prices are high). Rogaland County Council (RCC) has a regional goal of increased 0,25 TWh larger scale hydro power production and 0,25 TWh smaller scale hydro power production by 2020. RCC is currently working on a regulatory plan for smaller scale hydro power plants. While the vast majority of the hydro power potential is already developed, there is still a potential of energy efficient solutions and smaller scale hydro power. Hydro power is estimated to amount to almost half of the goal of 26, 4 TWh new renewable electricity productions in the common green electricity certificate market in Norway and Sweden.

Rogaland has a hydro power production of 12 TWh in a normal year. This is almost exclusively from larger scale hydro power plants. Although hydro power plants are found in large parts of Rogaland, the vast majority is produced in the eastern part of the county, Ryfylke.

5.2.2.3 Geothermal

Geothermal energy is one of the renewable energy sources that can provide continues supply of energy, in contrast to the intermittent energy from wind and solar plants. Since geothermal energy has no local emissions, it can be installed in populated areas, reducing the cost of energy transport and distribution.

The main drawback for geothermal plants is the high investment cost (up to 80percent) associated with drilling and construction of the geothermal wells. The Rogaland region is one of the main international centres for drilling RTD, thanks to the oil and gas industry in the region. The RTD activities target development of automated drilling to provide cheap and accurate drilling and well construction technology for the oil and gas sector, which provides a unique opportunity for knowledge transfer between the oil and gas sector and the renewable geothermal energy. Specialties such as system modelling, analysis, integration and monitoring of thermal power systems in the centre for sustainable energy solutions (cenSE) in combination with expertise in drilling and well construction provides the region with strong competence for further development and utilization of geothermal energy

5.2.2.4 Onshore wind

Onshore wind is counting for just above 1percent of Norway´s energy production with about 580MW installed (around 1.6 TWh). 170 MW is currently under construction. Onshore wind is an important contributor in the green electricity certificate market of Norway and Sweden. Electricity production from wind is estimated to amount to half of the goal of 26, 4 TWh new renewable electricity production in the two countries by 2020. It is expected that 3000-3500 MW to be installed, giving 7-8 TWh of wind energy production in Norway by 2020. Rogaland County has excellent conditions for energy production from wind, due to very good and stable wind resources, existing grid capacity and mild winters with few icing issues. Lyse Energi has permit to install 110 MW in fully and partly owned wind project. RCC decided upon a regulatory plan for wind power in 2007. The starting point was the global need of reducing greenhouse gas emissions. The main area for wind power production in Rogaland is Dalane, in the southern part of the county. The national authority for Water Resource and Energy Directorate has granted licenses to develop 1.9 TWh in Dalane.

5.2.2.5 Offshore wind

Norway has large areas offshore with very good wind conditions, mainly in deep water (40m ++). The Norwegian parliament decided in 2007 (St. meld 34, 2006-2007) that a national strategy for offshore wind power production should be developed. In June 2009, The Norwegian Government presented a new act and a strategy for offshore renewable energy. The intention was to provide a regulatory framework for offshore wind plants, and to give direction for the efforts needed to make offshore wind power an important part of Norwegian energy industry. The marine energy law was adopted in 2010 and is a framework. As a follow up, national authorities started a process of identifying geographical areas suitable for offshore wind production. An impact assessment for each area should also be conducted before the state opened up for applications. In February 2013, The Norwegian Ministry of Petroleum and Energy presents the results from a Strategic Environmental Assessment (SEA) of 15 offshore wind zones in Norway available for public consultation. The SEA gives an interesting update on how offshore wind could develop in Norway. 15 suitable areas for offshore wind production were identified along the Norwegian coast (see figure 6). Three of them are adjacent to the coast of Rogaland. An ecosystem approach and impact on other sectorial interests were taken into consideration during the identification. The timing for actual exploitation will depend on technology development, cost and demand. No commercial offshore wind power projects have been initiated in Norway.

Norwegian actors are involved in projects in other countries, like Germany and United Kingdom. This is mainly due to lack of sufficient subsidies/support schemes for offshore wind in Norway. Due to lack of financial support, mechanisms it is not expected any project development or installations before 2020.

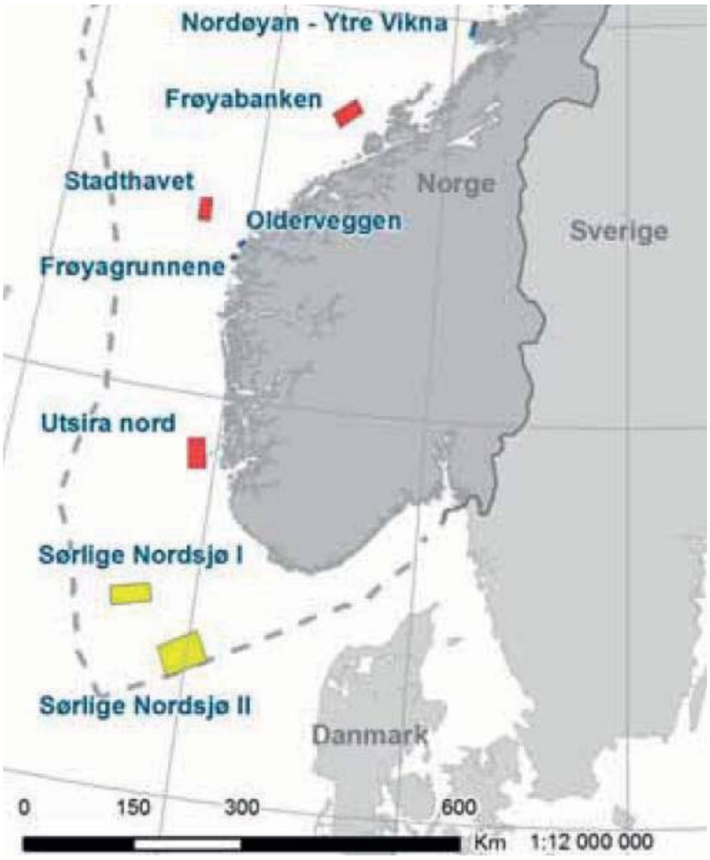


Figure 7: Selected areas for offshore wind installations
Source: regjeringen.no

Businesses in the regions of Rogaland and Hordaland in western Norway has been granted an Arena status by the Norwegian Research Council. Arena Norwegian Offshore Wind (Arena Now) is an industrial cluster of suppliers and operators working together to develop and deliver complete offshore wind power systems. The cluster covers a complete range of offshore wind products and services.

Rogaland has very good wind conditions with potential of around 10 m/s not far from shore. At this stage, fixed-bottom wind turbines are more profitable than floating turbines. Depth might be a problem in Norwegian waters. A continuous focus on innovation and research has opened opportunities for floating wind mills, especially within test and demonstration.

Marine Energy Test Centre (**METCentre**) was established in 2009. It is owned by local business actors and public authorities, among them Rogaland County Council.

METCentre offers excellent infrastructure and conditions for the testing of new technologies in marine energy production. The test field is ready for full scale testing of wind and wave energy technologies under various depth/conditions.

METCentre can offer

- Grid connection via sea cable
- Concession assistance
- Access to wind and wave data
- Operation and maintenance assistance
- Work base and warehouse facilities
- Collaboration with research institutes and universities

Two major players in Norwegian offshore wind are Statoil and Aibel AS. Statoil is a big offshore wind developer outside Norway, Sheringham Shoule and Doggerbank, (the last one in cooperation with Statkraft and two other participants) in UK.

Aibel, an offshore service company with main office located in Stavanger is developing an electrical HUB-platform in cooperation with ABB. The HUB-platform named DolWin Beta which will convert AC current produced from the adjacent windturbines in the park, is designed and built by Aibel whereas ABBs responsibility is cables and AC/DC converters. Dolwin Beta is a semi-submersible floating platform type, similar to those platforms used for oil- and gas production in the North Sea and is planned to be in operation in 2014 in German sector in the North Sea. This illustrates that competence and experience form the oil- and gas activities could be transformed and utilised for the development of off-shore wind-farms.

5.2.3 Hywind

Hywind is the first full scale floating wind turbine in the world. The good wind conditions were a crucial condition when Statoil decided upon location for its test wind turbine, Hywind. Off the island of Karmøy, north of Stavanger, Statoil has installed the world's first full-scale floating wind turbine. The demonstration unit combines technology from the wind industry with technologies from the oil and gas industry and draws upon Statoil's longstanding offshore experience. Through the first two years of testing the concept is verified, and the performance is beyond expectations. With few operational challenges, excellent production output, and well-functioning technical systems, the Hywind concept may revolutionise the future of offshore wind.

The Hywind pilot consists of a turbine placed on top of a ballasted steel cylinder. The floating turbine unit is fastened to the seabed by three mooring lines. The demonstration project has given proof to the technology, and based on the experiences gained, the concept is being optimised. Further conceptual enhancements, combined with a matured supply chain will offer significant reductions in cost of energy in the future.

Siragrunnen Vindpark

Siragrunnen Vindpark AS is a project company planning to build an offshore wind farm outside the coast of Rogaland. The wind farm will potentially be one of the largest wind farms in Norway. The site criteria include good wind conditions, short distance to existing grid, favourable floor conditions and existing infrastructure. It covers an area of 40,5 km_2 in a short distance from shore. The project will have an installed effect of 200 MW, which equals the consumption of 33 500 households. Electricity produced will be fed in to the existing electricity grid on land.

5.2.4 NORCOWE

Norwegian Centre for Offshore Wind Energy (NORCOWE) is an interdisciplinary resource centre for the exploitation of offshore wind energy as a natural and sustainable energy resource. The centre was founded in 2009 as one of eleven Centres for Environment-friendly Energy Research (CEER), and is hosted by Christian Michelsen Research AS in Bergen.

NORCOWE's partners cover a wide range of subject fields related to offshore wind energy, and several are international leaders in their fields. The centre encompasses areas such as resource mapping, modelling and measurements of the marine boundary layer, marine operations, operation and maintenance, wind and wake effects in wind farms, and layout design of wind farms. NORCOWE has expertise in modelling on a wide range of scales, from fine-scale CFD to the meso-scale. The University in Stavanger is work package leader for 'WP3 Design, installation and operation of offshore wind turbines'. NORCOWE has signed MoUs with Fraunhofer IWES, NREL and DTU. In addition, there is cooperation with Arena NOW, Greater Stavanger, Bergen Business Council, Business Region Bergen, Innovation Norway and NODE (Norwegian Offshore & Drilling Engineering)

5.3 Transmission infrastructure and system

5.3.1 Electrical grid

The main challenge in the years to come concerning the transmission grid is the upgrading from 300 kV to 420 kV during the next decades. This requires an investment of more than 50 billion NOK. In Rogaland and adjacent areas, the reinforcement and upgrading of the so-called "western corridor" (Sauda to Feda) and the new connection Lyse-Stølaheia will be the prioritized projects. If new alumina projects is to be realized at Karmøy (Hydro) and power from shore decided for Kårstø, upgrading and strengthening of the transmission grid in the northern part of Rogaland has to take place (see figure 7 below).

Figure 8: Planned and required upgrading of the transmission grid in Rogaland

5.3.2 New energy based infrastructure and services

The Norwegian Smart Grid Centre consists of three main locations; Demo Steinkjer, Demo Hvaler and Demo Lyse. Demo Lyse is located in Stavanger, and focuses its research mainly on new energy based service innovation, smart homes and ultimately smart energy regions. These are described in the following subchapters.

5.3.2.1 New energy based services

For the last decade, all the energy companies in the Rogaland County like *Lyse Energi*, *Haugaland kraft* and *Dalane Energi*, have deployed Europe's most comprehensive regional fibre optical infrastructure.
Lyse Energi, based in Stavanger has also developed and delivered new broadband services, and has through organic growth reached a number of more than 300.000 households. Lyse Energy is therefore a unique combination between an energy company and a telecom company. And in between energy and telecom, there is a new utility based service domain, consisting of new energy based end customer services, smart grid services and even services that enables elderly to live longer in their existing homes (Ambient Assisted Living).
The new energy based services will cover areas like energy efficiency (see next section), load shifting, grid balancing and security of the energy grid, and include end customers services.

5.3.2.2 Energy efficiency, AMS and smart homes

Energy efficiency is a central point in the further development of the Rogaland region, for private sector, industrial sector and transportation. As a result, more or less all development areas for private housing as well as for industrial buildings are targeting new and energy efficient approaches, requesting concepts and bid from as many as possible suppliers to further support the development of energy efficient solutions by increased competition. Nevertheless, the main challenge is retrofitting the existing households in the region, thus enabling end users and their home to become more energy efficient.
Norwegian authorities have decided that all homes must install a new electricity meter with communication capabilities before 1st of January 2019. Lyses approach to this challenge, is to install a smart gateway that takes care of the communication part. This smart gateway is generic, and can handle any kind of sensor/actuator, not only the electricity meter.
This way, the energy provider can also enable the consumers to control other energy consuming devices in the home, thus enabling energy efficiency services, as well as load shifting services in the existing housing. The energy provider will reuse the customers own devices like smart phones, tablets and television sets to both control and get status of their home, energy usage and energy savings via smart home solutions.

5.3.2.3 Moving towards a Smart region

The Rogaland County has probably the most comprehensive fibre infrastructure in Europe. In parallel to the AMS upgrade, Lyse Energi will also install Smart Gateways in all homes.
The combination of the two, will position the Rogaland region as one of Europe's smartest regions, and a true test bed for new and advanced energy service development. The rollout will start in Q4 2013.
Transportation is mainly targeting and further developing the energy efficiency in private transportation (e.g. supporting electrical vehicles) and habits of users (e.g. public transportation, bicycles). Supporting charging of electrical vehicles in residential areas will become a challenge in the grid, especially if "hurtigladere (quick charger)" will be deployed.

5.3.3 District heating/cooling

Waste energy from combustion of household disposal is the main energy source (represents 60-70 %) of the district heating system in Rogaland. For the time being, 20-30 percent of the heat (in particular during peak periods) is produced from natural gas and 5-7 percent from heat pumps. The total district heating network in Rogaland is 70 km and the annual distributed energy is 120 GWh. The total annual energy from combustion of waste is 275 GWh (FEKS 1 & 2) of which 45 GWh is utilized for electric power generation and 75 GWh is used in the district heating system. Hence, nearly half of the available energy from combustion of waste is utilized, and Lyse Neo is working hard in order to increase the share of the heat consumption from the district heating system. Lyse Neo has an ambition to deliver 100percent CO_2 neutral heat by 2020, and therefore replacement of natural gas by upgraded biogas during peak hours will be a prerequisite. Customers of heat (in the cold season) in well insulated buildings have a need for cooling in the summer time. Therefore, to be able to deliver district cooling is often seen as a prerequisite for heat sale to many customers. Lyse Neo has a growing business in district cooling which is expected to be near to 40 MW (of which 7.5 MW is free-cooling from sea) in 2013. Conventional compressors for cooling purposes have an efficiency of 2:1. Free-cooling on the other hand may have an efficiency of 10:1 (The ratio is: Cooling energy/supplied energy). In the emerging market, conventional compressors may be used temporarily and later be replaced by a free-cooling solution.

5.3.4 Natural gas grid

Gas from the North Sea is processed in the Kårstø processing plant and transported to customers by the onshore gas grid in extensive parts of the region (see figure 12). The grid is quite extensive, as Lyse has built 400-500 km in the southern part of Rogaland and GasNor another 100 km in the northern part of the county. Klepp Energy has also a 25 km grid, mainly for landfill gas.

Natural gas and upgraded biogas can use the same infrastructure. The existing infrastructure is a competitive advantage for biogas production in Rogaland.

Figure 9: Map of Rogaland natural gas grid

5.3.4.1 Grid for offshore oil & gas installations

The power consumption in the oil- and gas sector is increasing and in addition to processing plants onshore, more and more offshore installations are also expected to be supplied from shore, either via AC –cables (Troll A, Martin Linge, Gjøa etc) or DC-cables (Valhall). Valhall has a 80 MW DC-cable supplied from Lista and represents the conventional solution of one cable to one platform. The biggest project to date is however the development of the new oilfields Dagny, Edvard Grieg, Draupne and Johan Sverdrup where gas turbines on the platforms will be replaced by electric power from shore. The new concept is based on a central hub-platform where the DC/AC converter will be located and ordinary AC radials to the adjacent platforms/installations. When this concept is realized, annual CO_2 reduction of approximately 1 million tons can be achieved compared to operating local gas turbines on each platform.

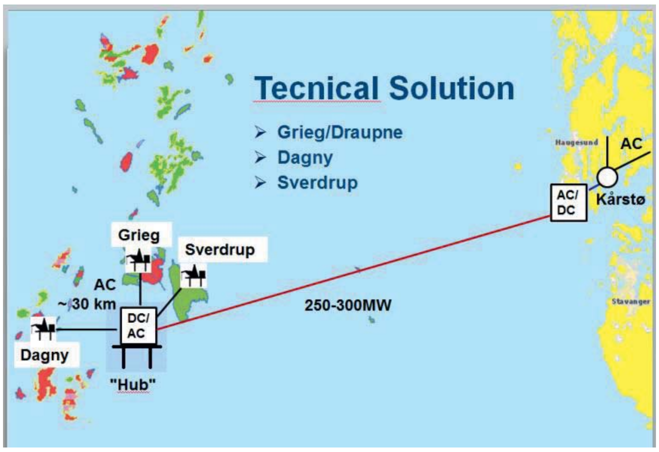


Figure 10: Schematic illustration of the concept with electrical cable to a central hub

When the HUB-platform is in place and in operation, there will be in principle an opportunity to connect offshore wind platforms in the area to the HUB. This would probably be an attractive option.

The following DC- interconnectors from south-western part of Norway are already in place: Skagerak 1, 2 and 3 to Denmark and Nor-Ned to the Netherlands. Another interconnector to Denmark is under construction and this will be the first interconnector where part of the transmission capacity will be reserved for balancing services to compensate for the high portion of intermittent wind generation in Denmark. By 2019-21 two other interconnectors with a capacity of 1400MW each are foreseen to be in operation – one to Germany and one to UK. Lyse Energi, Agder Energi and other partners have tried to develop merchant cables both to Germany and to Scotland, but so far this initiative has been blocked by Norwegian authorities.

Figure 11: Electrical cable connection to Germany and England

	Germany	England
Capacity	**1400 MW**	**1400 MW**
Submarine cable	**2 x 514 KM**	**2 x 715 km**
Land cable	**2 x 55 km**	**2 x 6 km**
Production	**2015 – 2018**	**2016 – 2020**
Installation	**2016 – 2018**	**2017 - 2010**

Source: Statnett

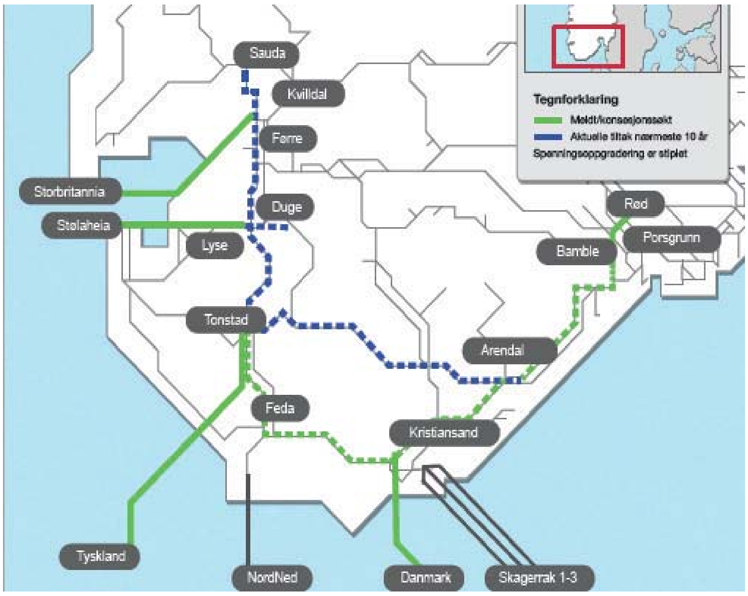


Figure 12: Electrical cable connection from Norway.

The Norwegian offshore gas grid, providing the main transport and export infrastructure, is owned and operated by the state (see figure 13). Future investments in the offshore gas grid development will only depend on new gas fields and the market pull for increased export. The figure below shows a general overview of the offshore gas grid.

On-going R&D activities are focused on technology development for more efficient processing (welding, testing, etc.) and placing of the pipe lines to shorten the construction time and thereby the costs.

Figure 13: International gas connections

5.4 Electricity consumption in various sectors

The consumption of electrical power for the period from 1993 to 2012 is shown in figure 3. It needs to be noted that “other” includes electricity consumed in household as well as transport. It is represented as one value, as the detailed split was not available for the years 2011 and 2012. However, as an overall average was about 0.92 % of the energy under “Other” consumed by transportation during the years from 1993-2010. A significant part can be assigned to heating as indicated by the periodic fluctuations.

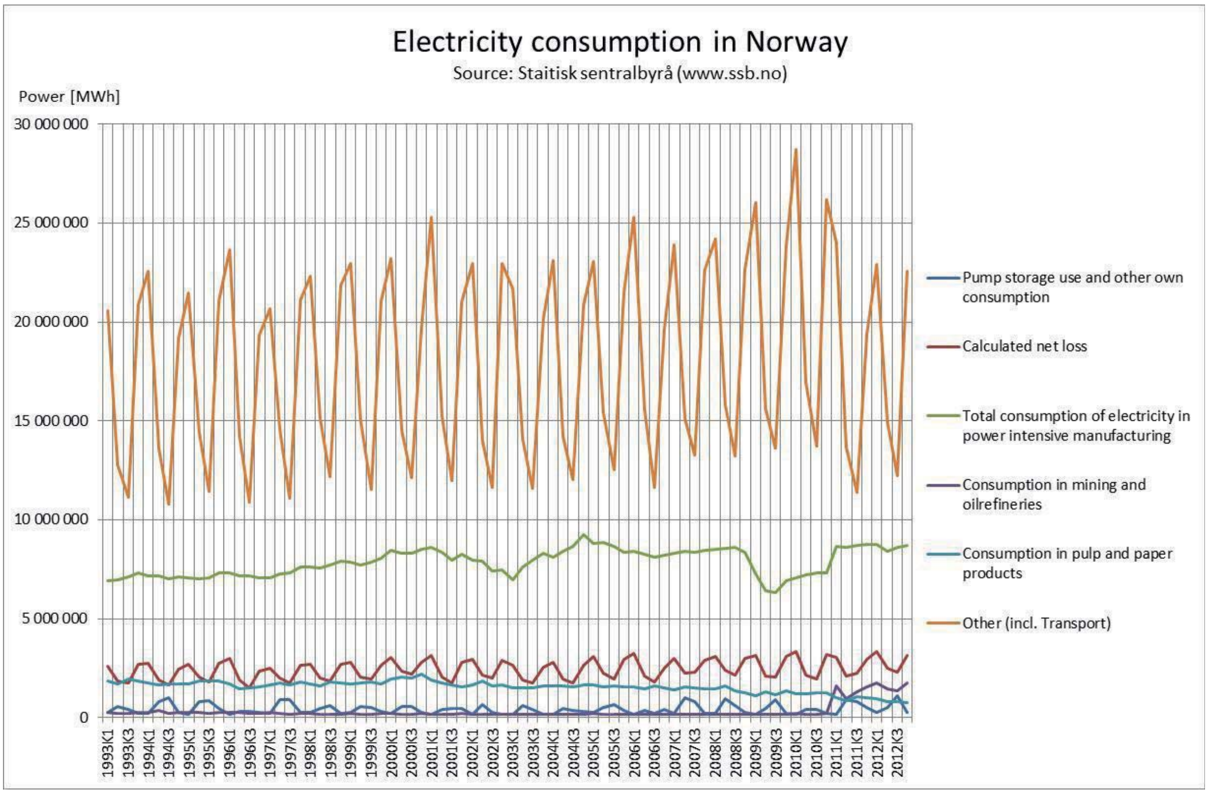


Figure 14: Electricity consumption in Norway

5.4.1 Renewable energy share

The actual biogas-production in the region is approximately 20 GWh. There are three plants, one at Åna which is producing 0.9 GWh (manure) for local consumption only (replacing oil for heating purpose) and one at Mekjarvik owned and operated by IVAR producing 12-15 GWh biogas from sewage annually. The produced gas is upgraded and injected into the natural distribution network. The main market for biogas is transport and renewable district heating.

In Klepp approximately 7 GWh of a potential of 20 GWh from landfill is utilized for district heating. A new biogas plant is planned at Grødaland by IVAR which will increase the amount of biogas produced in Rogaland by 65 GWh. At Mekjarvik an extension is foreseen which will double the annual biogas production to nearly 30 GWh. The bus fleet in the southern part of Rogaland is approximately. 350-400 buses which represent an annual consumption of 90-100 GWh, which is of the same magnitude as the planned production. The biogas potential from other substrates i.e. manure and others represents 600 GWh in which 300-400 GWh can be utilized provided low-cost small scale bioreactors, raw gas distribution networks and large scale upgrading systems are developed. Utilization of upgraded biogas as fuel in the transport sector is regarded to be a good solution in order to fulfil the requirements in the EU Renewable Directive which demands 10 % renewable transport by 2020.

Onshore wind is an important contributor in the green electricity certificate market of Norway and Sweden. Electricity production from wind is estimated to amount to half of the goal of 26, 4 TWh new renewable electricity productions in the two countries by 2020. It is expected that 3000-3500 MW to be installed, giving 7-8 TWh of wind energy production in Norway by 2020.

5.4.2 Energy efficiency

Energy efficiency is a central point in the further development of the Rogaland region, for private sector, industrial sector and transportation. As a result, more or less all development areas for private housing as well as for industrial buildings are targeting new and energy efficient approaches, requesting concepts and bid from as many as possible suppliers to further support the development of energy efficient solutions by increased competition. In the industrial area projects will increase energy efficiency in the energy intensive metal production (reducing and recovering waste heat, e.g. "Energy Efficiency Improvement via waste heat recovery and enhancement of production rate in aluminium industry") supported. Both approaches (building and metal production) are pushed even though they mainly consume hydro-generated electricity, thus not CO_2 relevant. The reduction of greenhouse gases, which is mainly generated in connection to oil and gas production and refining is also targeted via projects to increase either energy efficiency, such as EOOS (Optimisation of electrical energy production in offshore installations), or to eliminate the need of thermal power generation by electrically connecting platforms with the main land.

Transportation is mainly targeting and further developing the energy efficiency in private transportation (e.g. supporting electrical vehicles) and habits of users (e.g. public transportation, bicycles).

6 International cooperation

6.1 Energy Networks

The Rogaland region is an active member of several EU/international Energy Clusters that are presented in table 4.

Table 4: Energy Clusters

North Sea Commission	North Sea Commission was founded in 1989 to facilitate and enhance partnership between regions around the North Sea. Politicians from regions in the 8 countries around the North Sea are engaged in the work to lobby North Sea interest at the European level, and share best practice and develop common projects in the macro region. The daily work of the organisation is followed up by the president and executive secretary which in this period is located in Northern Denmark. North Sea Commission has five thematic groups to follow up on different thematic areas. The thematic groups cover the following fields: • Innovation and education • Marine resources • Transport • Sustainable development • Culture and tourism Rogaland County Council is an active member of the North Sea Commission. This is a useful network and a valuable channel to influence EU policy. Rogaland holds the chair in the Innovation and Education group, and the advisors (administrative leader of the groups) in the Marine Resource group and the Culture and Tourism group. The North Sea area is major economic entity, and the North Sea Commission adopted a strategy paper in 2011 to demonstrate how the North Sea region can contribute to the EU 2020 goals. The strategy paper will be followed up by a concrete action plan. More info about the North Sea Commission and the strategy paper see: www.northsea.org
Covenant of Mayors	Stavanger was the first city in Norway to sign (2009) the Covenant of Mayors Initiative. The Covenant of Mayors is an ambitious initiative of the European Commission that will bring together mayors of Europe's most pioneering cities in a permanent network to exchange and apply good practices across these cities and beyond to improve energy efficiency significantly in the urban environment.

Table 4: Energy Clusters (continues)

Cities of the Future	The city of Stavanger is also participating in the 'Cities of the Future' project, which was initiated by the Norwegian Minister of Environment in the spring of 2008. The initiative was a response to a Report to the Parliament on Norwegian Climate Policy and the compromise agreement on climate policy from early 2008. Through the 'Cities of the Future', the Government and the cities, which will prepare individual action plans, will work closely together in order to create cities with a better urban environment. In reaching the targets detailed in the process-oriented Covenant of Mayors, Stavanger is employing the action plans from the 'Cities of the Future' as a tool. In the 'Cities of the Future,' the twin cities of Stavanger and Sandnes were requested to prepare joint action programmes in specific areas. This request was accommodated through successful cooperation between the two cities. Work on the action plan was subjected to political discussion and internal working groups in both cities. In the action plan, emphasis was placed on strategic goals and measures. Both cities are working to revise their municipal master plans and are facing large-scale regional development tasks. At the same time, the Partial County Plan for Long-Term Urban Development in Jæren will set guidelines for urban development throughout the region. The action plans will emphasise on: • Transportation • Energy efficiency • Consumption and waste • Climate change adaptation
World Energy Cities Partnership (WECP)	Established in 1995, WECP is a non-profit organisation whose members are globally recognized as international energy capitals. These member cities actively seek and develop opportunities to learn, exchange and engage in activities to the mutual benefit of the partnership. WECP is bound by a co-operative agreement signed by the Mayors of each city, who serve as board members, is directed by an elected President and Vice-President, and supported by a Secretariat office, which is based in Houston, USA. WECP provides a worldwide network of industry support services and resources, and serves to facilitate business-to-business interaction, the sharing of industry knowledge, contacts and experiences, and partnerships in energy-related activities. The organisation facilitates trade missions for local businesses to travel to member cities and capitalize on business development opportunities. WECP strives to continuously increase the stream of information flowing between its member cities. The World Energy Cities Academic Partnership (WECAP) is a collaborative effort to generate relevant research activities through WECP member universities. The initiative addresses issues such as CO2 emissions, usage of fossil fuels and renewable energy sources. Stavanger and Aberdeen (Scotland) are both members of World Energy Cities Partnership (WECP).

Table 4: Energy Clusters (continues)

Cooperation Haugaland Vekst/ Emden	The city of Haugesund in Rogaland and the city of Emden in Lower Saxony are twin cities. This has provided a window of opportunity for cooperation also within business development. Developing offshore wind and relevant sub-contractors is of common interest and the basis of a common project. A number of workshops have been organized both in Norway and Germany to demonstrate opportunities for cooperation and business potential. The Haugesund region is dominated by a maritime offshore oriented industry specialized in complex maritime operations. The region can provide enabling knowledge and specialized services and products based on the high standards for health, safety and environment from the petroleum sector in the North Sea. This comprises disciplines such as: • offshore and marine engineering of structures and technology • manufacturing of structures and technology • meteorological and oceanographic insight • maritime and offshore operational experience both in subsea and surface construction, maintenance and decommissioning
European Energy Research Alliance (EERA)	EERA is an alliance of leading organisations in the field of energy research. EERA aims to strengthen, expand and optimize EU energy research capabilities through the sharing of world-class national facilities in Europe and the joint realization of pan-European research programmes (EERA Joint Programmes). The primary focus of EERA is to accelerate the development of energy technologies to the point where they can be embedded in industry-driven research. In order to achieve this goal, EERA streamlines and coordinates national and European energy R&D programmes. The University of Stavanger and the International Research Institute of Stavanger are members of the national reference group for EERA. IRIS is also a member of the EERA working group on Geothermal Energy.
European Enterprise Network (EEN)	Enterprise Europe Network is one of the EU's major initiatives. This is a networking and support organisation that covers all of Europe and offers companies advice and guidance on technology transfer, EU rules, EU market, EU programs and research links. One aim of the network is to minimize regulations related and administrative obstacles that take resources from your core business, but rather support Norwegian companies should be able to make use of European options. 6 000 advisers cover different expertise within the EU, technology and business. They are located at 600 contact points in Europe, and IRIS (International Research Institute of Stavanger) coordinates the EEN activity in the Rogaland region.

Table 4: Energy Clusters (continues)

European Regions Research and Innovation Network (ERRIN)	The Rogaland County Council (through VRI) is a member of ERRIN. ERRIN stands for the European Regions Research and Innovation Network. It is a network of more than 90 regions across Europe. The overall aim of ERRIN is to strengthen the member region's research and innovation capacities. ERRIN thus serves as a platform where its members can exchange regional good practices, develop EU projects as well as receiving updated information about EU policy and EU programmes. ERRIN also aims to influence EU policies in order to make them respond better to the needs of European regions. ERRIN membership enables regions to involve its practitioners in EU wide innovation communities. Through the network, its members receive important updates on key EU policy developments and timely intelligence on EU project calls. EU staff regularly participates in the networks meetings and brief ERRIN members on upcoming calls and new policy developments.
European Turbine Network (ETN)	ETN is a non-profit association bringing together the entire value chain of the gas turbine technology community in Europe. Through the co-operative efforts of our members, ETN facilitates gas turbine research and technology development, promoting environmentally friendly gas turbine technology with reliable and low cost operation. Collaboration across the whole value chain creates a powerful network with the ability to achieve tangible advances in gas turbine technology. A common strategy and research effort between all the stakeholders, along with a supportive European Union policy, will enable the expansion and increased competitiveness of the gas turbine sector in Europe. The University of Stavanger and IRIS are members of the European Turbine Network. UiS is also a partner in the H2-IGCC project, co-funded by the European Union's 7th Framework Programme for Research and Development, which is based on the initiative outlined in the European Turbine Network's (ETN) Position Paper on Gas Turbine Fuel Flexibility.
EU-GCC clean energy network	The EU – GCC Clean Energy Network aims to respond to the common interests of stakeholders, both in the GCC and the EU, active in the field of clean energy. The EU - Gulf Cooperation Council (GCC) Clean Energy Network is the practical instrument for development of concrete cooperation activities on clean energy, including the related policy and technology aspects, among various players across the EU and GCC countries. UiS is a member of the expert group for this network, responsible for the working group clean natural gas applications (www.eugcc-cleanergy.net).

6.2 Projects

Partners from Rogaland (academic, public or companies) are involved in 22 energy related FP7 projects. The Energy related relevant projects in the Rogaland region are as follow:

Table 5: Energy projects in Rogaland region

Dalane vgs (VeWind)	One of the most challenging tasks for the wind power sector is to certify a sufficient amount of qualified personnel. Dalane upper secondary school in Rogaland is the first school in Norway to start vocational education and training of wind technicians. The lack of experience and competence in this field of vocational education and training made it clear that the school had to go outside to national borders to be able to develop and offer a high quality education. Vet Wind is an abbreviation for Vocational Education and Training of Wind Technicians. Dalane upper secondary school is the lead partner in a project with partners from Sweden, Germany, the Netherlands, Belgium, Spain, England and Finland. The working goal for this "Transfer of Innovation" project will be to transfer knowledge and experience beyond borders from existing and upcoming VET wind skill training programs in various European countries, and then adapt and further customize these programs regarding lesson and training materials, teacher training, adaptation and/or upgrading of competence profiles, methods and approaches in countries both with and without these programs
EU-implement, Sustainable development with biogas	This project aims at common development of Scandinavian biogas project, in Skive municipality in Denmark with 8 million Euro support from EU. Project partners from Norway are Rogaland biogas, Østfold Fylkeskommune, Klepp's-, Hå's and Time's municipality. For more details about the project visit: http://www.interreg-oks.eu/se/Menu/Om
Gas-Future Advanced Capture Technology Options (GAS-FACT)	This is a fully UK financed project where 5 UK based universities, namely Cranfield Univ., Edinburgh Univ., Imperial college, Leeds Univ., and Sheffield Univ., in collaboration with two international partner universities, i.e. Carnegie Mellon University (USA) and UiS/cenSE (Norway) will develop and evaluate innovative carbon capture (CCS) technologies for natural gas fired power plants. The large scale CCS test facilities in UK are to be used to generate experimental data for validation of theoretical model developed within the consortium.

Energy efficient buildings	The energy consumption of houses and buildings taking into account the whole life cycle is responsible for 40percent of total EU energy consumption and is the main contributor to greenhouse gas (GHG) emissions (about 36percent of the EU's total CO2 emissions and for about half of the CO2 emissions which are not covered by the Emission Trading System). Therefore reducing energy consumption during the whole life-cycle of the buildings is an effective action against climate change and will also contribute to decreasing the EU's energy import dependence.
SEEDS	UiS participates in the Self learning Energy Efficient builDings and open Spaces (SEEDS) project (FP7) which focuses on harnessing advances in self-learning methods, wireless sensor technology and building technology to develop a novel system for Self Learning Energy Efficient builDings and open Spaces (SEEDS). It will aim to develop an energy management system that will allow buildings to continuously learn to maintain user comfort whilst minimising energy consumption and CO2 emissions. SEEDS will develop an open architecture suitable both for retrofitting existing buildings and open spaces and for new building design. SEEDS will be based on research and scientific advances in wireless sensor technology, machine learning, and Bayesian networks, as well as standard statistical methods to enable the relationships between key variables to be continuously learned, facilitate prediction and enable control. SEEDS' results will be validated in two pilots at opposite sites of Europe: i) part of a university campus (Stavanger, Norway) including several buildings and open spaces and ii) an office building plus parking area (Madrid, Spain). The Consortium includes organisations from the building, electronic and ICT and energy sector.
PIMES project (Play it more efficient, Sam)	The Rogaland County Council is lead partner of this project within the Concerto program of the European Commission. 14 partners from four European countries are delivering a project of retrofitted old buildings, low energy housing and offices and improved use of sustainable energy sources. Research partners from the Basque region of Spain, Germany, Hungary and Norway are supporting the projects at scientific as well as practical level. The building activity takes part in the Basque capital Vitoria-Gasteiz, Szentendre in Hungary and Sandnes in Rogaland, Norway. At Dale in Sandnes Municipality the PIME'S project will build new flats and houses with an energy performance 30 % better than Tech 07. This includes retrofitting and rehabilitation of the old hospital building and new buildings. Partly single family houses and houses of flats. The energy system includes Microgrids, developed by the Basque partner Tecnalia. This smart grid system includes an energy manager as well as surveillance system for individual energy usage. When fully developed, the system will use historic data in combination with information on weather as well as energy market prices – in real time – in order to find the most energy efficient and economic source. The energy system at Dale will be a combination of electricity from the national grid (hydropower), heat pump from the fjord, and a combined heat and electricity unit powered by natural gas or wood chip. Further to this an old hydro power plant will be restored and taken into use.

ENERCOAST	This project aims at mobilizing biomass for energy, through improved supply chains and increased cooperation in the North Sea Region. Project partners consist of University of Oldenburg (the lead partner), Landwirttschaftskammer Niedersachen, Ryfylke IKS and Rogaland I Vestnorge from Norway, and Innovatum Teknikpark, Trollhättan, Northumberland College.
Innovative Foresight Planning	Greater Stavanger Economic Development was lead partner of the Interreg project Innovative Foresight Planning which ended in 2011.The project had 16 partners from 6 regions around the North Sea. Foresight is a process systematically attempting to look into the longer- term future of science, technology, the economy and society with the aim of identifying the emerging generic technologies likely to yield the greatest economic and social benefits. The project aimed to improve decision making by developing and applying innovative foresight planning as a tool. One important outcome for Rogaland was a more innovative methodology for regional assessment, making it more instrumental for decision making.
Power Cluster	Greater Stavanger Economic Development participated in the Interreg project Power Cluster, a project with participants from 6 countries around the North Sea. The POWER cluster partnership aimed to tackle crucial challenges for the further roll out of offshore wind technology in Northern Europe by cooperating beyond borderlines and sector barriers. Furthermore the POWER cluster project seeks to develop cooperation between individual countries in order to take advantage of future growth in offshore wind and identifying future markets. The POWER cluster partnership build on the previous POWER (Pushing Offshore Wind Energy Regions) project. The partnership was therefore able to draw on a huge range of expertise – not only in offshore wind energy, but also in oil and gas and other related marine sectors. Participation in POWER cluster gave us a the South Western part of Norway an unique opportunity to learn and exchange experiences with other offshore wind communities. Actors from Rogaland could contribute with experience from the petroleum sector and maritime operations.

7 ENSEA collaboration – expectations

7.1 Knowledge exchange and best practice

A major task for the ENSEA project is identification of the "best practice" in the participating regions. Identification of successful collaboration patterns and support schemes in one region will provide the other regions with knowledge and information on the local barriers for successful implementation of similar measures. Another important outcome of the ENSEA project will be identification of organisations with suitable competences and experiences that could be approached when a concrete project is to be started. The competence in one region and its usefulness in other region(s) will be identified through an interregional SWOT analysis. Each participant region should carry out the SWOT analysis and the outcomes will be used for interregional studies/applications.

7.2 SWOT analysis in Rogaland region

The starting point for the Rogaland SWOT is the regional innovation system.

7.2.1 The innovation system in Rogaland

In the latest regional comparison of R & D and innovation in Norway (Indikatorraporten 2013 et al.) It can be observed that, the south west of Norway has relative low R&D investments compared to other regions in Norway (Figure 15). Still, south west of Norway (especially Rogaland) is one of the most innovative and richest regions (measured GDP per Capita) in Norway and the world (Rune Dahl Fitjar and Andrés Rodríguez-Pose, 2011). There have been several studies on the innovation system in the city region of Stavanger and south west Norway. In an article by Rune Dahl Fitjar and Andrés Rodríguez-Pose (2011) they explain why this is the case and reasons behind the high levels of innovation and competitiveness of firms in the region. They found that long distance international cooperation is the most important factor to product innovation (more important than local collaboration, agglomeration and clustering). According to Rune Dahl Fitjar and Andrés Rodríguez-Pose (2011) this may also be an effect of smaller regions as they have smaller markets and critical masses of industry and innovative centres. They further argue, "values and attitudes of managers are important in explaining why some businesses are more internationally connected than others "(2011, p 556). This is because businesses with more open-minded managers tend to cooperate with many international partners while the more trusting managers will focus more on regional networks. Even though trust does not seem to have such a big effect on building international networks this may be because of high level of trust already existing in the region, which may have made trust institutionalized and therefore already benefiting all companies in the region. The relative high educational level in Norway may also be important for the innovation capacity of Rogaland, and other regions in Norway. In a paper by Rune

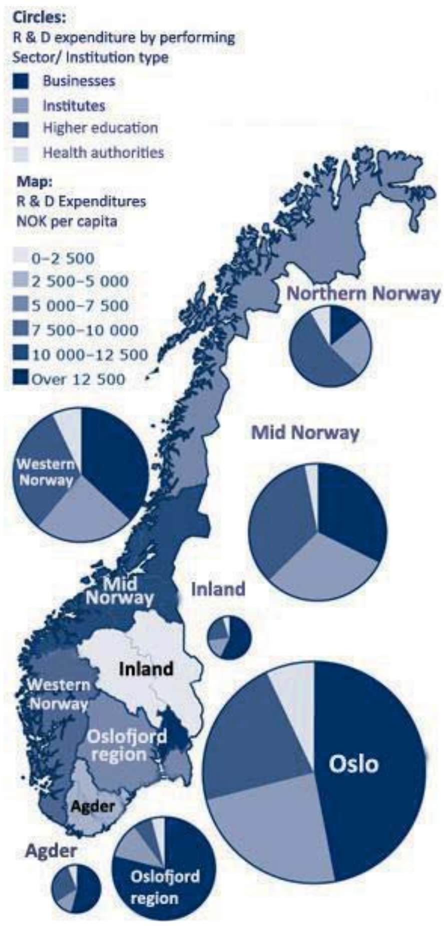


Figure 15: Innovation system in Norway

Dahl Fitjar and Andrés Rodríguez-Pose presented at Regional Innovation Policies, 8th International Seminar (2013) they argue that "regional education levels tend to make regional and national collaboration less effective for product innovation, but to increase the effects of international collaboration" (2013, p20).
They further argue that regional development literature should consider regional environment factors "not only in terms of their direct effects on innovation or in relation to local interaction, but also in terms of their mediating effects on global pipelines" (2013, p20). According to them Rogaland could therefore be better off by further developing global pipelines through which they could assimilate ideas from the main global nodes of knowledge.
The ENSEA project, through interregional cooperation, could therefore in the case of Rogaland be important in bringing local companies closer to global pipelines of knowledge and foster innovation in our region.

7.2.2 Regional innovation support scheme

This section provides a brief overview on supporting regional innovation system from idea to commercial market introduction.

The idea phase
In this phase, the following actors are relevant:

Government actors	Innovation Norway Norwegian Research Council The University of Stavanger's center for innovation research The University of Stavanger's center for student entrepreneurship
Private actor	There are a number of private actors in this area. For example Venture Cup for entrepreneurs

Start-up phase
When the idea has matured, it will be natural to develop a business idea further and prove that it works. It can be done through the creation of a new company or startup of a project. Different actors have different roles. There is a support for this, which include:

Public actors	Prekubator which is an organisation whose purpose is to facilitate the commercialization of research-based ideas. Ipark incubator is an organisation that can help companies with a structured course from idea to commercialization through active ownership. Business development parks are facilities where companies in a start-up and development phase can gather, share common features and encourage a creative environment. Support schemes from Innovation Norway including start-up grants . SkatteFUNN (see SkatteFUNN in Table 3: Research council's national programs) may also be relevant in this phase.
Private actors	IRIS Research Invest whose purpose is to commercialize R & D results Business development parks which houses various businesses and projects , there are a number of these in the county , including Ipark Business Angels who have experience in developing businesses that can contribute with funding Foundation SR -Bank business that offers financial support for early development of

	ideas with commercialization potential Connect Springboard helps entrepreneurs to refine ideas DNB Innovation Award is an example of how financial actors can support innovative companies. Other examples include Ernst & Young Entrepreneur of the Year. Statoil Innovate is an example of how a large company facilitates open innovation

Early growth phase

Government measures may be important in this phase.

Government actors	Funds, in which the state and private investors come together to mobilize capital for businesses or projects that are at an early commercialization phase .
Private actors	Business Angels who have experience in developing businesses and that have some capital to contribute with. There is not a complete overview of business angels in Rogaland. Private funds that are more or less formalized. There is not a complete overview in the county. The availability of mentors can be of great importance to entrepreneurs and innovators in this phase.

Growth Phase

Once the business model is proven, product or service leads to revenue and the business model is scalable, the business or project is in a growth phase. This is usually where the commercial entities enter the business or project.

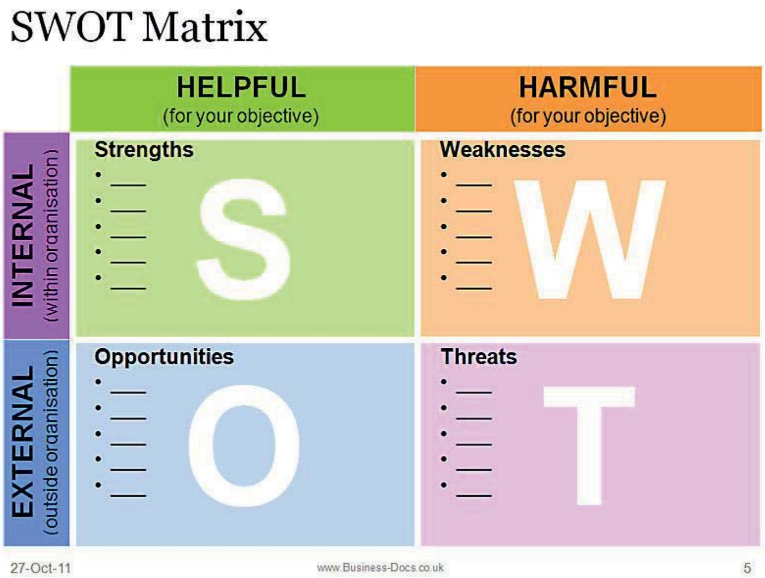
Government actors	At this point there are a limited public actors present. However, you can find public presence through venture funds Argentum
Private actors	Venture capital fund makes and supervisory personnel available to the expansive companies with development potential. Examples include Energy Growth, Energy Ventures, HiTec etc. Companies, investment groups and individuals who want to invest and take the company forward.

Mature phase

This is the phase where further development is part of normal business operations.

7.2.3 The SWOT list

The SWOT analysis for Rogaland region was carried out throughout the regional ENSEA workshop on 18.04.2013 at University of Stavanger. The figure below shows the set up for the SWOT analyses. The results from the SWOT are described in the text below, and represent the views of the participants in the regional workshop.



Strengths (Internal):

1. **Hydro power and reservoirs:** is one of the most important assets of Norway, as well as the Rogaland region. Availability of large hydro power production capacity as well as reservoirs in the region (50% of Europe's hydro reservoirs are located in Norway), is a strength and provides Norway with almost 100% renewable electricity. The existing power production units, combined with DC cables are already providing the North Sea region and Scandinavian countries with green hydro power, as well as balancing services, especially to Denmark.

2. **Offshore oil and gas:** is a major R&D driver in the region. Knowledge transfer from oil and gas sector can boost development of renewable energy in the region. There are immediate synergies between:

- Offshore installations and marine operations with offshore wind
- Drilling- and well technology with geothermal energy
- Natural gas infrastructure with biogas
- Long term maintenance and asset management with renewable energy installations, etc.

High education level of the work force in the oil and gas sector can provide needed boost to the renewable energy sector in terms of human resources.

3. **Strong marine industry cluster** in the region is a strength that can provide the needed support for growth of renewable energy sector, especially the offshore wind sector.
4. **Numerous service companies** in the region supply the oil and gas companies with support and solutions. Further development and growth of innovation driven SMEs in the region is boosted by the strong oil and gas sector.
5. **The fibre optical infrastructure:** Rogaland is a frontrunner at international level when it comes to installation of high speed fibre optic network. Almost every single household and building in the region is connected to the network, which provides the region with unique capability concerning data and information exchange. Combined with smart technologies

and intelligent methods and tools this asset enables real life implementation of smart grids for end use services, control and optimization.

6. **Talent attraction** to the oil and gas sector, with strong ability to pay good salaries, has resulted in a strong and well educated international work force in the region.

Opportunities (External):

1. **Hydro power and reservoirs:** The ever growing need for balancing and backup power in Europe calls for flexible, reliable, and clean energy. The hydro power and reservoirs in Norway and in Rogaland provides opportunities for green energy export as well as balancing and backup services to Europe. Additional cable connections between Norway and the continental Europe would enhance these services and support utilization of the pump storage capacities in the region. The pump storage capabilities in the region are considerable but not fully utilized at the moment. Development of a strong infrastructure in the North Sea region would provide necessary boost to develop these resources.
2. **Offshore oil and gas:** The demand for oil and gas export from Norway has required development of a sophisticated pipeline network that provides opportunities for future CO2 transport to storage site in the North Sea.
3. **Fibre optic network:** The existing high speed network and on-going pilot projects provides the region with unique opportunity for energy efficiency applications.

In general, Rogaland region's strengths (knowledge) in the oil and gas industry can be used to address new challenges in the renewable industry (e.g. offshore wind). Rogaland has important offshore wind industry clusters e.g. Arena NOW and industry/academia links in NORCOWE. In addition, on Haugalandet Rogaland has a strong maritime cluster that could also create opportunities and synergies for the environmental and renewable industry. Maybe the biggest potential of the Rogaland region in a European perspective is the opportunities for delivering back- up and balancing services (Hydro) to Europe. Smart grids will also play an important role in the future and Rogaland may have a role to play both in national and international levels.

Weaknesses (Internal):

1. Too much focus on oil and gas in politics, industry, R&D and education. This is also relevant when it comes to competition for skilled workforce, e.g. it is difficult to attract skilled people to jobs in the public sector as wages are so much higher in the petroleum sector. High activity in oil and gas at the moment leads to no incentive to focus on high risk projects, i.e. low risk culture.
2. High cost level in Norway
3. Norway is on the outside of EU, less chance of influencing policy making and information deficit. European energy policy is not in line with Norwegian needs and business perspectives.
4. Ageing infrastructure
5. The goals in the national/regional plans are not realistic.
6. No home market for new renewables. It is important to separate between renewables (hydro power in Norwegian context) and new renewables. We already have a large green electricity production which leads to low incitement for more production (NB obligations in EU renewable directive)
7. Slow bureaucracy
8. Lack of strong network/database of available actors within renewable energy field (including both companies and research institutes)
9. The visibility of renewable energy is low compared to petroleum. This is even more urgent for energy efficiency, since no one talks about (reducing) use of energy in Norway.
10. Will we have enough competence within renewable energy? Is current education program set to meet future demands within this sector?

11. It is too expensive to live in Rogaland if you are not in oil and gas, which generates competitive disadvantage for Stavanger/Rogaland
12. We are too "well fed" in this region, people are too busy – no time for long term planning. It is difficult to get investment and high skilled work force to renewable energy sector
13. Janteloven, not an environment for standing out/ thinking big
14. Infrastructure issues limit the size of the work market.

Threats (external):

1. Framework/support schemes do not match the need of the industry. ENOVA priorities are not predictable. The programs are too limited. We had an unpredictable framework until 2012 (green certificates).
2. Electricity prices.
3. Norway might enter the renewable energy revolution too late
4. Norway is the second largest gas exporter in the world, and Europe is the main market. Gas is however not a large part of the European Energy Mix in 2050, according to existing scenario.
5. EU aims to become self-sufficient with back up/balance capacity (coal with ccs, shale gas etc.)- thus no pull for Norwegian gas or hydro/wind export
6. Will new cables to Europe be a threat to Norwegian energy demanding industry?
7. Acceptance of renewable energy. More cables to UK/the European continent are by public opinion closely related to higher electricity prices.
8. Lengthy debate about who will invest in cables/infrastructure

   Current economic incentives in Norway does not support and encourage increased production of new renewable energy (wind, biogas, etc.).

7.3 Information and coordination

Within the frame of the ENSEA project, regional workshops will be arranged to inform the stakeholders about the project and its goals, and facilitate initiation of collaboration between stakeholders. A cross regional workshop will also be arranged to facilitate collaboration between the actors in different regions. Identification of the contact points for different industry sectors in different regions will also contribute to improved knowledge exchange between the regions.

8 Summary and conclusions

8.1 Benefiting from regional SWOT analysis

Concerning the setup of our SWOT, there are items here that have not been taken into account in Rogaland's SWOT and there are items that are not listed here. Issues to take forward for consideration in Joint Action Plan based on the inter-regional SWOT are to be concluded in the main report. In general, based on Rogaland's SWOT analysis, the strongest possible contributions to the future cross regional collaboration towards developing a reliable, integrated energy system in the North Sea region can be considered as:

9. Availability of the flexible renewable energy in terms of hydropower for balancing and backup power
10. Capability for knowledge transfer from a strong offshore petroleum sector to the offshore wind area
11. Use of the fibre optic network for energy efficiency and end user services and intelligent methods and tools for monitoring
12. Control and optimization of the energy system

Items brought up in the applications, as well as the expectations at the time of writing the application is summarized in the following tables.

Table 6: Focus and alignment of ESI related activities in academic, company and public sector

Themes	Academic	Government	Company base	Overall for region
Supply flexibility	2	5	3	Weak link between research and industry in the region
Storage	5	4	2	Industrial activity on hydro storage, limited research (fuel cells)
Demand flexibility	7	8	5	Industrial investment in optic fiber net, growing activity level
Grid / Infrastructure	8	3	4	No strong link between research and industry in the region
Integration Methods	1	7	6	An area of focus for academy, weak connection to industry
Boundary Conditions	6	1	7	Focus area for authorities, weak connection to research
Renewable generation	4	2	1	Strong/ Aligned
Carbon Capture & Storage	3	6	8	Strong link between research and oil & gas industry in the region

Table 6 (above) represents a simplified version of the detailed matrix worked out within WP2. The qualitative assessment presented in table one is further explained/motivated below:
The colour code used in the matrix demonstrates the strength and weaknesses within the specific areas listed. The figures in the matrix shows the ranking according to 1= strongest and 8= weakest / not in focus for the regional actors. The ranking presented for the industrial sector reviles only the power producing industry's interest area.
The last column, overall for region, shows the coordination between the three other columns.

Supply flexibility:
Fuel (heat) based power generation with both renewable and fossil fuel is a central research activity for the R&D organisations in our region. Especially the gas turbine technology has been a major focus area for some time. Evaluation of flexibility of existing as well as future thermal plants to cope with the fluctuations in the grid will be part of Horizon 2020 and therefore important R&D area for future project proposals.
Supply flexibility can be provided from existing hydro power stations without hydro pump storage. Currently Norwegian power from existing plants is covering the supply flexibility needed to support the Danish grid, which has a large share of fluctuating wind energy.
Concerning authorities there is no activity in this area at regional level
The lack of strong collaboration between research organisations and industry, concerning supply flexibility is the reason for the colour code selected for the column with the heading “overall for region”.

Storage:
The Norwegian reservoirs for hydropower provide a considerable storage capacity. Given the fact that regional power producers are owner and operator of the reservoirs and hydropower installations in the region, this topic is considered as regional strength.
Gas storage in gas pipelines from Norway to main land Europe provides an important storage capacity.
Fuel cells, and particularly solid oxide fuel cells, have been a field of academic research for some time and detailed, validated tools and methods have been developed to investigate their performance in hybrid and stand-alone installations.
At regional level, there are funding opportunities which motivates the colour code selected.
The limited coordination between research organisations and the industry is the reason behind selected colour code.

Demand flexibility:
Although demand flexibility has not been a focus are so far, it is currently a growing area for R&D in the region and collaboration between research organisations and industry has been established.
However, there is no activity from authorities’ perspective at regional level.

Grid/Infrastructure:
There is no specific R&D activity on grid/infrastructure in Rogaland region. However, it is worth mentioning that Rogaland has the only existing distribution gas grid in Norway.
The regional infrastructure planning carried out and supported by the authorities at regional level is motivating the colour code selected.

Integration methods:
Integration methods as listed in the original matrix comprise many items. System modelling, simulation and analysis as well as ICT are main focus area of R&D activities at research organisations in Rogaland. As a result of many years of R&D activity in this field, the research groups at UiS and IRIS have developed a variety of detailed validated models for system and component analysis and monitoring. Although there is a strong collaboration between research and oil and gas industry, the collaboration between academy and power sector is rather weak, and there is no activity at regional level concerning the authorities, which explains the selection of the colour code for this topic.

Boundary conditions:
The regional authorities are putting considerable efforts in development of the boundary conditions and there is limited R&D activity at both UiS and IRIS. However, the industry sector is not so active in this field, which explains the selection of the colour code.

Renewable generation:
Since almost all power generation in the region is based on hydropower, renewable generation is a very strong industry sector in the region. Research organisations in the region have focus on modelling and analysis of renewable generation concerning biogas/bio mass based power generation as well as wind energy and it is also a strong focus area for authorities at regional level. However, collaboration between academy and industry is rather weak in this area, which explains the colour codes selected.

Carbon capture and Storage (CCS)
CCS is a focus area at national level in Norway. The Test Center Mongstad (TCM) is a unique research center for carbon capture testing and development. There is strong CCS related activity within research and development organisations in the region where UiS is focusing on carbon capture and IRIS on carbon storage in combination with enhanced oil recovery. The oil and gas industries in the region are also engaged in EOR activities using CO2 as driving force, but authorities at regional level do not have any specific activity in this area. However, the power industry in the region is not involved in CCS activities, which explains the selected colour code.
OBS! Given the fact that activities related to authorities are sometimes integrated at a higher level that the regional level, i.e. Rogaland, the matrix part related to authorities could be altered as listed below:

- Supply flexibility: 6- yellow - some project activity, low connection between triple helix on regional level
- Storage: 5- yellow, political goals, low connection between triple helix on regional level
- Demand flexibility: 8- red, low governmental involvement
- Grid/ infrastructure : 3- yellow, public ownership (mostly national level)
- Integration methods: 7- red, low governmental involvement
- Boundary conditions:1- green, focus area for authorities
- Renewable generation: green 2 Public funding and involvement, focus area for authorities
- CCS: 4- yellow, political goals

Summary of related works to renewable energy in Rogaland region i.e. R&D, energy production and future policies are shown in table 7.

Table 7: Academic, Company and Public sector focus on renewable energy

Themes	Academic	Government	Company base	Overall for region
Wind onshore	Limited research activity	Regional cluster projects Realization of Vet-Wind project	Possible 1-2 TWh wind power in Rogaland before 2020	There are industrial activities and clusters dealing with wind farms, however, limited research activities
Wind offshore	Major R&D activities in this field	Public ownership of test-center Regional Cluster projects Realization of Power Cluster and IFP	Not enough incentives for industrial production	Strong research activities in this field, however lack of economic incentives make that there is limited industrial interest in this field.
Solar	Not an area of interest	No specific activity	No specific activity	Not a focus area
Geothermal	Competence in geology and drilling, combined with system analysis capabilities	No specific activity	A certain interest, but no industrial activity	Competences in the field of geology and drilling combined with system analysis and system integration provides a solid base for development. However, there is not enough strong driving force in place right now.
Biomass	There has been research activities in the field of biogas	Regional Cluster projects Realization of Enercoast	Biogas for transportation	There are regional opportunities and interests, but there is limited collaboration between industry and R&D sector
Hydro	Limited research activity	Regional cluster projects	Main region's strength	Industrial production but limited collaboration between research and industry
Micro generation	Thermal micro generation has been in focus	No specific activity	No specific activity	No specific collaboration between industry and R&D sector
Marin power	No specific activity	No specific activity	No specific activity	Not a focus area
Energy from waste	Limited research activity	No specific activity	Industrial production	Not a focus area

8.2 Identification of demand driven research projects

Triple helix setup of the ENSEA provides opportunity for identification of needed R&D for realisation of the European carbon-free energy system, taking all stakeholders' viewpoints into account. This will facilitate prioritisation of the issues, creation of the competence pool and financing of the activities. Several project topics have already been identified by the ENSEA group to handle the holistic system integration approach addressed by the project. Examples of such project topics are: Backup and balancing power, pipelines and infrastructure for electricity and gas, governance and decision models. The main topics for the future projects will be identified in collaboration with the stakeholders during the ENSEA workshops.

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Appendices

Date:
18th February 2014

1 General appendices

1.1 Appendix: 2013 Regional Innovation Union Scoreboard (ENSEA partner) results

A part of the data collection process was carried out by a Consultant –Technopolis. This information primarily related to Regional Innovation Scoreboard (RIS) data. A sample of this material that relates to the ENSEA partner regions and some leading regions in the EU as well as the average RIS score for all of the regions in the EU.

The Regional Innovation Scoreboard (RIS) provides a useful mechanism for assessing the relative strengths and weaknesses of parts of the innovation system because it provides data that enables a relatively objective comparison with a region against other regions in the EU-27 and EU benchmark levels for activity.

Potentially these metrics provide a way to identify areas for the exchange of best practice between ENSEA partners.

The Regional Innovation Union Scoreboard is broken down into 12 metrics under three headings of 'Enablers' (factors external to companies), 'Firm activities' and 'Outputs' (the economic effects of company activities). Populating these with data collected by Technopolis it was possible to compare and rank each ENSEA partner.

This data is available as an excel file produced by Technopolis for the ENSEA project.

Overall results

Regional Innovation Score	Noord-Holland	Niedersachsen	Scotland	Rogaland
Human resources				
Research				
Finance				
Firm investments				
Linkages				
Intellectual assets				
Innovators				
Economic effects				

Table contents
Green colour – score above EU-27 average, Amber – score around EU-27 average, Red – score below EU-27 average

Results summary
The results overall suggested that the Energy valley and EmsAchse were innovation leaders and Scotland and Rogaland were innovation followers.

Some concern existed about lack of appropriate energy data (RIS covers the whole of the economy) or accurate regional data (particularly for Rogaland and EmsAchse). The RIS data also uses about half the number of metrics of the EU member states' Innovation Union Scoreboard and currently lacks any metrics data for assessing research quality.

Typically RIS metrics relate to a % rather than absolute value (of for example investment in R&D). This can have drawbacks. For example, in the case of Norway (a country with a very high GDP per head) relatively large absolute amounts of investment in R&D are measured as a relatively low % of GDP figure.

Summary of the top ENSEA scorers for the indices used in RIS Scoreboard

	Leading region by score
Enablers	
Human resources	Noord Holland
Research*	Netherlands
Finance and support	Noord Holland & Scotland
Firm activities	
Firm investments	Lower Saxony
Linkages and Entrepreneurship	Noord Holland
Intellectual assets	Lower Saxony
Outputs	
Innovators	Lower Saxony
Economic effects	Lower Saxony

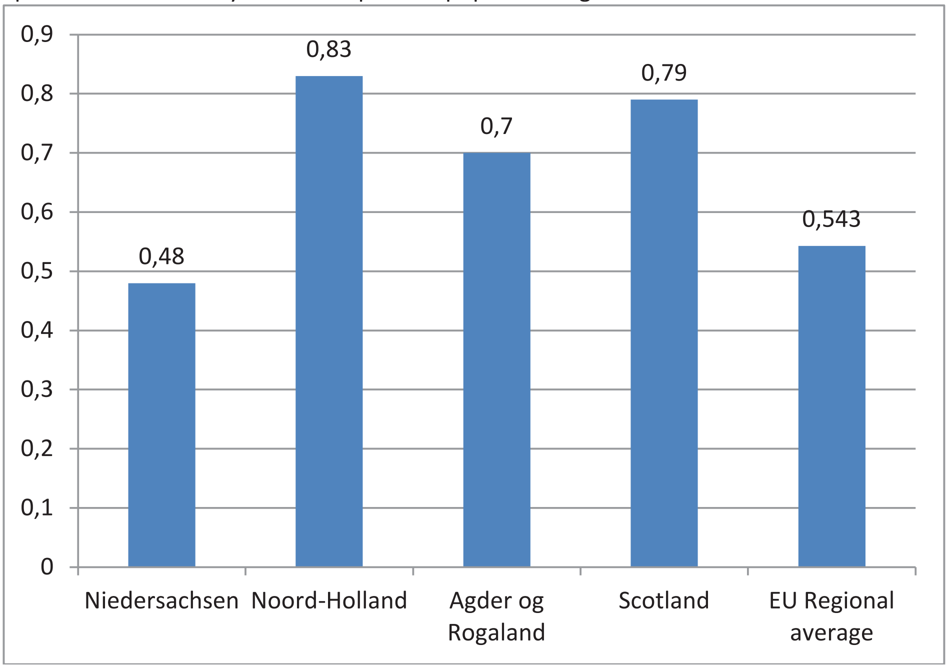
*Only national data available

A specific set of scores that also include some leading regions as well are shown below.

Enablers – drivers of innovation external to companies
Enablers capture the main drivers of innovation performance external to the firm and cover 3 innovation dimensions: 'Human resources', 'Open, excellent and attractive research systems' as well as 'Finance and support'.

Human resources
One indice is used in the RIS to measure Human resources. Population with tertiary education per 100 population aged 25-64. Noord-Holland followed by Scotland had the highest % of population with tertiary education (and so scored highest). Lower Saxony was the only region with a lower than EU average score.

Population with tertiary education per 100 population aged 25-64.

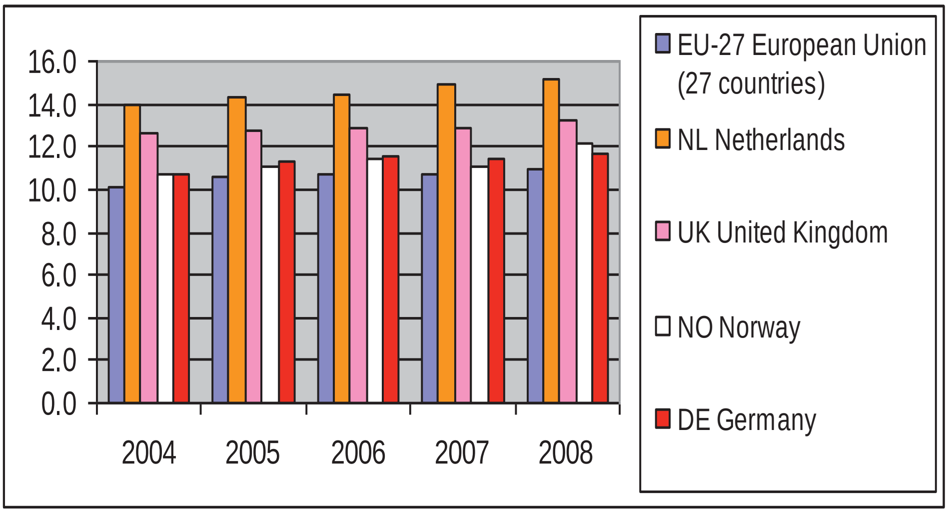


Open, excellent attractive research

There are no regional indices to measure 'Open, excellent attractive research systems' as there are for EU member countries.

Taking one of the national IUS measures Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country The Netherland scored highest with UK coming second.

Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country

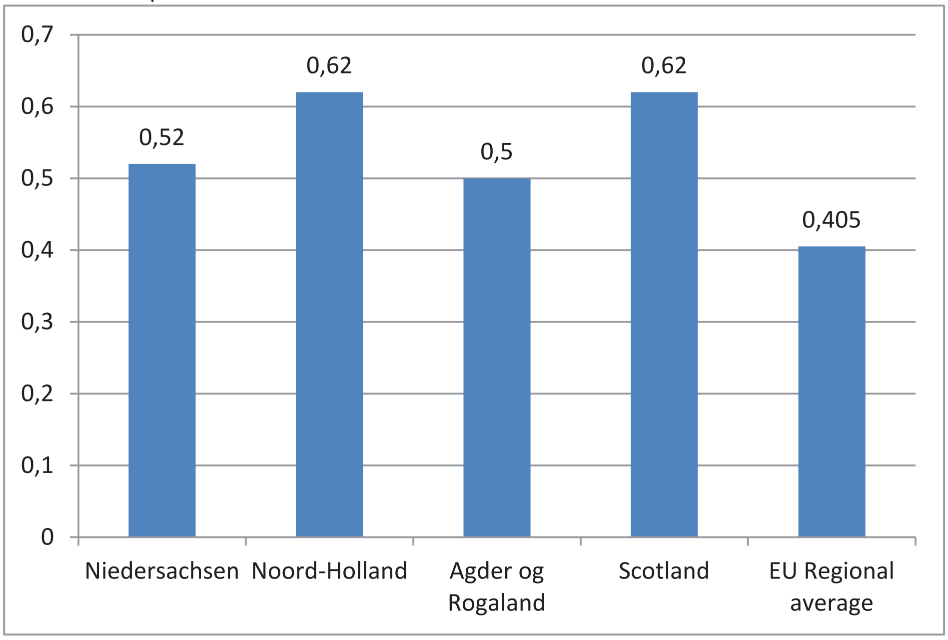


All the ENSEA countries scored higher than the EU average overall in all of the national research measures available.

Finance and support

One indice was used to measure Finance and support - Public R&D expenditures as % of GDP. Noord-Holland and the UK scored equal highest but all the ENSEA countries scored higher than the EU average.

Public R&D expenditures as % of GDP



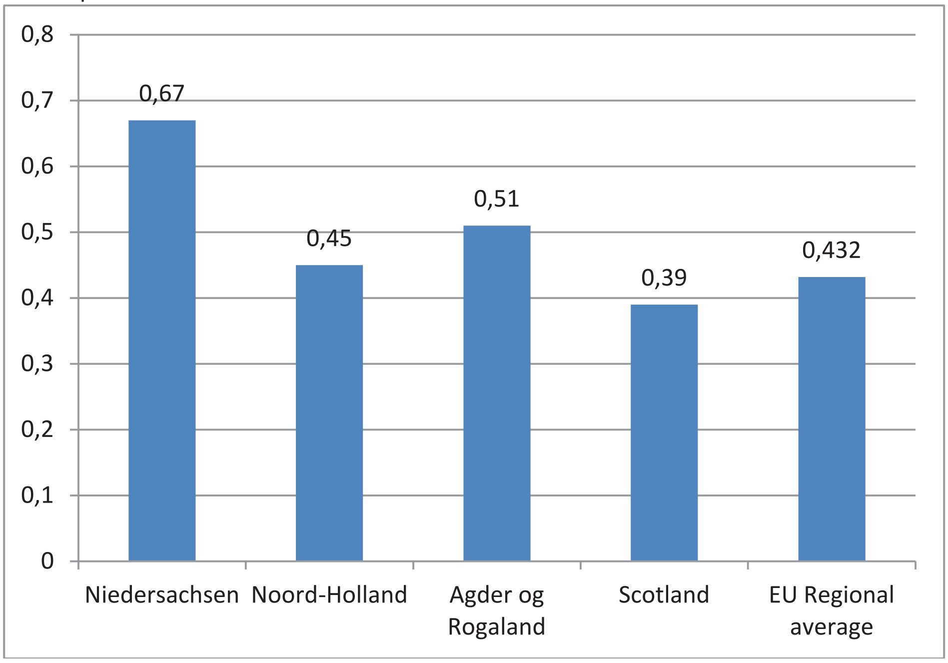
Firm activities – innovation activities of companies

Firm activities capture the innovation efforts at the level of the firm, grouped in 3 innovation dimensions: 'Firm investments', 'Linkages & entrepreneurship' and 'Intellectual assets'.

Firm investments

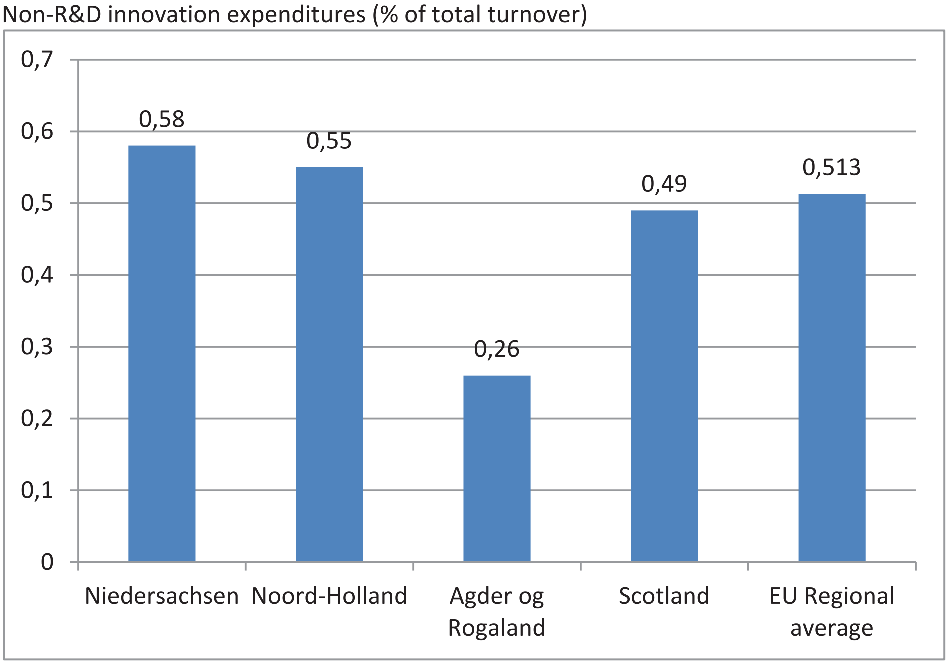
Two indices were suggested for measuring Firm investments – Business R&D expenditures (% of GDP) and Non-R&D innovation expenditures (% of total turnover). Lower Saxony scored highest for this metric and Rogaland second. Only Scotland's business sectors out of the ENSEA countries invested less than the EU average overall as a % of their GDP.

R&D expenditure in the business sector as % of GDP



However in the second metric used to measure Firm investments both Scotland and Rogaland scored below the EU average.

Non-R&D innovation expenditures (% of total turnover)

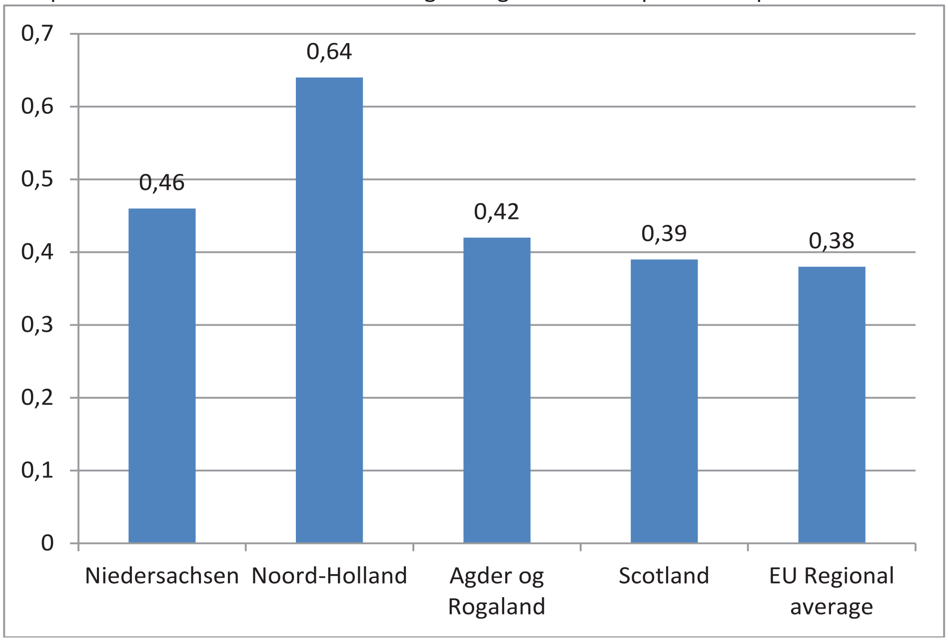


In the case of Scotland the likely issue is that the region's company base is dominated by very small firms which often lack the resources or skills to innovate.

Linkages and Entrepreneurship

Three indices were used to measure Linkages and Entrepreneurship - SMEs innovating in-house (% of all SMEs), Innovative SMEs collaborating with others (% of all SMEs) and Public-private co-publications per million population. Overall Noord-Holland scored highest by quite a margin followed by Lower Saxony. All of the ENSEA regions scored higher than the EU average.

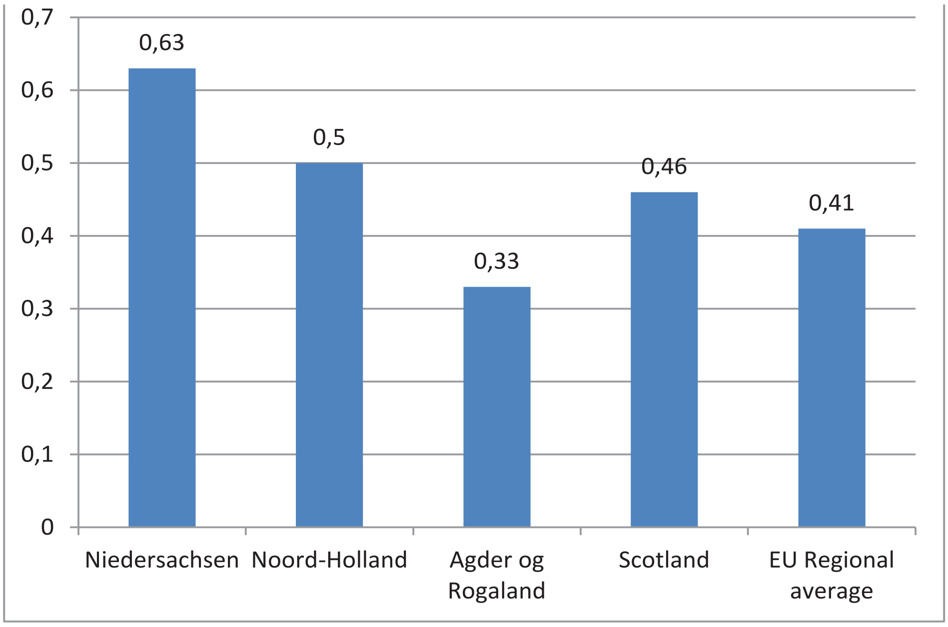
Composite score for 3 metrics measuring Linkages and Entrepreneurship



Intellectual assets

One indice was used to measure Intellectual assets and related to patent applications, trademarks and new product designs - EPO patents per billion GDP. Lower Saxony scored highest by a margin with Noord-Holland coming second. Rogaland scored lower than the EU average using this ranking.

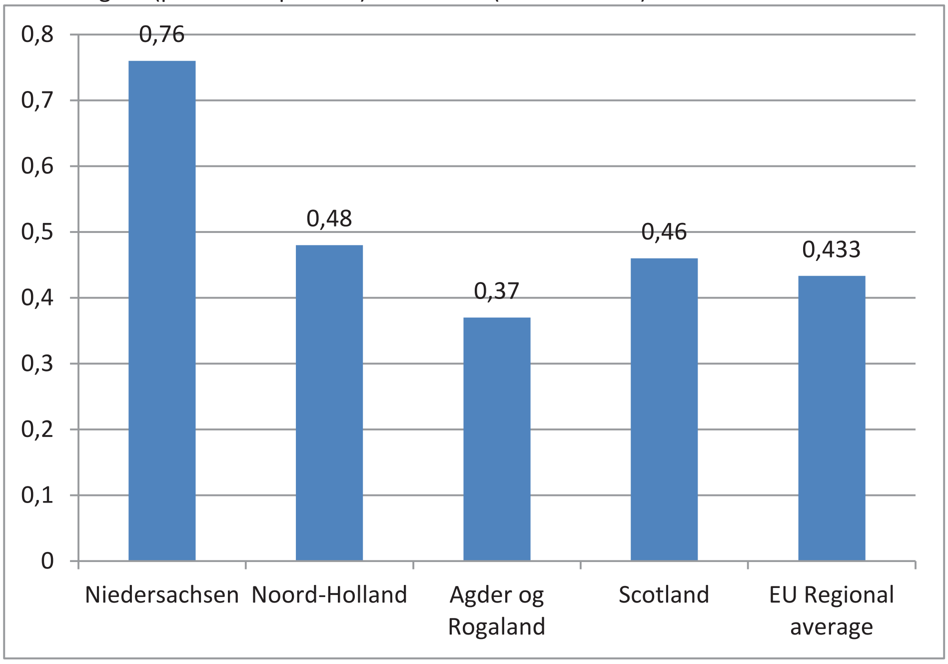
EPO patents per billion GDP



Outputs – the effects of company activities
Outputs cover the effects of firms' innovation activities in 2 innovation dimensions: 'Innovators' and 'Economic effects'.
Innovators

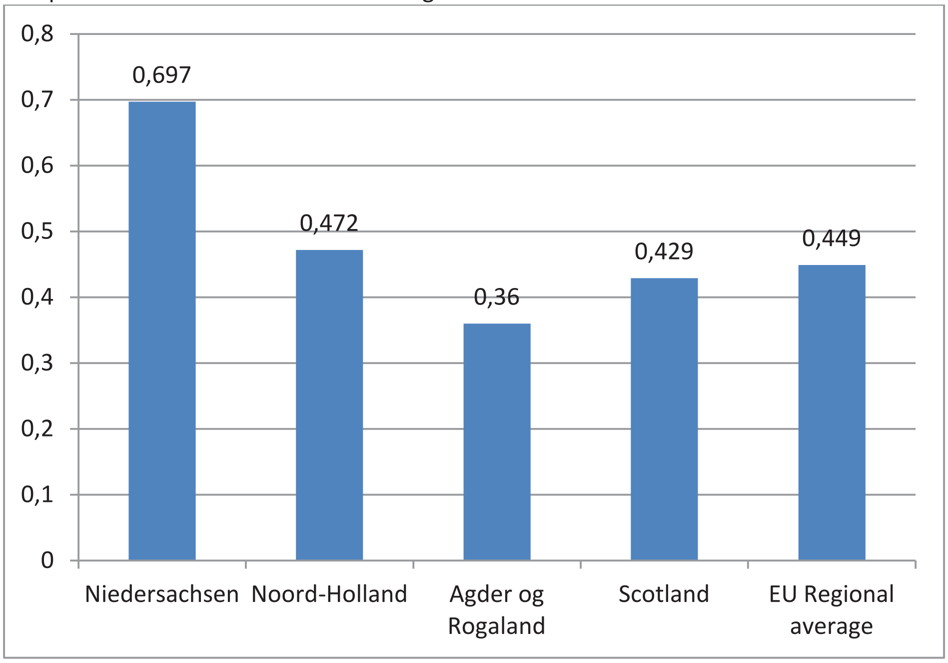
One indice was used to measure Innovators - Technological (product or process) innovators (% of all SMEs). Lower Saxony scored highest with the Netherlands coming second. Rogaland scored lower than the EU average score using ranking.

Technological (product or process) innovators (% of all SMEs)



Economic effects
Three indices were used to measure Economic effects and related to employment, exports, sales of new innovations and license and patent revenues from abroad. Lower Saxony scored highest with the Noord-Holland coming second. Both Scotland and Rogaland scored lower than the EU average using these rankings.

Composite score for 3 metrics measuring economic effects



Conclusions on Regional Innovation Scoreboard results for ENSEA regions

The RIS metrics suggest that higher activity in the private sector is needed to generate tangible economic benefits from innovation. For example, Scotland has a relatively well educated workforce, good research base and public spending but is not benefiting from this in the way that Lower Saxony is because of its weaker private sector activities. Similarly Rogaland has above average EU metrics for human resources, research and also for private sector innovation spend but is below the EU-27 average for entrepreneurship.

1.2 Appendix: Work package 2 information collection plan

A task in this Work package was define the information and format for collection to be used for the ENSEA region analysis. The table below shows the proposed WP2 collection plan with the material listed in the Work package to be collected and methods (and sources) used to collect this.

	Collection method	Main benefits of this activity
Method 1	Consultant	EU innovation scoreboard metrics
Method 2	Desk research	Detailed information
Method 3	SNA	Linkages
Method 4	Interviews	Detailed information - especially future (Horizon 2020) intentions
Method 5	Network events	Feedback & validation

Task	Indicator in the ENSEA tender	Preliminary Collection method	Comment
1	· Research strengths in the sector, public actors	Method 1 - Consultant	This measures strengths in energy. For the project areas (storage etc) see new tasks 21 22 below
2	· Research strengths in the sector, private actors	Method 1 - Consultant	This measures strengths in energy. For the project areas (storage etc) see new tasks 21 22 below
3	· Industrial capabilities in the sector	Method 1 - Consultant	Industrial or innovation capabilities needed ? Assume innovation capabilities here
4	· R&D expenditure, including public and private sector investment	Method 1 - Consultant	
5	· Existing policy and support mechanisms (including knowledge transfer, commercialisation, R&D, innovation and other relevant business support and current use of EU Structural Funds)	Method 2 - Desk research	List and describe these
6	· Effectiveness of policy and support mechanism (e.g. number of companies spun out of each region’s Higher Education establishment, number of patents generated, number of new products created)	Method 1 - Consultant	
7	· Existing cluster initiatives and activities: linkages within the research driven clusters	Method 1 - Consultant	

8	· Existing cluster initiatives and activities: degree of trans-regional linkages between the ENSEA members	Method 2 - Desk research	List links with other ENSEA regions - Number of trans ENSEA linkages (for Universities, SMEs)
9	· Other EU/international links and collaboration projects	Method 1 - Consultant	
10	· Effectiveness of existing linkages and collaborations	Method 1 - Consultant	Assume this means how 'good' the cluster is at doing collaborative innovating
11	· Barriers to effectiveness of policy and support mechanisms, particularly as perceived by SMEs	Method 5 - Network events	Get qualitative feedback from SMEs
12	· Access to finance (public and private)	Method 1 - Consultant	Get qualitative feedback from SMEs, Universities
13	· Skills availability	Method 1 - Consultant	
14	· Talent attraction	Method 1 - Consultant	
15	· Infrastructure	Method 2 - Desk research	Assume this means infrastructure for innovation - list assets eg laboratories, test and demo sites, other
16	· Market demand (regional, national and international)	Method 2 - Desk research	
17	· Capacity to attract inward investments, with particular focus on R&D	Method 1 - Consultant	
18	· Capacity for EU and international engagement	Method 1 - Consultant	
19	· Regional innovation initiatives	Method 2 - Desk research	List and describe these (try to quantify eg amounts of money taken by cluster)
20	· Regional sector initiatives (including towards Smart Specialisation Strategies where applicable)	Method 2 - Desk research	List and describe these (try to quantify eg amounts of money taken by cluster)
21	· Research strengths in the sector, public actors (for project areas eg storage)	Method 4 - Interviews	*Universities*
			1. List the departments or Professors that include [example Balancing] in their areas of research focus now

			2. List research projects by name, their start-finish dates, and the amount of money for [example Balancing] projects (say covering the years 2008-20**20**)
			3. List patents in [example Balancing] produced (say covering the years 2008-2012)
			4. List licenses [example Balancing] given out to private companies and their value (say covering the years 2008-2012)
22	· Research and development and knowledge exploitation strengths in the sector, private actors (for project areas eg storage)	Method 4 - Interviews	*Start ups and SMEs (under 250 employees)*
			5. List start ups and SMEs that include [example Balancing] as their business focus now
			6 What is each ones' turnover, staff numbers, research and development spend
			7 List research projects by name, their start-finish dates, and the amount of money for [example Balancing] projects (say covering the years 2008-2020)
23	National and regional policy making bodies	Method 2 - Desk research	List these

1.3 Appendix: Overview of the Innovation System

An Innovation System is a set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process. Current thinking emphasises the interactive nature of the innovation process and the importance of absorptive capacity of firms as a complement for their own internal knowledge resources.

A series of six functions which make up the idealised Innovation System have been identified. They are:

13. Policy formulation and advocacy
14. Policy Implementation
15. Facilitation and direction of R&D
16. Knowledge creation and development
17. Knowledge diffusion and exchange
18. Entrepreneurial activities (knowledge exploitation)

In addition, it is important to acknowledge the importance and influence of national and supra-national policy making and innovation support. Hence four additional functions comprise

19. EU Policy & Objectives
20. EU Innovation Support & Implementation measures
21. National wide Innovation Policy making bodies
22. National Formulation & Implementation of Innovation Policy

These functions are shown in Figure 1 below.

Whilst the Innovation System implies a hierarchy of functions leading from EU policy through to institutions (firms and organisations engaged in entrepreneurial activity), the reality is more complex with functions linked together in a number of different feedback loops and flows.

The functions represent the requirements for effective innovation, *however it is the institutions within the system and the architecture they design and implement that ultimately determine effectiveness.* How these evolve and change and are co-ordinated and managed provides the dynamic nature of the system. The functions are shown as distinct in order to give a structure to the analysis, but critically in many cases institutions (organisations) are actively contributing to more than one function.

Organisational Functions

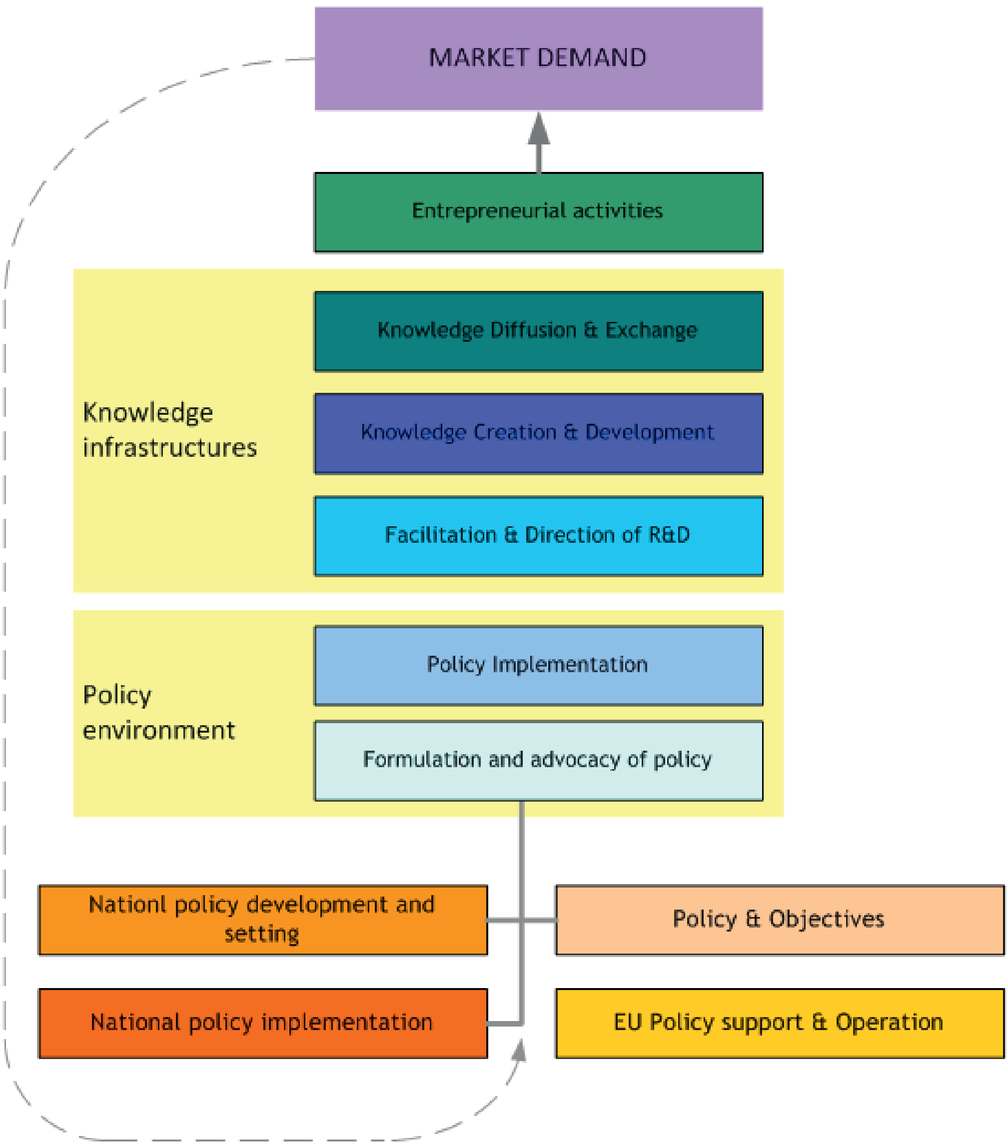


Figure: Diagram of a generic Innovation System

The flows of knowledge between functions and the intra function linkages are important elements of the effectiveness of the innovation system – so the functions analysis should be viewed as the building blocks of the approach with the actions of the institutions (organisations or participant) being the mechanisms to create flows and interactions that generate innovation activity.

How these then evolve and change in response to market and industry requirements is critical. A managed and co-ordinated approach will help ensure that the dynamic nature is optimised. In addition, this allows for the absorption and realignment of actions in response to the potential impact of emerging disruptive technologies.

The functions are defined as follows:

- **Policy Formulation & Advocacy**
  This function captures the strategic direction aspects of the model - within the function the institutions have broad economic and social agendas and will balance innovation along with industry development policy priorities. The policy decisions taken within this function should have the ability to direct national innovation capability and to precipitate/direct actions which will strengthen the framework environment and to positively impact on the conditions for development. A key aspect of this function is to direct system governance and to ensure consistency between regional, national and EU policy measures as they effect both innovation and systems integration.

- **Policy Implementation**
  The focus of this function is on managing and directing the implementation of policy and on the development and design of innovation support measures and other economic development interventions. The general emphasis is on the development of systems integration in a region but it will also have specific objectives relating to innovation support and promoting a coherent approach.

- **Facilitation and Direction of R&D**
  The focus of this function is on the facilitation and direction of (public) support for knowledge creation, business innovation and R&D to tackle the challenges of the industry. This function is dominated by publicly funded bodies, but not exclusively so. Since resources are not a limitless commodity, it is important that choices are made and specific foci selected. Institutions in the function should be seeking to ensure complimentarity exists between regional, national and EU innovation and R&D support schemes.

- **Knowledge Creation and Development**
  The key focus of this function is to support innovation which is (a) capable of generating new knowledge which is applicable to local firms or markets, (b) able to capture knowledge which is applicable to a region and (c) able to provide training in R&D and innovation skills which are retained within the region. Working effectively this function will be able to provide widely accessible, focused, timely and responsive support for optimal levels of innovation in both universities and firms.

- **Knowledge Diffusion and Exchange**
  This is an intermediate function linking the functions in knowledge creation and development with the entrepreneurial activity and its focus is on knowledge brokering or diffusion. A key aspect of this function is the ability to identify valuable technologies or knowledge and to match this with appropriate mechanisms. The mediation and sharing of knowledge between knowledge creators (e.g. Universities) and firms is a fundamental aspect of this function. Efficient knowledge diffusion and exchange is of particular importance for those firms who through smaller size or limited experience have less capability in identifying and exploiting valuable technologies and face barriers (scale barriers, risk aversion, information deficiency etc) to engage directly with knowledge generators.

- **Entrepreneurial Activity**
  In this function the objective is to exploit the knowledge base to generate new competitive products and services and to thereby achieve enhanced profitability or business value. Knowledge exploitation will be undertaken by firms that are primarily linked through (vertical) supply chains and trading relations and (horizontal) collaborative networks. For effective innovation, firms should have strong internal innovation capabilities; there will be robust (local) supply chains which are characterised by

strong knowledge flows between trading partners; and there will be a high incidence of horizontal collaboration networks.

The national functions have policy and innovation formulation and implementation roles which have an impact on how the industry in a region operates. These functions can act as a support or hindrance to the effectiveness of innovation but the existence of differences can also offer opportunity for a region. In addition, the role of EU policy and support measures and in particular EU development priorities for innovation are important since support for innovation and R&D in a region is provided by Structural Funds and Framework Programmes.

Systems Integration Institutions

The institutions which constitute the innovation model are grouped by the function they contribute to most. The inclusion of national and EU institutions emphasises the role and influence of institutions extraneous to a region have on the effectiveness of the system.

A number of institutions have roles in more than one function or across functions. In addition, the architecture designed by the institutions to fulfil the function or to support flows and linkages within and between functions is also shown.

The different institutions, their roles and rationale for inclusion in the model are discussed below. This summary representation acts as a useful view on the whole system, but does not illuminate the scale of influence or the degree of connectedness of the institutions and does not illustrate fully intra and inter function linkages and their effectiveness. Thus, this view summarises the population, but not the dynamics.

Our approach to selecting institutions and to a lesser extent the architecture for inclusion in the model has built on Scottish analysis and been complemented by assessing their influence on the system. This included considering the following criteria:

- Focus on Energy Systems Integration
- Ability to set and implement policy
- Ability to determine and create knowledge (the Knowledge generators and those determining the focus of knowledge generation)
- Ability to interact – or should interact – to share and mediate knowledge (the Knowledge mediators and those determining the focus or extent of knowledge sharing)
- Ability to exploit knowledge – those acting at the market – entrepreneurial activity focuses on the differences in firms' characteristics which differentiate their ability, capacity, and propensity to exploit knowledge.

Additionally, the review of the institutions, knowledge flows and exploitation has been informed by challenge from a range of stakeholder and industry players.

The institutions in the system are identified below for each of the functions and the architecture designed by the institutions to fulfil the functions remit are then identified where such exist.

2 Appendices Scottish Regional Report

APPENDIX A: Summary of Scottish Academic Research Metrics

Energy Research Categories			Research in the public sector				
			Scottish Universities				
			No. senior academics (Profs./Drs/Principal Investigators) with the energy topic in current research focus.	No. Public Funded Research projects from 2008-2012 (UK)	Value of public funded research projects from 2008-2012 (£M)	No. EU Funded Research projects from 2008-2012	Value of EU funded research projects from 2008-2012 (€M)
Supply flexibility	Gas-fired Powerplant						
	Coal-fired Powerplant						
	Hydro Pumped Storage						
Storage	Hydropower						
	Power to Gas						
	Batteries (inc. chemical storage)		14				
	Gas Storage						
	Fuel cells			2	£2,135,853		
	Other storage (hydrogen, etc.)			1	£495,647		
Demand flexibility	Industrial customers						
	Comercial customers						
	Domestic customers						
	Smart Meters						
Grid / Infrastructure	Balancing	Engineering	43	11	£8,249,911		
		Comercial planning					
	Gas Grid	Distribution					
		Transmission					
	Power Grid	Distribution/Smart Grid					
		Transmission					
		Super Grid (HVDC)					
Integration Methods	Data						
	Systems						
	ICT (information communication techn.)						
	Modelling Simulation						
	Scenarios/Analysis						
	Power Electronics						
	Materials						
Boundary Conditions	Policy						
	Social Acceptance						
	Legal Aspects						
	Economics						
Renewable generation	Wind offshore & Onshore*		17	1	£935,646		
	Wind onshore*			4	£6,479,216	1	€ 1,226,659
	Wind offshore*			1	£244,206		
	Solar*		30	23	£17,944,907	2	€ 8,834,541
	Geothermal			tbd			
	Biomass*		50	14	£8,144,818	6	€ 18,132,985
	Hydropower			tbd			
	Microgeneration			tbd			
	Marine Power*		19	9	£11,846,873	1	€ 5,482,036
	Energy from waste*			2	£1,304,552		
Carbon Capture & Storage	All Carbon Capture & Storage Activities**		130++	29	£28,389,941	1	€ 2,963,463
Totals				*97*	*£86,171,570*	*11*	*€ 36,639,684*

NB: All values provided for projects are total project value and not disaggregated to the value received for the Scottish partner(s). ++ academic numbers comprised of academics which work in

<u>Sources:</u>

	ETP BDM, 2013
*	Scottish Enterprise Database (O'Herlighy consultancy, Aug 2013)
**	SCCS Database, Nov 2013

APPENDIX B: Summary of Government (Scottish Enterprise) Metrics

System Integration WP2 analyses				Scottish Enterprise projects examples 2008-2012	Scottish Enterprise investments 2008-2012 £M
Topic	Supply (flexi-bility)		Gas-fired Powerplant		
Topic	Supply (flexi-bility)		Coal-fired Powerplant		
Topic	Supply (flexi-bility)		Hydro Pumped Storage		
Topic	Storage		Hydropower		
Topic	Storage		Power to Gas		
Topic	Storage		Batteries (inc chemical storage)	Shetland NINES and Orkney projects	0.0
Topic	Storage		Gas Storage		
Topic	Storage		Fuel cells		
Topic	Storage		Other storage (hydrogen…)	Energetica Smart Grid DF	0.0
Topic	Demand flexibility		Industrial customers		
Topic	Demand flexibility		Comercial customers	POC - Smart Building System	0.3
Topic	Demand flexibility		Domestic customers		
Topic	Demand flexibility		Smart Meters		
Topic	Grid / Infrastructure	Ba-lanc-ing	Engineering		
Topic	Grid / Infrastructure	Ba-lanc-ing	Comercial planning		
Topic	Grid / Infrastructure	Gas Grid	Distribution		
Topic	Grid / Infrastructure	Gas Grid	Transmission		
Topic	Grid / Infrastructure	Power Grid	Distribution/Smart Grid	PNDC, Energetica Smart Grid	5.5
Topic	Grid / Infrastructure	Power Grid	Transmission		
Topic	Grid / Infrastructure	Power Grid	Super Grid (HVDC)		
Topic	Integration Methods		Data	Fraunhofer IoP Photonics	2.2
Topic	Integration Methods		Systems		
Topic	Integration Methods		ICT (information communication techn.)		
Topic	Integration Methods		Modelling Simulation	Super Compomputing Scotland	0.1
Topic	Integration Methods		Scenarios/Analysis		
Topic	Integration Methods		Power Electronics		
Topic	Integration Methods		Materials	Advanced forming centre	3.3
Topic	Boundary Conditions		Policy		
Topic	Boundary Conditions		Social Acceptance		
Topic	Boundary Conditions		Legal Aspects		
Topic	Boundary Conditions		Economics		
Topic			Across all renewables	See below exc PNDC	47.8
Topic	Renewable generation		Wind onshore		
Topic	Renewable generation		Wind offshore	POWERS, Catapult, various	8.9
Topic	Renewable generation		Solar		
Topic	Renewable generation		Geothermal	Energetica, RED	0.1
Topic	Renewable generation		Biomass	Celtic Renewables, SAD project, Renewable Energy for Priority Industries, Renewable Energy:Bio-fuel Market Development	1.5
Topic	Renewable generation		Hydropower		
Topic	Renewable generation		Microgeneration		
Topic	Renewable generation		Marine Power	WATERS1 & 2, WATES, Catapult, EMEC, various companies,	24.3
Topic	Renewable generation		Energy from waste	Celtic Renewables, Recyclatec, Impact Labs	0.2
	Carbon capture		Carbon capture and storage		0.4

Source: Scottish Enterprise project reporting data, December 2013, Scottish Enterprise

European North Sea Energy Alliance

APPENDIX C: Summary of Industry Metrics

System Integration WP2 analyses			research strengths in the sector, private actors				research strengths in the sector, private actors			
			Start ups and SMEs (under 250 employees)				non SMEs			
Topic			(22.5) List start ups and SMEs that include [the topic] as their business focus now	(22.6) What is each ones` turnover £M	(22.6) What is each ones` staff number	(22.6) What is each ones` research and development spend	(22.5) List non SMEs that include [the topic] as their business focus now	(22.6) What is each ones` turnover	(22.6) What is each ones` staff number	(22.6) What is each ones` research and development spend
Supply (flexi-bility)		Gas-fired Powerplant	29	?	?	?	2	675	380	
		Coal-fired Powerplant	17	?	?	?	2	360	713	
		Hydro Pumped Storage	?	?	?	?	2	36	70	
Storage		Hydropower	?	?	?	?	?	?	?	?
		Power to Gas	?	?	?	?	0	?	?	?
		Batteries (inc chemical storage)	13	?	?	?	18	?	?	?
		Gas Storage	?	?	?	?	3	?	?	?
		Fuel cells	29	?	?	?	0	?	?	?
		Other storage (hydrogen…)	13	?	?	?	0	?	?	?
Demand flexibility		Industrial customers	?	?	?	?	?	?	?	?
		Comercial customers	?	?	?	?	?	?	?	?
		Domestic customers	?	?	?	?	?	?	?	?
		Smart Meters	49	?	?	?	26	?	?	?
Grid / Infrastructure	Ba-lanc-ing	Engineering	?	?	?	?	3	?	?	?
		Comercial planning	?	?	?	?	3	?	?	?
	Gas Grid	Distribution	12	400	689	?	3	?	?	?
		Transmission	10	80	575	?	3	?	?	?
	Power Grid	Distribution/Smart Grid	30	1,020	1758	?	33	?	?	?
		Transmission	25	204	1465	?	2	?	?	?
		Super Grid (HVDC)	?	?	?	?	2	?	?	?
Integration Methods		Data	83	?	?	?	48	?	?	?
		Systems	52	?	?	?	33	?	?	?
		ICT (information communication techn.)	55	?	?	?	36	?	?	?
		Modelling Simulation	5	?	?	?	2	?	?	?
		Scenarios/Analysis	5	?	?	?	2	?	?	?
		Power Electronics	70	?	?	?	5	?	?	?
		Materials	5	?	?	?	0	?	?	?
Boundary Conditions		Policy	5	38	152	?	0	?	?	?
		Social Acceptance	18	?	?	?	0	?	?	?
		Legal Aspects	7	?	?	?	0	?	?	?
		Economics	3	?	?	?	0	?	?	?
		Across all renewables				?		?	?	?
Renewable generation		Wind onshore	193	1,026	2235	?	2	?	?	?
		Wind offshore	60	50	943	?	1	?	?	?
		Solar	86	85	287	?	0	?	?	?
		Geothermal	0	-	0	?	0	?	?	?
		Biomass	89	30	2510	?	0	?	?	?
		Hydropower	114	232	503	?	2	?	?	?
		Microgeneration	97	?	282	?	0	?	?	?
		Marine Power	86	9	577	?	0	?	?	?
		Energy from waste	19	40	161	?	0	?	?	?
Carbon capture		Carbon capture and storage	16	?	?	?	?	?	?	?

Sources:
'Scottish Enterprise Energy Baseline Study - Final report', November 2009, SQW
'Scottish Smart Grid Fore sighting study – Discussion paper' 2013, Scottish Enterprise

Partners:

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ENSEA-Joint Action Plan

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1. Introduction

The Joint Action Plan (JAP) expresses the vision and strategy of the ENSEA-Consortium to drive economic development through joint R&D activities, smart specialisation and internationalisation. It is based on the results of the regional JAP´s.

Our goal is to build a sustainable, secure and competitive future energy supply. Furthermore, the ENSEA Consortium stands for active climate protection and effective and economic development of renewable energies.

According to this goal the ENSEA-Consortium attaches importance to realizable, economically sustainable energy system integration. This results in a Joint Action Plan which accommodates this approach to a great extent.

2. Vision of the European North Sea Energy Alliance

The way we currently produce and use energy is not sustainable. The resulting greenhouse gas emissions and the immense consumption of resources threaten the means of livelihood for future generations and ourselves.
We, the ENSEA consortium want to use our skills and expertise for a restructuring of the energy supply systems on sustainable energy production and for using energy more efficiently.

Based on the visions of the four ENSEA partners (highly abbreviated description – regional JAPs contain full versions):

- … Since in 2014 renewable energy has been a mainstay of energy supply, in 2025 a reliable energy mix of fossil fuels and renewable energy together with high performance storage systems ensure economic growth … (Wachstumsregion Ems-Achse, Germany).

- … Scotland's huge renewable energy resource, coupled with its commitment to fulfil ambitious climate change targets, offer the potential for Scotland to become one of the world leaders in renewable energy development[…] Scotland, United Kingdom).

- … The global community needs to address the great challenge of climate emissions and global warming. The demand for energy is meanwhile increasing worldwide. It is thus crucial to cover the increasing energy demand with environmental friendly energy solutions […] (Rogaland, Norway).

- ... the Energy Valley Region strongly benefits from the trend of energy activity to move to the shore and in fact to the North Sea itself. The main strategic goal of Energy Valley is to not only support this trend, but also try to reinforce it and to develop into a region of energy and sustainability excellence[…] (Energy Valley, Netherlands).

the ENSEA consortium is determined to act structure-forming and to develop a common vision for the North Sea Region. And yet, the goal is certain:

We Europeans want to design our energy supply sustainable, secure and competitive. We want active climate protection and an effective and economic development of renewable energy.

And the milestones are certain:

1) Expansion of renewable energy in line with the power grids
We in Europe have big plans, if it is assumed that renewable energies are to become a mainstay of energy supply by 2050. But not only is this aspect very ambitious. The transition to a comprehensive use of renewable energy sources is a huge challenge for electricity networks, therefore the modernization of the network infrastructure is the centrepiece of a sustainable energy supply, in addition to the expansion of renewable energies. For this purpose we need an intelligent load management as well as intelligent market and economic systems.

2) Development of a reliable energy mix from renewable and fossil energy

In the future, conventional power plants will remain indispensable for our electricity supply, because they provide electricity in line with demand and reliable, right at the moment when it is needed. In addition, the fluctuations in the supply of electricity from renewable energy systems must be constantly balanced to ensure the stability of the system. Currently only flexible conventional power plants can render this.

3) Increase energy efficiency

Energy efficiency is a guarantee for a successful energy policy. Especially in the field of building renovation and in the operational process optimization of SMEs and industry there is huge potential. In essence, it's about the decoupling of economic performance and energy consumption.

4) Development of energy storage systems ready for practical implementation into the overall system

The development of large-scale energy storage systems is a central component in the conversion of our energy supply system. Only with such systems the current renewable energy sources can provide electricity effectively and demand-driven.

In the center of research will be both, the short-term balance of current fluctuations as well as long-term storage.

5) Promoting energy research and future technologies

The great complexity of the conversion of the energy system imperatively requires profound scientific expertise. Firstly, innovation and new technologies are the focus of research. Here it is all about the development and demonstration ready to market. Secondly, it involves the development of suitable methods for energy system integration with a focus the core areas listed here.

Each ENSEA partner cut one’s own path to a future-proof energy supply.

But the ENSEA consortium would like to work together to develop these individual challenges under the umbrella of energy system integration / energy balancing for the North Sea Region.

Here, these three pillars are of fundamental importance for the consortium:

- Establishment of a North Sea Research Association
- Establishment of strategic partnerships in the North Sea area for the development of a European energy system integration
- Establishment of a quadruple-helix cluster structure as operational level in the North Sea area

3. Establishment of a North Sea Research Association

Energy research has always been an integral part of energy policy. In the context of the "energy transition" the contribution of research and science gets an even more prominent role. It is about the understanding of highly complex processes in the interaction of the individual components of energy, renewable and fossil, electricity transmission, storage and use of electricity in comparison with market mechanisms. New priorities and aspects are in demand in energy research. This involves a trans- and interdisciplinary cooperation of different research disciplines and specializations. This form of cooperation allows the use of different core competencies and the realization of desirable synergies. Here, the ENSEA consortium would like to strategically focus on the most innovative technologies in the above-mentioned core areas or on the development of highly innovative market mechanisms.

Furthermore, the ENSEA consortium is aware of the fact that the envisaged North Sea Research Association needs a good cooperation between research and industry - this is a key for successful market introduction of new energy technologies. The ENSEA Consortium perceives energy research also as economic growth driver.

The ENSEA Consortium also sets great value on expanding its scientific collaborations and is very interested in cooperating with other European research institutions.

4. Establishment of strategic partnerships in the North Sea area

We need Europe in order to ensure a secure and affordable energy supply in the European states in the future. Only together this Herculean task can be overcome – for example just thinking about the expansion of European power infrastructure. Likewise, today technological developments must be evaluated increasingly from European and also from the global perspective. The ENSEA consortium would like to meet these demands and build new partnerships in the North Sea area.

5. Establishment of a quadruple-helix cluster structure as operational level in the North Sea area

The transformation of our energy supply does not run like clockwork but requires research and to the same degree economics and politics. Moreover, the consumer acceptance is added as a serious factor. Most important of all, the European population has to go along the path of renewal of our energy supply.

The ENSEA consortium is aware that a purely academic treatment of the claim "system integration" is not doing justice to "energy transition" as a whole. The involvement of all relevant forces is of particular importance. This JAP is evidence of a wide range of fields that have to be challenged together with the economy, and on which basis a realistic and accepted system integration can be carried out in the North Sea Region.

In the spirit of Albert Einstein: "You cannot solve a problem with the same thinking that created it", the ENSEA consortium strives for building a quadruple-helix cluster, consisting of politics, science, economy and society, whereupon this ENSEA cluster would be supported in an outstanding manner by the intended North Sea research association. With this cluster the ENSEA consortium would attempt to act as a coordinating platform for the energy sector.

In addition, the ENSEA consortium has a clear commitment to the Triple Helix principle plus involvement of society in order to avoid a one-sided orientation of the cluster and to ensure long-term social acceptance of the transition of our energy supply.

Centerpieces of the cluster organization are national contact points that are contact for all local stakeholders and also co-ordinate and promote the implementation of the cluster projects. For the coordination between the cluster members a coordination committee and as a direction-giving body of the ENSEA cluster a Steering Group is conceivable. At this point one can fall back on the excellent experience within the project structures of the current project ENSEA.

In particular, the planned ENSEA cluster shall take over cross-sectional tasks ensure coordination:

- Development / implementation of an internationally coordinated strategy
- Expansion of the triple-helix structure to a „quadruple-helix“
- Initiation of joint research and development projects between economy and research institutions from the entire value chain in the energy sector
- Strengthening the knowledge transfer between science and industry
- Advising national policy levels in matters of energy system integration
- Bundling and support of existing initiatives, clusters and institutions in the field of energy

The ENSEA Consortium is absolutely convinced that we can only find suitable solutions for the great challenge „energy transition“ if we bring together science, economy, politics and society and if we ask ourselves the central question of how do we influence the overall project energy system integration with the implementation of our regional or national concerns. Here, the ENSEA consortium will not lose sight of the aim to develop a secure, affordable and environmentally acceptable energy supply. Furthermore the ENSEA consortium wants to cooperate with other stakeholders of the North Sea Region to contribute together to the energy transition.
Furthermore the ENSEA consortium wants to cooperate with other stakeholders of the North Sea Region to contribute to the energy transition together.
At this point the European North Sea Commission has to be mentioned in particular, because this organization stands for a coordinated approach in the North Sea region.

It has already adopted the strategy document *North Sea Region 2020* in 2011 in response to the growth and demand for renewable energy. The ENSEA consortium would like to share its knowledge and experiences with the North Sea Commission as a forum of the North Sea region.

The path of future developments is marked by the ENSEA consortium with its present "Joint Action Plan". Many different issues are addressed in this JAP. Based on the cross-cutting issues such as technology transfer to business, education or social acceptance, elaboration of detailed problems within the different energy production methods, network infrastructure, or energy storage to overall consideration of system integration, significant project outlines have been drawn up for each area.
Due to the high relevance of energy system integration for our future energy supply, the ENSEA consortium committed itself to ten flagship projects to be implemented in short term in the ENSEA area. In line with the European Strategic Energy Technology Plan (SET-Plan), those flagship projects shall lead to an accelerated development and implementation of innovative Energy technologies in the North Sea region. Moreover the projects shall strengthen the international partnership and help to develop it further.

Overall-JAP - JOINT ACTION PLAN (JAP) for the four ENSEA regions

6. Strategic objectives of the ENSEA cluster and elaboration of a JAP

In line with the description of work document, the strategic focus of ENSEA is to formalize existing cooperation between North Sea regions to develop a European Region of Excellence in the field of energy. The cross border management structure ensures triple helix representation, as well as the integration of top-down political support with bottom-up thematic collaboration through alignment of research agendas and financial instruments. By joining forces the North Sea regions aims at developing into a European hot-spot of energy investment boosting funding for fundamental and applied research while driving innovation and economic growth.

To accelerate innovation performance, ENSEA elaborates a Joint Action Plan for improving framework conditions and access to finance for demand driven RTD by creating synergies between regional, national and European funding. All ENSEA partners have a strong track record within several energy research themes and a common understanding of the need for system integration. The balancing function of the ENSEA regions is not only a crucial precondition for sufficient and affordable sustainable energy, but also contributes to the development of a competitive and innovative economy.

7. JAP methodology

The project ideas, research projects and derived lighthouse projects were developed and shaped by a methodological procedure that was aligned between the partners:

1. Elaboration of competence profiles
2. Execution of potential analyses for the strategic objectives 'economic growth through R&D', 'smart specialization' and 'internationalization'
3. From there, development of possible project ideas and research activities ('list of actions')
4. Transformation of the list of actions into a database structure
5. Database analysis: Filtering and clustering of actions by specific objectives
6. Analysis of research funding programs, above all Horizon 2020, but also other regional and interregional programs such as Interreg

7. Coupling project idea clusters with funding programs to build the basis for lighthouse projects

Figure 1: Generation of ENSEA Lighthouse Projects

The formation of triple helix competence pools were seen as demand driven and were decided to be carried out during the preparation of project drafts. If possible, relevant stakeholders were involved - e.g. through a survey - in the generation of the competence profiles and potential analyses.

To determine the regional competences, competence profiles were generated based on the regional SWOT analyses (output from WP2). The individual criteria of the SWOT analyses were combined to regionally specific strategic success criteria and then measured on a scale depending on their relevance and importance for the cluster. In the following, competencies with respect to the particular strategic success factors were then ranked on a scale of 1 (poor) to 10 (good). Based on the identified strengths and weaknesses in the competence profile, the potential analysis was used to determine potential for improvement with respect to the targeted goal. For that purpose the own performance per strategic success factor was set in relation to the possibilities that would arise if all the required resources would be abound.

The determined potential for improvements on the basis of the potential analysis was included as identified field of action in the JAP. The related goals of the cluster or the region were shortly illustrated for each field of action, as well as a description of the project idea, basic funding opportunities and responsibilities.

Given the project ideas (list of actions) and subdivided by the strategic objectives (economic growth through R&D, smart specialization, internationalization), the list of research ideas was transformed into a database structure and clustered by specific objectives. It is important to state that for any of the idea clusters, the focus was always laid on energy system integration. In parallel, the upcoming research funding programs, above all the Horizon 2020 but also other regional and interregional programs such as Interreg were analyzed and taken into consideration. The ENSEA project idea clusters together with respective calls in e.g. Horizon 2020 were then coupled to build the basis for a joint action project among the partners, i.e. a lighthouse project (see also figure 1).

8. JAP results

Following the ENSEA description of work (DoW) document, WP3 competence profiles and potential analyses dealt with the three strategic objectives:

1. Economic growth through research and development
2. Smart specialization
3. Internationalization strategy for reaching new markets

Taking into account all fields of action and research activities from all the regions, an action list with a total number of n= 158 ideas was generated. The individual proportion of research ideas within the three main strategic objectives can be seen in figure 2:

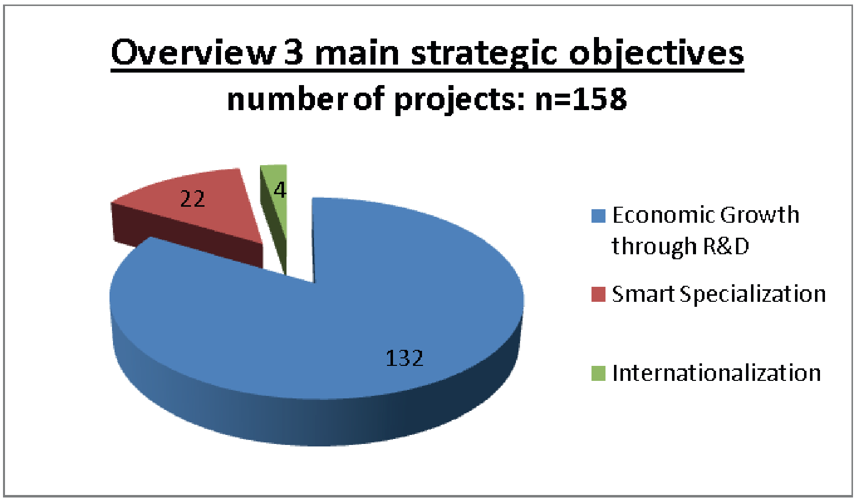


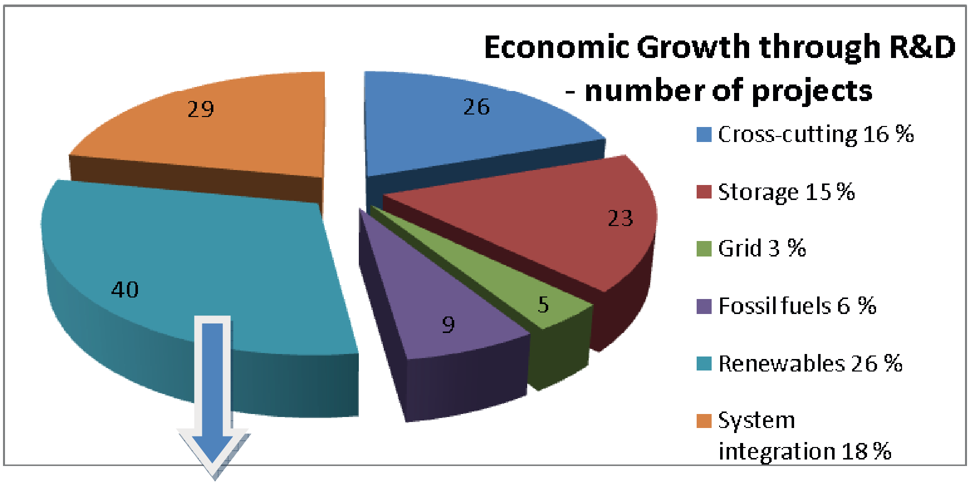
Figure 2: Overview: Proportion of projects for 3 main strategic objectives

Economic growth

Innovations are the major drivers for growth, employment and social cohesion. Successful innovations pave the way to the markets of tomorrow. Due to the exceptionally well experience, the principle of regional clusters has proven to be of value as a central tool to increase the economic competitiveness and innovative capability. Chances of success for an effective innovation environment increase, when from the beginning, business, research and in the broadest sense, the region is involved in the developments.

And innovation is more than technical progress. It evolves from the interaction of economic, technological, and organizational abilities and many soft factors, such as cultural norms and values. Accordingly, in addition to technical issues basic framework conditions, such as communication structures, trust and social acceptance, have to be adapted and developed consistently.

The foregoing is emphasized by an OECD study[1] stating that "undoubtedly the capability to innovate and to bring innovation successfully to market will be a crucial determinant of the global competitiveness of nations over the coming decade. There is growing awareness among policymakers that innovative activity is the main driver of economic progress and well-being as well as a potential factor in meeting global challenges in domains such as the environment, health and energy. Not only has innovation moved to centre-stage in economic policy making, but there is a realization that a coordinated, coherent, "whole-of-government" approach is required."



[1] OECD 2007 INNOVATION AND GROWTH - RATIONALE FOR AN INNOVATION STRATEGY

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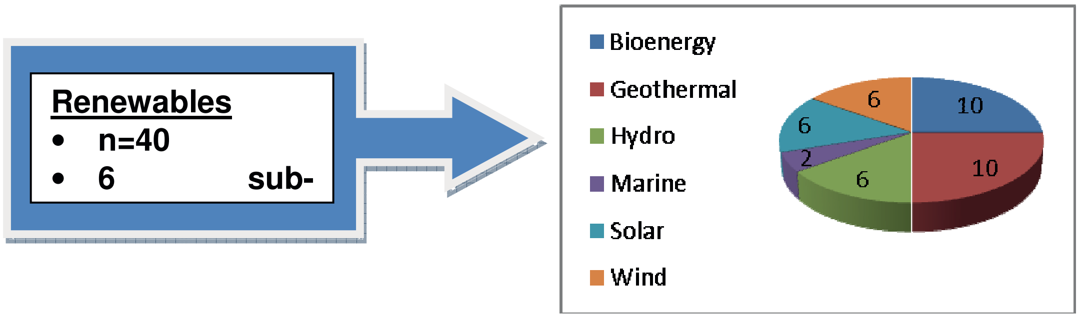

Figure 3: Number and allocation of projects within the strategic objective 'economic growth through R&D'

The research activities in economic growth through R&D have the biggest share of all activities (122:158) and cover the broadest range of topics. As far as quantities are concerned, renewables (40 ideas), system integration (29 ideas), cross-cutting issues (26 ideas) and storage (23 ideas) have the highest entries whereas fossil fuels (9 ideas) and grid/ infrastructure (5 ideas) have the lowest share in this strategic objective. However, some grid/ infrastructure research activities were appointed to smart specialization (system integration/ balancing) and, in order to avoid double appearances, were not appointed to economic growth.
Within the energy category "renewables" project ideas aiming at bioenergy and geothermal energy showed the highest entries (10 ideas each).

Smart specialization

In line with the Commission's understanding, smart specialization is a new innovation policy concept designed to promote the efficient and effective use of public investment in research. Its goal is to boost regional innovation in order to achieve economic growth and prosperity, by enabling regions to focus on their strengths. Smart specialization understands that spreading investment too thinly across several frontier technology fields risks limiting the impact in any one area.

A smart specialization strategy needs to be built on a sound analysis of regional assets and technology. It should also include an analysis of potential partners in other regions and avoid unnecessary duplication. Smart specialization needs to be based on a strong partnership between businesses, public entities and knowledge institutions – such partnerships are recognized as essential for success.

For the ENSEA consortium - characterized by the above mentioned triple helix structure - this means to concentrate the resources on key priorities - the strengths are to be strengthened. It is also about reaching a critical mass of activities in the region in order to cause a lasting boost to innovation. Given the increasingly vanishing industry boundaries it is not primarily about a sharp industry specialization, but rather a specialization that is capable of coping with the complex issue of energy in all its facets, upstream and downstream value chains.

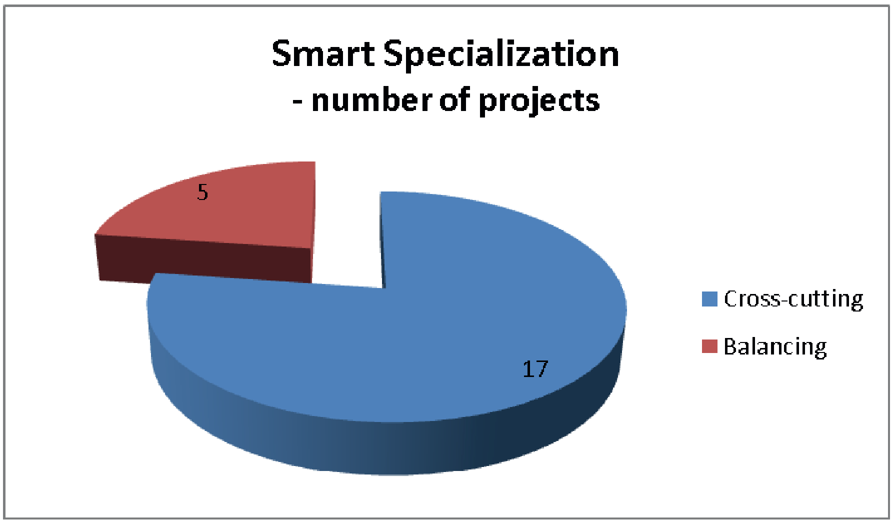

Figure 4: Number and allocation of projects within the strategic objective 'smart specialization'

As far as quantities, i.e. number of projects, within the strategic objective smart specialization are concerned, cross-cutting issues (17 ideas) showed three times higher entries than system integration/ balancing (5 entries).
The topics for cross-cutting issues mainly aimed at educational aspects whereas system integration/ balancing mainly aimed at models and pilots for smart and sustainable communities.

Internationalization

In order to continue to push the internationalization process within the ENSEA consortium, the partners are going for an intensive exchange in international, issue-focused projects.

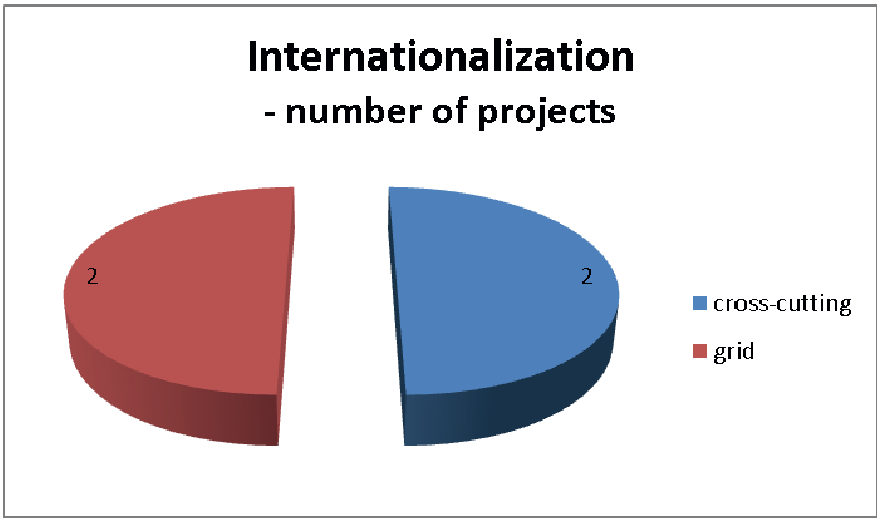

Figure 5: Number and allocation of projects within the strategic objective 'internationalization'

The number of project ideas within the strategic objective internationalization was the lowest of all the three strategic objectives. Two project ideas aimed at cross-cutting issues and another two concerned the power grid. However, several other projects within the first and the second strategic objective tackle the issue of internationalization and, therefore, were left there in order to avoid double appearances.

9. ENSEA Lighthouse Projects

As per understanding of the ENSEA consortium, lighthouse projects represent a vital bridge between R&D and markets of the future. It is also understood that lighthouse projects form the core for a broad subsequent marketing and should both initiate and pave the way for this.

Lighthouse projects also serve to make the products and services associated with energy system integration known to a broad spectrum of the public, as well as allow initial practical experience with these products and services to be gained and the trust of future users and suppliers, especially small and medium-sized companies, to be built (quadruple helix approach).

ENSEA lighthouse projects therefore have a wide reach, in both a technological and a geographical sense. They play a decisive role in shaping and actively promote the innovative strength of the North Sea neighboring states along with energy system integration. They should look for creating and consolidating partnerships between industries, academics and other research providers, public authorities and the citizens to ensure the replicability of solutions and - on a case to case basis - the funding from various sources.

Furthermore, in lighthouse projects, financial resources from the public and private sectors are concentrated in such a way that the minimum levels of technological competence and financial strength required for efficient research and development and successful subsequent demonstration are achieved, thus allowing a good ratio of expense to effect to be attained. In this way, synergistic potentials are utilized to the full and interdisciplinary collaboration is promoted[2].

Given the 158 project ideas deriving from the 4 regional JAPs and subdivided by the strategic objectives (economic growth through R&D, smart specialization, internationalization), the following lighthouse projects were determined:

9.1 Educational North Sea Networks

The lighthouse project "Educational North Sea Networks" aims at developing a strategy for professionalization and institutionalization of educational aspects on energy system integration in the North Sea area. This strategy includes operational tasks such as the setting up of online programs (e-learning), qualification strategies, academic exchange and knowledge alliances as well as the establishment of energy industry professorship programs within a North Sea Energy Academy.

Relevant funding programs are within the ERASMUS+ and H2020 LCE20 and Marie Curie calls.

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[2]National Development Plan for the “Hydrogen and Fuel Cell Technology Innovation Programme” Strategierat Wasserstoff Brennstoffzellen, 30.04.2007

Educational North Sea Networks

Region	Strategic objective	Specific objective	Field of action	Activity/ research idea
Ems-Achse	Economic growth through R&D	Cross-cutting areas	Qualification strategies to meet the demand	Evaluation of demands of the energy industry vs. University topics
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Setting up online degree programmes
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	E-Learning
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Qualification strategies during initial training
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Interdisciplinary qualification of graduates
Energy Valley	Smart Specialization	Cross-cutting areas	Sustainable communities - Academy Europe: The human factor in the energy system	Demand driven educations and increased energy literacy
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	Boost the capacity within energy related industry to execute and commercialise innovation activity - developing the marketing, customer engagement as well as technical capabilities of firms
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	Encourage increased focus on innovation as a driver of growth in the energy sector
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	Establish a proportionate balance of funding for energy system related spin outs and R&D and for the transfer of IP/Technology from universities into companies
Rogaland	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Establish an energy institute/ academy North Sea
Rogaland	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Establish in "industry energy professorship"
Rogaland	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Establish an Industry PhD
Rogaland	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Establish Knowledge Alliances
Rogaland	Smart specialization	Cross-cutting areas	Training & Education	Competence in the field of renewable energy

Figure 6: Educational North Sea Networks project idea clusters

9.2 SME Networks around the North Sea

The lighthouse project "SME Networks around the North Sea" aims at developing a technology transfer database to increase energy systems related R&D with a direct feedback slope to SME in order to boost the commercialization of innovation activities. It furthermore aims at raising internal capabilities and resources of smaller firms to access and assimilate technology relevant to support energy system integration and to increase demand-driven education for SMEs around the North Sea.

Relevant funding programs are within the ERASMUS+ and H2020 LCE20 and Marie Curie calls.

North Sea SME-Network

Region	Strategic objective	Specific objective	Field of action	Activity/ research idea
Ems-Achse	Economic growth through R&D	Cross-cutting areas	Energy Efficiency	Optimization of production lines in SMEs
Ems-Achse	Economic growth through R&D	Cross-cutting areas	Qualification strategies to meet the demand	Evaluation of demands of the energy industry vs. University topics
Ems-Achse	Internationalization	Cross-cutting areas	Technology Transfer (SMEs), implementation of scientific research results to applicable technologies	Development of a technology transfer database
Ems-Achse	Internationalization	Cross-cutting areas	Technology Transfer (SMEs), implementation of scientific research results to applicable technologies	Installation of an international/ transregional information centre
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing innovation capacity of/in the region	Enabling of feasibility studies to prepare innovations for SMEs
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Setting up online degree programmes
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	E-Learning
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Qualification strategies during initial training
Ems-Achse	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Interdisciplinary qualification of graduates
Energy Valley	Smart Specialization	Cross-cutting areas	SME valorisation within new industrial value chains	Stimulate focused knowledge exchange by increased social network interaction within and between regional SME networks
Energy Valley	Smart Specialization	Cross-cutting areas	Sustainable communities - Academy Europe: The human factor in the energy system	Demand driven educations and increased energy literacy
Rogaland	Smart specialization	Cross-cutting areas	Increasing scientific expertise in the region	Establish an Industry PhD
Rogaland	Smart specialization	Cross-cutting areas	Training & Education	Competence in the field of renewable energy
Rogaland	Smart specialization	Cross-cutting areas	Training & Education	Knowledge Transfer (external)
Rogaland	Smart specialization	Cross-cutting areas	Training & Education	Knowledge Transfer between industries
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	increase energy systems related R&D activities, especially collaborative approaches that engage more small companies and suppliers to Tier 1 companies
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	boost the capacity within energy related industry to execute and commercialise innovation activity - developing the marketing, customer engagement as well as technical capabilities of firms
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	Encourage increased focus on innovation as a driver of growth in the energy sector
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	Establish a proportionate balance of funding for energy system related spin outs and R&D and for the transfer of IP/Technology from universities into companies, and ensure there is sufficient funding focus for collaborative innovation projects for smaller firms in partnership with 'companies of scale' and the HEIs
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	Identify approaches to raise internal capabilities and resources of smaller firms to access and assimilate technology relevant to support energy systems integration;
Scotland	Economic growth through R&D	Cross-cutting areas	Development of Innovation Policy for ESI	Develop and improve dedicated energy sector innovation services where overall innovation activity is well below average
Scotland	Economic growth through R&D	Cross-cutting areas	Increasing innovation commercialisation capability of SMEs	Create an ENSEA-wide programme to support SMEs in addressing applied Energy Systems R&D
Scotland	Economic growth through R&D	Cross-cutting areas	Increasing innovation commercialisation capability of SMEs	To provide a platform that is fluid, accesible and useful to companies to access to University resources (expertise, facilities) over

Figure 7: SME Networks around the North Sea project idea clusters

9.3 Hydro Power - balancing and storage for the North Sea region[3]

The lighthouse project "Hydro Power" aims at a demonstration of hydro power as green balancing and backup power for the European energy system integration and to demonstrate hydro power as a green large scale storage capacity option for Europe's energy supply stability. It also takes into consideration the current and future interconnector capacities.

Depending on the scale of the project approach, different H2020 funding calls are relevant:

- LCE-02-2014: Hydropower: Boosting peak power through sustainable hydropower
- LCE-02-2015: Developing the next generation technologies of renewable electricity and heating/cooling
- LCE-05-2015: Innovation and technologies for deployment of meshed off-shore grids
- LCE-09-2015: Large scale energy storage

9.4 North Sea Power Ring System

The lighthouse project „North Sea Power Ring System" aims at demonstrating large scale energy storage to balance the production and consumption of high quantities of electricity and during longer time periods. Demonstration activities in this project aim to progress large scale energy storage and reduce the barriers associated with new storage concepts. An important market uptake challenge is to reduce the barriers (technological, economic, regulatory, environmental, social and other acceptance, etc.) associated with the deployment of existing or new storage concepts.
A relevant funding program is within the H2020 LCE-09-2015 (large scale energy storage).

9.5 Sustainable communities around the North Sea[4]

The lighthouse project „sustainable communities around the North Sea" aims at participation and consumer engagement for sustainable energy, esp. for homes, schools and businesses.

[3] Adopted from Norwegian JAP
[4] Adopted from Dutch JAP

A relevant funding program is within the H2020 SCC-2015: Smart cities and communities

9.6 Green decommissioning: Exploring the potential for optimal (re-)use of existing Oil & Gas infrastructure in the North Sea[5]

The lighthouse project "green decommissioning" aims at a science-based essay for EU policy-makers and a broad group of North Sea (energy) stakeholders which aims to open a discussion on system integration of energy infrastructure in the North Sea region in general and re-use of Oil & Gas infrastructure in specific. The output will be a roadmap including the following aspects:

- Further explore options for reuse of existing energy infrastructure and for system integration of energy infrastructures and assess feasibility; develop criteria & conditions, business cases & pilot options.
- Further explore the effect of decommissioning options, incl. liability, on business case for reuse.
- Organize stakeholder dialogue including O&G operators, renewables & decommissioning & waste handling sector to better understand drivers and barriers to change.
- Build a powerful North Sea coalition, cooperating with related initiatives.
- Develop pilots projects to show potential.
- Develop vision for alternative employment of decommissioning cost savings, enhancing societal gains.

9.7 Energy System Integration Doctoral Training Network[6]

The lighthouse project "Energy System Integration Doctoral Training Network" aims at implementing cross-cutting aspects of the JAP having in mind the enhancement of energy system integration competences and capabilities of PhD students. The training program will be in line with the "EU Principles for Innovative Doctoral Training" and focus on research excellence, attractive institutional environment, interdisciplinary research options, exposure to industry, international networking,

[5] Adopted from Dutch JAP
[6] Adopted from Scottish JAP

transferable skills training, quality assurance within the field of energy system integration.

Relevant funding programs are within the H2020 MSCA ITN, Interreg IVB and regional UK calls

10. Conclusion

The success of an energy transition in Europe depends to a very high degree on a holistic realization of energy system integration. Technological progress, society and economy have to act in concert to build a stable basis. The Joint Action Plan of the ENSEA consortium depicts „fields of action" in more detailed questions but also in interdisciplinary issues. Notwithstanding the above, this Joint Action Plan illustrates the importance and the need for large-scale approaches on an international stage.

In the light of these enormous future challenges as well as the ambitious goals in the field of energy a state or a single region cannot manage this mission alone. In this situation the expertise and strong will of the European partners is in demand to shoulder these challenges together. The ENSEA consortium has already agreed to accomplish this mammoth task and is ready to go.

We know what we have to do.
We see the chances.
And we know that the time for action is now.

The ENSEA consortium

Annex[7]

Further Potential Relevant Funding Sources

As a matter of fact, the potential areas for action deriving from the action list are not exclusively covered by the ENSEA lighthouse projects. Further collaboration between ENSEA partners will be realized by bilateral or trilateral projects (e.g. two or three ENSEA regions) or on a purely national level. Hence, a wide range of funding sources at local, regional, national or EU levels can be made available. However, it is important to state that the overall focus of all the activities is on energy system integration.

A number of relevant EU calls for proposals (e.g. within the Horizon 2020/ INTERREG programmes) which may have synergies with the areas for regional and national strategic focus in energy, training and innovation, are summarised below. The list below is not comprehensive and serves to illustrate potential opportunities.

Horizon 2020: Secure, Clean and Efficient Energy- Low Carbon Energy (LCE):

- LCE1 2014: New knowledge and technologies. Size: approx €2-4 million. Deadline: 01.04.14. Stage 2: 23.09.14 – Type of Action: Research and Innovation Action

Focus on accelerating the development of transformative energy technologies or enabling technologies that have reached TRL2. Innovative solutions and their supply chains such as materials and advanced manufacturing will also be supported as long as the application is clearly energy. New approaches to existing technologies with potential for significant improvements in the overall performance are also allowed.

[7] Adopted from the Scottish Regional JAP

• LCE 6 2015: Transmission grid and wholesale market. Size: approx €12-15 million. Deadline: 03/03/2015 – Type of Action: Innovation Actions/Research and Innovation Actions

Integrating and validating solutions to grid challenges, concentrating on field demonstration of system integration, up-scaling at industrial scale and supporting R&D. Preparing first replication of the solutions in different contexts and/or countries. Appropriate market models, business cases, user and general public acceptance, regulatory, market up-take (e.g. regulatory issues, capacity building and access to finance), social, environmental and resource efficiency aspects should be included. Opening up demonstration facilities for targeted practice-oriented education and training is encouraged.

• LCE 7 -2014: Distribution grid and retail market. Size: €2,5 – 3m. for limited proposals; €20 – 25 m. for large- scale demonstration proposals. Deadlines 07/05/14 & 03/03/2015. - Type of Action: Innovation Actions/Coordination and Support Action

Projects could focus on integrating and validating solutions to grid challenges concentrating on field demonstrations of: energy systems integration; distribution level validation of renewable energy and demand response; advanced solutions to medium-high voltage network monitoring and control; flexible architecture for smart metering decoupling metrology from user functionalities; etc.

• LCE 8: Local small-scale storage. Size: €8 - 12 million. Deadline 07/05/2014. Type of Action: Innovation Actions

Project proposals have to deal with interaction between: grid district heating-cooling, CHP, micro generation, local renewable generation and ICT optimization. Demonstration proposals will only focus on market uptake measures, performance verification, electrochemical and other storage.

• LCE 9 – 2015: Large scale storage. Size: €22 – 25 million. Deadline 03/03/2015.

Proposals under this call will deal with storage to balance large-scale production and consumption during longer periods of time. Demonstration levels should range from

Technology Readiness Level TRL5 to at least TRL6/7. Technologies such as hydro, power-to-gas, seawater storage opportunities can be included in the proposals. Action: Innovation Actions

- LCE 10 – 2014: Next generation technologies for energy storage. Size: €6 – 9 million. Deadlines 07/05/14 & 03/03/2015. Type of Actions: Research and Innovation Actions

This call relates to life-cycle assessment and economic modelling for improved storage technologies, based on grid interactions, synergy possibilities etc.

- LCE 19 – 2014/2015: Supporting coordination of national R&D activities. Size: €0.1 – 0.5 million. Deadline: 10/09/14.- Type of Actions: Coordination and Support Actions

Focus is on the areas and challenges targeted in this 'Competitive low-carbon energy' call. Research and Innovation activities in the proposals should focus on bringing technology solutions from TRL 3 to TRL 5. Activities should focus on supporting either:

The transfer of knowledge among participants and other dissemination activities, activities to foster the use of research outcomes by industry of a project resulting from synchronised funding processes of at least three Member States, or

The coordination of call for proposals of at least three Member States, for instance, through support to networking activities of public funding bodies, leading to the promotion of the use of single peer-reviewed evaluations, development and use of harmonised monitoring and review methodologies, support to the preparation of high risk, high cost large scale pilots for joint actions with or without EC funding, linking national research programmes and other funding mechanisms and building partnerships with the necessary scale and scope etc.

- LCE 18 – 2014/2015: Supporting Joint Actions on demonstration and validation of innovative energy solutions. Size: €10 – 20 million. Deadline: 07/05/14. Type of Actions: ERA-NET Co-Fund

The focus of the call is coordinating the research efforts of the participating Member States, Associated States and Regions in the areas and challenges targeted in this

'Competitive low-carbon energy' call or in the 'Smart Cities and Communities' call and implementing a joint transnational call for proposals resulting in grants to third parties with EU co-funding to fund multinational innovative research initiatives in this domain. Proposers are encouraged to implement other joint activities including additional joint calls without EU co-funding.

- SIE 1 – 2014/2015: Stimulating the innovation potential of SMEs for a low carbon and efficient energy system Size: €0.2 – 0.5 million for Phase 1 projects towards successful implementation of Phase 2. Deadline: 17/12/14.

The SME instrument consists of three separate phases and a coaching and mentoring service for beneficiaries. Participants can apply to phase 1 with a view to applying to phase 2 at a later date, or directly to phase 2. In phase 1, a feasibility study shall be developed verifying the technological/practical as well as economic viability of an innovation idea/concept with considerable novelty to the industry sector in which it is presented. In phase 2, innovation projects will be supported that address the specific challenges outlined in the legal base of the Horizon 2020 Societal Challenge 'Secure, Clean and Efficient Energy' and that demonstrate high potential in terms of company competitiveness and growth underpinned by a strategic business plan. Activities should focus on innovation activities such as demonstration, testing, prototyping, piloting, scaling-up, miniaturisation, design, market replication and the like aiming to bring an innovation idea (product, process, service etc) to industrial readiness and maturity for market introduction, but may also include some research.

- LCE 20 – 2014: The human factor in the energy system. Size: €2 – 4 million. Deadline 10/09/2014. Type of Actions: Research and Innovation Actions, Coordination and Support Actions

This call focuses on awareness, perception and behaviour related to energy relevant technologies. It may involve development and support for vocational education and training networks, and providing new or updated competences where shortage exists.

•	LCE21 - 2015: Modelling & Analysing the energy system, its transformation & impacts. Size: €2 – 4 million. Deadline: 03/03/15. Type of Actions: Research and Innovation Actions

Call's focus areas are: - Comparative assessment of the impacts and the sustainability performance of all relevant energy technologies, including renewable, fossil, and nuclear technologies; - Comparative assessment of transformation paths towards a sustainable energy system and the related impacts on environment, society and economy; - Analysing and modelling the impacts of technological development and innovation on the energy-system and its dynamics; - Analysing and modelling of technology policy measures in the framework of the SET-Plan to promote the transition towards a sustainable energy system, assessment of the impact of these measures on society, environment and economy, including safety and access to clean, reliable and affordable energy.

Horizon 2020: Secure, Clean and Efficient Energy- Energy Efficiency (EE):

•	EE 6 – 2015: Demand response in blocks of buildings. Size: €3 – 5 million. Deadline: 10/06/15. Type of Actions: Innovation Actions

At the level of a block of buildings, the focus should be on real time optimisation of energy demand, storage and supply (including self-production when applicable) using intelligent energy management systems with the objective of reducing the difference between peak power demand and minimum night time demand, thus reducing costs and greenhouse gas emissions.

•	EE10: Consumer engagement for sustainable energy. Size: €1 – 1.5 million. Deadline 05/06/14. Type of Actions: Coordination and Support Actions

Project proposals should focus on changing the behaviour of consumers in their everyday life (e.g. at home, at work, at school), using market segmentation and focussing on 'action', the last step of the AIDA (Awareness – Interest – Desire – Action) framework. Equipment responsible for main energy consumption (e.g. heating and cooling, lighting, domestic appliances, and consumer electronics), as well as products from the small scale renewable energy market, should be addressed in priority.

Horizon 2020: Secure, Clean and Efficient Energy- Other Actions (Public Procurement Calls):

- B2.7 Energy Storage Mapping & Planning. Deadline: 4th Quarter 2014

- B2.3 Support to Research & Innovation Policy in the areas of Renewable Energy, CCS and clean coal. Framework Contract (for 20 contracts) Deadlines 2014 & 2015

- B2.15 support to key activities of the European Wind Energy Technology Platform (TP Wind). Deadline: 2nd Quarter 2014.

- B2.16 Support to R&D Strategy in the area of SET Plan activities in smart grids and energy storage. Deadline: 2nd & 4th Quarters 2014

- B4.2 Modelling and analysing energy policy system transformation & climate change measures. Deadline: 2nd quarter 2014 & 2015.

Horizon 2020: Marie Sklodowska-Curie Actions (MSCA):

- MSCA-ITN-2014. Innovative Training Networks (European Training Network and European Industrial Doctorate).Deadline 13/01/15.

The Innovative Training Networks (ITN) supports competitively selected joint research training and/or doctoral programmes, implemented by partnerships of universities, research institutions, research infrastructures, businesses, SMEs, and other socio-economic actors from different countries across Europe and beyond.

Other EU:

- Call: INNOSUP 1 – 2015: Cluster facilitated projects for new industrial value chains. Size: €2.5 – 5 m. Deadline 30/04/15.

Projects could be initiated to develop approaches to support new SME value chains where mutually reinforcing competences support development of emerging industries. Also on changing behaviour of consumers in their everyday life. Educational activities or tools may be necessary; innovative technologies and social innovation should be considered.

1. Potential Relevant Funding Sources

The potential areas for action may be funded by a range of sources at local, regional, UK or EU levels. A number of relevant EU calls for proposals (e.g. within the Horizon 2020/ INTERREG programmes) which may have synergies with the areas for Scottish strategic focus in energy, training and innovation, are summarised below. The list below is not comprehensive and serves to illustrate potential opportunities.

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Integrating and validating solutions to grid challenges, concentrating on field demonstration of system integration, up-scaling at industrial scale and supporting R&D. Preparing first replication of the solutions in different contexts and/or countries. Appropriate market models, business cases, user and general public acceptance, regulatory, market up-take (e.g. regulatory issues, capacity building and access to finance), social, environmental and resource efficiency aspects should be included. Opening up demonstration facilities for targeted practice-oriented education and training is encouraged.

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Project proposals have to deal with interaction between: grid district heating-cooling, CHP, micro generation, local renewable generation and ICT optimization.

Demonstration proposals will only focus on market uptake measures, performance verification, electrochemical and other storage.

- LCE 9 – 2015: Large scale storage. Size: €22 – 25 million. Deadline 03/03/2015.

Proposals under this call will deal with storage to balance large-scale production and consumption during longer periods of time. Demonstration levels should range from Technology Readiness Level TRL5 to at least TRL6/7. Technologies such as hydro, power-to-gas, seawater storage opportunities can be included in the proposals. Action: Innovation Actions

- LCE 10 – 2014: Next generation technologies for energy storage. Size: €6 – 9 million. Deadlines 07/05/14 & 03/03/2015. Type of Actions: Research and Innovation Actions

This call relates to life-cycle assessment and economic modelling for improved storage technologies, based on grid interactions, synergy possibilities etc.

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The transfer of knowledge among participants and other dissemination activities, activities to foster the use of research outcomes by industry of a project resulting from synchronised funding processes of at least three Member States, or

The coordination of call for proposals of at least three Member States, for instance, through support to networking activities of public funding bodies, leading to the promotion of the use of single peer-reviewed evaluations, development and use of harmonised monitoring and review methodologies, support to the preparation of high risk, high cost large scale pilots for joint actions with or without EC funding, linking national research programmes and other funding mechanisms and building partnerships with the necessary scale and scope etc.

- LCE 18 – 2014/2015: Supporting Joint Actions on demonstration and validation of innovative energy solutions. Size: €10 – 20 million. Deadline: 07/05/14. Type of Actions: ERA-NET Co-Fund

The focus of the call is coordinating the research efforts of the participating Member States, Associated States and Regions in the areas and challenges targeted in this 'Competitive low-carbon energy' call or in the 'Smart Cities and Communities' call and implementing a joint transnational call for proposals resulting in grants to third parties with EU co-funding to fund multinational innovative research initiatives in this domain. Proposers are encouraged to implement other joint activities including additional joint calls without EU co-funding.

- SIE 1 – 2014/2015: Stimulating the innovation potential of SMEs for a low carbon and efficient energy system Size: €0.2 – 0.5 million for Phase 1 projects towards successful implementation of Phase 2. Deadline: 17/12/14.

The SME instrument consists of three separate phases and a coaching and mentoring service for beneficiaries. Participants can apply to phase 1 with a view to applying to phase 2 at a later date, or directly to phase 2. In phase 1, a feasibility study shall be developed verifying the technological/practical as well as economic viability of an innovation idea/concept with considerable novelty to the industry sector in which it is presented. In phase 2, innovation projects will be supported that address the specific challenges outlined in the legal base of the Horizon 2020 Societal Challenge 'Secure, Clean and Efficient Energy' and that demonstrate high potential in terms of company competitiveness and growth underpinned by a strategic business plan. Activities should focus on innovation activities such as demonstration, testing, prototyping, piloting, scaling-up, miniaturisation, design, market replication and the like aiming to bring an innovation idea (product, process, service etc) to industrial readiness and maturity for market introduction, but may also include some research.

• LCE 20 – 2014: The human factor in the energy system. Size: €2 – 4 million. Deadline 10/09/2014. Type of Actions: Research and Innovation Actions, Coordination and Support Actions

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• LCE21 - 2015: Modelling & Analysing the energy system, its transformation & impacts. Size: €2 – 4 million. Deadline: 03/03/15. Type of Actions: Research and Innovation Actions

Call's focus areas are: - Comparative assessment of the impacts and the sustainability performance of all relevant energy technologies, including renewable, fossil, and nuclear technologies; - Comparative assessment of transformation paths towards a sustainable energy system and the related impacts on environment, society and economy; - Analysing and modelling the impacts of technological development and innovation on the energy-system and its dynamics; - Analysing and modelling of technology policy measures in the framework of the SET-Plan to promote the transition towards a sustainable energy system, assessment of the impact of these measures on society, environment and economy, including safety and access to clean, reliable and affordable energy.

Horizon 2020: Secure, Clean and Efficient Energy- Energy Efficiency (EE):

• EE 6 – 2015: Demand response in blocks of buildings. Size: €3 – 5 million. Deadline: 10/06/15. Type of Actions: Innovation Actions

At the level of a block of buildings, the focus should be on real time optimisation of energy demand, storage and supply (including self-production when applicable) using intelligent energy management systems with the objective of reducing the difference between peak power demand and minimum night time demand, thus reducing costs and greenhouse gas emissions.

• EE10: Consumer engagement for sustainable energy. Size: €1 – 1.5 million. Deadline 05/06/14. Type of Actions: Coordination and Support Actions

Project proposals should focus on changing the behaviour of consumers in their everyday life (e.g. at home, at work, at school), using market segmentation and focussing on 'action', the last step of the AIDA (Awareness – Interest – Desire – Action) framework. Equipment responsible for main energy consumption (e.g. heating and cooling, lighting, domestic appliances, and consumer electronics), as well as products from the small scale renewable energy market, should be addressed in priority.

Horizon 2020: Secure, Clean and Efficient Energy- Other Actions (Public Procurement Calls):

• B2.7 Energy Storage Mapping & Planning. Deadline: 4th Quarter 2014

• B2.3 Support to Research & Innovation Policy in the areas of Renewable Energy, CCS and clean coal. Framework Contract (for 20 contracts) Deadlines 2014 & 2015

• B2.15 support to key activities of the European Wind Energy Technology Platform (TP Wind). Deadline: 2nd Quarter 2014.

• B2.16 Support to R&D Strategy in the area of SET Plan activities in smart grids and energy storage. Deadline: 2nd & 4th Quarters 2014

• B4.2 Modelling and analysing energy policy system transformation & climate change measures. Deadline: 2nd quarter 2014 & 2015.

Horizon 2020: Marie Sklodowska-Curie Actions (MSCA):

- MSCA-ITN-2014. Innovative Training Networks (European Training Network and European Industrial Doctorate).Deadline 13/01/15.

The Innovative Training Networks (ITN) supports competitively selected joint research training and/or doctoral programmes, implemented by partnerships of universities, research institutions, research infrastructures, businesses, SMEs, and other socio-economic actors from different countries across Europe and beyond.

Other EU:

- Call: INNOSUP 1 – 2015: Cluster facilitated projects for new industrial value chains. Size: €2.5 – 5 m. Deadline 30/04/15.

Projects could be initiated to develop approaches to support new SME value chains where mutually reinforcing competences support development of emerging industries. Also on changing behaviour of consumers in their everyday life. Educational activities or tools may be necessary; innovative technologies and social innovation should be considered.

2015

Measures Towards Implementation of the Joint Action Plans

17-12-2015

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Contents

Abbreviations

BBSRC	Biotechnology and Biological Sciences Research Council
CEF	Connecting Europe facility
DE	Germany
EE	Energy efficiency
EEA	Energy Academy Europe
EERA	European Energy Research Alliance
EFZN	Energie-Forschungszentrum Niedersachsen, Germany
EID	European industrial doctorates
ENSEA	European North Sea Energy Alliance
EOI	Expression of interest
EPSRC	Engineering and Physical Sciences Research Council
ESI	Energy system integration
ESRC	Economic and Social Research Council
ETN	European training network
ETP	Energy Technology Partnership
EU	European Union
EUREC	European Renewable Energy Research Centres
E&P	Exploration and production
GHG	Greenhouse gas emissions
ICT	Information and communications technology
IRIS	International Research Institute of Stavanger
ITN	Innovative training network
JAP	Joint action plan
JTI	Joint technology initiative
MSCA	Marie Sklodowska-Curie Actions
NERC	Natural Environment Research Council
NL	The Netherlands
NO	Norway
O&G	Oil and gas
PCI	Project of common interest
PHES	Pumped hydropower energy storage
PMB	Project management board
PPP	Public private partnership
RTD	Research and technological development

R&D	Research and development
SET	Strategic Energy Technology
SME	Small and medium-sized enterprises
STFC	Science and Technology Facilities Council
TRL	Technology readiness levels
UiS	University of Stavanger
UK	The United Kingdom
WG	Working group
WP	Work package
WP4	Work package four

Executive summary

Partners in the European North Sea Energy Alliance (ENSEA) project share a common aim to address the challenges of the changing energy mix and transition to increased energy system integration for renewable and low carbon energy sources. The ENSEA project demonstrates a clear commitment to the "triple-helix" principle of industry-public-academic collaboration. Furthermore, ENSEA advocates and promotes involvement and consideration of community and societal needs throughout all aspects and scales of energy sector activity.

Work package four (WP4) of the ENSEA project, led by the Norwegian partner Prof. Assadi, capitalises on the activities and results of the previous WPs. The main goal is the implementation of the developed interregional Joint Action Plan (JAP). The joint action plan will bring the research organisations, regions and companies closer in addressing the important energy challenges around the North Sea. The aim is to establish ENSEA as a centre of excellence with respect to energy system integration.

Work package 4 focused on internationalisation strategy, identification & definition of projects and setting up joint demand driven research program on system integration. To enhance the focus on various prioritised research areas identified within WP3, several working group were established, knowledge gaps and financing sources were identified, European partners with complementary competences were contacted and layouts for project proposals were prepared.

The close collaboration between the partner regions, well focused R&D activities towards energy system integration around the North Sea and continuation of collaboration with other stake holders and regions are the main outcome of the WP4 activities, which are presented in detail in this report.

Stavanger

December 2015

1. Introduction

Partners in the European North Sea Energy Alliance (ENSEA) project share a common aim to address the challenges of the changing energy mix and transition to increased energy system integration for renewable and low carbon energy sources. The ENSEA project demonstrates a clear commitment to the "triple-helix" principle of industry-public-academic collaboration. Furthermore, ENSEA advocates and promotes involvement and consideration of community and societal needs throughout all aspects and scales of energy sector activity.

Work package four (WP4) of the ENSEA project capitalises on the activities and results of the previous WPs. The main goal is the implementation of the developed interregional Joint Action Plan (JAP). All partners will contribute by developing activities that will be carried out at the regional level with stakeholders and key players within the regions and activities at the partnership (interregional) level. The joint action plan will bring the research organisations, regions and companies closer in addressing the important energy challenges around the North Sea. The aim is to establish ENSEA as a centre of excellence with respect to energy system integration.

The WP4 comprises different tasks including:

- Task 4.1 Formalise ENSEA collaboration
- Task 4.2 Initiate internationalisation strategy
- Task 4.3 Identification & definition of projects
- Task 4.4 Set up joint demand driven research program on system integration

The aim of this section is to present different tasks (Tasks 4.1 to 4.4), their specific objectives and deliverables. Following sections of this document present a summary of different activities that have been carried out under the framework of WP4.

1.1. Task 4.1 – Formalise ENSEA collaboration

The developed JAP is a strategic plan rooted within regional smart specialization strategies for the North Sea and for the EU, including directions of R&D and topics of common interest at the EU level. To enforce this, ENSEA partners will explore ways to formalize the collaboration to facilitate a common way of working ensuring sustainable and competitive cross border collaboration. The partners within this collaboration will join efforts in arranging co- financing for activities described within the JAP. Other energy clusters can join this collaboration at their own costs.

1.1.1. Objective 4.1

Formalize research & innovation collaboration around the North Sea.

1.1.2. Deliverable 4.1

Signed agreement formally establishing ENSEA.

The JAP will be finalized in M18. Within 6 months an efficient collaboration framework will be designed based on this JAP, lessons learned from the collaboration within Hanse Energy Corridor (existing collaboration between Germany and the Netherlands) and the experience of the 1.5 years collaboration between the four partners within ENSEA.

According to ENSEA's mandate, Annex I of the Grant Agreement (Description of Work), the deliverable states that ENSEA partners will sign an agreement formalizing their collaboration. Although the collaboration has been formally established to a certain extent through a signed agreement in the form of an "Expression of Interest", the description of work also states that ENSEA partners "will explore ways to formalize the collaboration" implicating a multitude of activities contributing to this formalized collaboration. After a short elaboration on ENSEA's achievements thus far these activities will be explained briefly consisting of setting up working groups (WG) on key themes identified in the JAP, the expression of interest (EOI), a joint demand driven research program, cluster of excellence, internationalization, associated members and link to other organisations around the North Sea. These activities are either completed or ongoing up until the end of the project.

1.2. Task 4.2 – Initiate internationalisation strategy

ENSEA will stimulate a common approach to install visible regional single points of contact to facilitate to favour the valorisation of regional resources, competencies, specializations linked to human capital, energy industries, research infrastructures, RTD strategies and programs, as well as supporting (financial and non-financial) schemes. More specifically, the central contact point will provide insight into available supply and offer of academic expertise and business opportunities within participating clusters. In doing so the central point will facilitate SME's to share resources with larger companies and excellence in academic resources and therefore penetrating the international market.

1.2.1. Objective 4.2

Arrange co-finance to implement activities described within JAP.

1.2.2. Deliverable 4.2

Database of single points of contact of ENSEA related regions. Contact for investment, capabilities and resources.

1.3. Task 4.3 – Identification & definition of projects

Different activities will be performed including:

- To compose and substantiate objectives of the project in line with R&D roadmap in the JAP;
- To set definition of goals of the project and identify practical possibilities for implementation;
- To perform surveys of available national and European funding possibilities and programs for realization of project ideas. INTERREG A and B, research funding programs of EFRE, particular national and regional programs for the advancement of innovation in SMEs, use of the particular Research Framework Programs, project related consulting and information of the interested members of the cluster depending founding possibilities are within those potential programs and activities; and
- To compile and assort consortia consisting of members from economy, science and local authorities.

1.3.1. Objective 4.3

Enable joint research and innovation projects with further funding.

1.3.2. Deliverable 4.3

Joint demand-driven research program on system integration: with contributions of business (large & small)

1.4. Task 4.4 – Set up joint demand driven research program on system integration

To align the research programs of the regional energy academies with the R&D roadmap identified in the JAP and coordinate industry involvement, the following coordination activities will be initiated:

- Facilitation of staff exchange and joint commissions of professionals to enhance trust and gain hands on experience with each other's programs
- Organize network meeting & events to actively link research demand from companies to available academic excellence on regional and interregional level
- Organize joint trainings related to the system integration approach
- Apply for mobility programs (Initial Training Networks, Erasmus Mundus etc) to transfer knowledge between established researchers

1.4.1. Objective 4.4

Initiate an international joint Energy Academy to strengthen the research driven clusters.

2. Introduction to WG reporting

The main idea behind ENSEA has been strengthening the North Sea Regions by combining the participating regions' capabilities and realizing the potential synergies between the regions. To do so, the status of energy system integration in all four participating regions was documented in regional reports, followed by a regional SWOT analysis. Given the fact that there were no complete state of the art report in the participating regions describing the energy system in the region, the ENSEA report provided a valuable contribution, which was highly appreciated by the regional actors. The fact that ENSEA has been constructed as a triple helix organization, where local authorities, industries and research organizations are present, provided the base needed to illuminate the regional needs and capabilities from a holistic point of view.

The ENSEA group merged the regional reports and SWOT analysis to identify the potential synergies between the regions by combining their strengths. The final report that was made available on the project's home page demonstrated the ENSEA methodology concerning practical approaches for knowledge transfer around the North Sea. The figure below shows the merged regional SWOT analysis result, which was the point of departure for next step, i.e. generation of the JAP.

Based on combined strengths of the four participating regions, the ENSEA group established a list of demand driven research topics consisting of more than 160 project ideas.

The JAP report summarized the methodology used to identify local needs and competences as well as the possible synergies between the regions. The projects listed in the JAP were prioritized according to their urgency and importance. The final step in ENSEA project presented in WP4 consists of three main parts, namely:

- Formalization of the ENSEA as triple helix organization beyond the project lifetime;
- Generation of a regional database and a regional contact point as facilitator of collaboration between interested partners and organizations as well as a database with funding opportunities; and
- Establishment of the base for development of research and innovation proposals needed for realization of the ENSEA vision, i.e. the energy system integration for reliable and environmentally friendly energy system covering the whole North Sea region.

The methodology developed to establish demand driven projects could be summarized by following steps:

- Prioritization of the project ideas;
- Establishment of working groups that could focus of specific targeted areas;
- Selection of WG coordinators to organize the information exchange between WG partners;
- Identification of financing bodies to finance the research and innovation actions;
- Selection of external partners to provide full coverage of competences and resources needed; and
- Formulation of project objectives, identification of research topics, drafting of proposals.

In the following sections, activities of the WGs are presented in detail.

3. The working group establishment

Followed by finalizing JAP through WP3, the first action in WP4 was to prioritize more than 160 identified project ideas. In order to make a rational working structure, the project ideas have been categorized and sorted by the highest priority on the top of each category. The result was establishment of 11 working groups as follow:

1. Governance & Modelling;
2. North Sea Power Ring;
3. Green Decommissioning;
4. Energy Efficiency & Sustainable Communities;
5. Educational Collaboration and Training;
6. Innovation and SME's;
7. ENSEA Cluster (formalization);
8. Large-Scale Storage; and
9. Heat & Biomass.

The main working group activities include:

- Selection of competence pool/associate partners;
- Mapping existing projects;
- Identification of resources needed and researchable topics;
- Suggestion for consortium members; and
- Identification of financing opportunities;

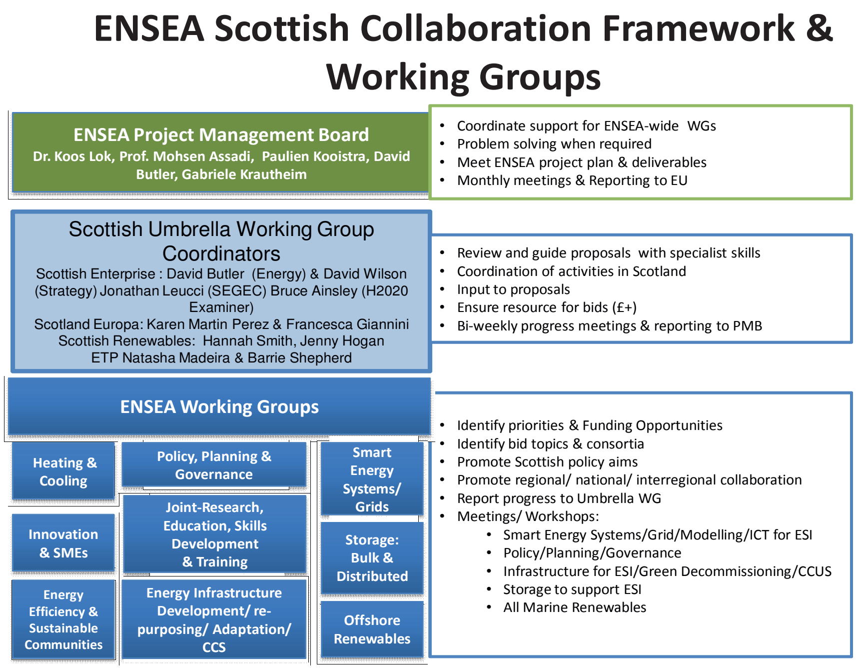

Figure 1: An example of implemented working group structure

A steering group has been also established to support the working groups in enabling contact networks, helping with scope identification, problem solving and following up the working group progress.

4. Report of the working groups

The following table lists all the existing working groups with participants. This section presents a summary of the activities/processed and achievements of the different working groups in the ENSEA project.

Table 1: List of different working groups and their participants

#	Working Group	Participant
1	Governance & Modelling	
2	North Sea Power Ring	Knut Kappenberg (WG leader), Kathrin Bayer, Paulien Kooistra, Koos Lok, Catrinus Jempa, Natasha Madeira, Mohsen Assadi, Peter Breuhaus, Karen Martin Perez, AP's / Externals: André Faaij – EAE
3	Green Decommissioning	Koos Lok (WG leader), David Butler, Catrinus jempa, Natasha Madeira, Knut Kappenberg, Carolin Schuback/Gabriele Krautheim, Astri Kvassnes, Mohsen Assadi, Karen Martin Perez, Paulien Kooistra
4	Energy Efficiency & Sustainable Communities	Carolin Schuback / Gabriele Krautheim (WG leader), Koos Lok, Ingrid Klinge, Petra Muller, Erik Matien, Paulien Kooistra, Knut Kappenberg, Natasha Madeira, David Butler Farhad Rad, Camilla Løvås Stavnes, Karen Martin Perez
5	Educational Collaboration & Training	Natasha Madeira (WG leader), Koos Lok, Knut Kappenberg, Barrie Shepherd, Mohsen Assad, Anne Beaulieu (to be replaced), Jannes Kalfsbeek, Kyrre Aas, AP's / External partner, André Faaij (EAE)
6	Innovation & SME's	Robbin van der Linde(WG leader), Ingrid Klinge, Bruce Ainsley, David Butler, Hilde Uppstad, Christian Quale, Carolin Schuback, Kyrre Aas, Jannes Kalfsbeek, AP's / External partners: Danish: Aalborg University & Region Jutland, NEPIC
7	ENSEA Cluster (formalization)	Ingrid Klinge (WG leader), Robbin van der Linde, Paulien, Jannes, Mette Fossan-Bergem, David Wilson, Natasha madeira, Gabriele Krautheim, Carolin Schuback, Karen Martin Perez, Sandra Dijkstra (EAE)
8	Large Scale Storage	Koos Lok (WG leader), Mohsen Assadi Carolin Schuback/Gabriele Krautheim, Ingrid Klinge, Machiel van Steenis (Energy Valley), Patrick (Energy Valley), Catrinus Jempa, Natasha Madeira, Can Yilmaz, David Wilson, Karin Martin Perez
9	Heat & Biomass	Alan Liddle (WG leader), David Butler, Jamie Robinson, Ingrid Klinge, Mohammad Mansouri, Mohsen Assadi

4.1. Governance & Modelling

One of the ENSEA targets is to initiate so called enabling (lighthouse) themes, i.e. joint activities that typically relate to triple helix conditions for integrated joint governance and investment activity in and around the North Sea area. A clear example of such a theme is: "setting up frameworks for energy cluster development and associated coordination and collaboration of various energy innovation related activities at the official level and/or under the auspices of the energy triple-helix cluster organisations of the various North Sea regions." (see also European North Sea Energy Alliance – working together to create a sustainable and secure energy future, 2014, page 9).

A first step has been taken in the spirit of the above, to try to initiate with the help of others a triple-helix organisation structure covering the whole North Sea area. Although in various countries around the North Sea, local, regional and even state-level triple-helix energy organisations have been set up, they primarily have remained national, that is to say concentrated in one specific country. Clear examples are the ENSEA partners.

At the same time a number of international organisations, initiatives, stakeholder groups, networks etc. have emerged lately with a clear focus on the North Sea area (see also next). However, a solid North Sea based organisation structure with a triple-helix character and dealing with the main energy and energy transition challenges of the North Sea region as a whole seems to be missing. Given the complexity of the energy system developments in and around the North Sea and the strategic role of it in the overall EU energy system, it seems that many challenges related to investment, governance, regulation and research would require the modelling of an organisation overseeing the complete energy system, and able to play a strategic information role, coordinating role, and possibly advisory or, ultimately, even decision making role. ENSEA sees it as part of its mandate to consider how a beginning could be made with setting up such a North Sea triple helix organisation.

4.1.1. Teambuilding and management

With regard to the organisational setting, teambuilding and management on the medium and longer term, the target could be to turn the ENSEA 2.0 organisation into a formal public private partnership (PPP) in accordance with the EU system. The EU distinguishes in this regard between two PPP forms: a contractual PPP and an institutionalized PPP, the latter also being called joint technology initiative (JTI). Both are partnerships initiated and led by industry, and based on a contractual agreement between the European Commission and the industry partners involved. Such a contract sets out objectives, commitments, key performance indicators and outputs to be delivered.

A contractual PPP, however, is a less far reaching organisational structure than a JTI, which is why the former usually precedes the latter. Whereas a JTI has a fully earmarked budget, a clear theme, shared management costs, no commitology, requires stronger involvement of industry partners and derogations of the Framework Programme, a contractual PPP instead only involves an indicated budget, an industry proposed strategy and commitment, but implementation by the EC, and requires the usual Horizon 2020 commitology and rules for participation.

Either way, both options require a lenghty preparatory process which is why, as argued, they probably are typical options for the medium and long term. The new organisation should – as an initial thought – be a legal entity initiated by the ENSEA underlying triple helix organisations, and needs to be well structured organisation-wise. It would have an own budget based on contributions from the various participants (official authorities and the industry could be asked to contribute financially, public research institutes in kind as an option), and a clear mission and mandate.

Finally, the new organisation should be able not only to collect the various studies and research activities relevant for the North Sea energy system, but also to initiate new activities that would be needed for energy systems integration. The mandate of such new initiatives could range from organising stakeholder meetings and discussion platforms, and formulating policy advices and lobbying, to supporting the setup of new projects and taking responsibility for the execution of triple helix integrated energy systems projects. It would seem important that this organisation also directly reports not only to all stakeholders involved, but also to the European Commission and the various national governments.

4.1.2. Identification of activities and funding opportunities

In order to identify the activities and funding opportunities, it is necessary to investigate if and to what extent the key representatives of the main North Sea initiatives as mentioned above are willing to collaborate or even merge.

It is also necessary to investigate under what conditions ENSEA would need to take the initiative to set up a major workshop to which most of the key stakeholders of the above-mentioned organisations would be invited. That workshop would address just one single question: "is there a need for a strong interdisciplinary triple-helix North Sea energy organisation focusing on energy systems integration, and are the existing organisations prepared to join such an initiative?"

4.1.3. Identification of the relevant call for research proposal

It is clear from the various projections that investment in offshore wind activity in and around the North Sea is only in its infancy, but is likely to grow massively involving multi-billion investment amounts during the next few decades. Some projections even suggest investment figures surpassing one hundred billion euros. At the same time much of the currently existing oil and gas (O&G) exploration activity on the North Sea will start to disappear, which requires very significant decommissioning investment, probably amounting to monetary figures in the order of some fifty billion euros or more. Finally energy transition related activity around the North Sea is booming almost everywhere, as has clearly been illustrated in the overall ENSEA regional analysis, and again involves new investment activity in the dozens of billions of euros for the next few decades.

An example may clarify the scope for cost savings if the different stakeholders succeed in working together properly. Because somehow the offshore wind energy will need to be brought onshore, a formidable infrastructural challenge emerges to convert, store, and to transport that energy. The investment costs of an electrical grid for dealing with the new renewable intermittent North Sea energy supply are formidable, as are the related balancing and back-up challenges. Various ideas are now floating around suggesting that the traditional infrastructure – the O&G platforms and installations and the storages and grid connecting them with onshore activity – can play a crucial role in supporting the efficiency and return of the upcoming offshore wind activity if wind energy can be converted and stored in other forms. Examples are that offshore wind farms convert the electricity generated into other forms of energy (hydrogen, methane, syngas, chemical substances, heat, compression etc.) when electricity prices are low or even negative. The existing platforms can be used for conversion and storage, and the existing grid can be utilised for transport purposes in order to convert and store that energy for sale later on. Such synergy between the old fossil and the new renewable energy worlds at the North Sea could create substantial cost savings and have serious positive safety and public acceptance impact, but requires serious intermediation and coordination.

That is typically what ENSEA 2.0 could strive to accomplish. Other examples could be given, such as linking offshore wind to hydro storages, linking offshore wind to bio based chemical activity, linking renewable sources to modern forms of mobility (e.g. hydro or electric) etc. All these cases of integration of usually quite separate energy systems and can only come off the ground if supportive organisations will play an active role in bringing the various stakeholders together, in establishing links between the various “energy worlds”, and in demonstrating by solid studies and research what the cost savings and efficiency impact of such collaboration can be. That is precisely what ENSEA 2.0 should focus on.

4.1.4. Further proceeding

A distinguishing mission of ENSEA 2.0 could be to reconcile the upcoming renewable, mainly offshore wind energy production activity and the various new energy activities around the North Sea with the traditional O&G exploration activity and related infrastructure use. This should be accomplished to create synergies, higher efficiencies and cost savings, and possibly to better meet issues of public resistance, regulation and licensing.

4.2. North Sea Power Ring

Given the unique starting point for the ENSEA consortium - five energy regions from five different European countries surrounding the North Sea within one Region of Knowledge project - the North Sea Power Ring project concept embraces a macro-regional approach. In particular, the aim of the project is to analyse and evaluate pathways for transformation of the North Sea Energy System towards a Region of Energy Excellence.

Methods to reach this aim are using energy-related simulations, new mathematical optimization models and optimization methods as well as analyses of the European energy system. Furthermore, feasibility and energy-economic implications of different transformation pathways are examined in the context of this project. The project also considers connection of synchronous / market areas, the planning and operation of meshed multi-terminal high voltage direct current (HVDC) networks for different applications, the integration of existing storage capacities in Norway, Scotland, the Netherlands, Germany and Denmark as well as the integration of new offshore storage concepts for the provision of compensation and flexibility options for secure network operations. With respect to North Sea power ring, a short project proposal template has been provided by this WG that can be found in Appendix A.

4.2.1. Teambuilding and management

Several meetings were held between EFZN and Energy Valley in which the project was shaped. During a number of project management board (PMB) meetings in the scope of ENSEA the results were shared with the preliminary project consortium members from Norway, Scotland and Denmark and the project conception was jointly rolled out in more detail.

4.2.2. Identification of activities and funding opportunities

The activities shaped in the project core group showed from a very early stage that this project is not "just a normal R&D project", but instead a major and complex innovation-related activity with the potential to change the entire energy system in the North Sea area. This calls for a pan-European approach. Altogether, it was decided to identify funding opportunities through European project funds, such as H2020.

4.2.3. Identification of the relevant call for research proposal

The call H2020 - LCE-21-2015 has been identified.

Topic of the call: Modelling and analysing the energy system, its transformation and impact

Type of action: Research & Innovation Actions

Specific challenge:

In order to ensure efficient follow up of the integrated roadmap, following the Communication on Energy Technologies and Innovation, the complex links, interactions and interdependencies between the different actors, the available technologies and the impact of the different interventions on all levels from the individual to the whole energy system need to be better understood. Furthermore, due to the central role of energy for our societies, the choice of a particular portfolio of energy technologies has far-reaching impacts not only on the energy system, but also on the environment, the economy and the society.

It is necessary to provide model based decision support tools for the different actors in the energy system in order to facilitate handling the complex system.

Scope:

Proposals should cover one or several of the following aspects:

- Comparative assessment of the impacts and the sustainability performance of all relevant energy technologies, including renewable, fossil, and nuclear technologies. Comparative assessment of transformation paths towards a sustainable energy system and the related impacts on environment, society and economy.
- Analysing and modelling the impacts of technological development and innovation on the energy-system and its dynamics. Analysing and modelling of technology policy measures in the framework of the SET-Plan to promote the transition towards a sustainable energy system, assessment of the impact of these measures on society, environment and economy, including safety and access to clean, reliable and affordable energy.

Where appropriate this will include development of new or refinement of existing modelling tools.

The Commission considers that proposals requesting a contribution from the EU of between EUR 2 to 4 million would allow this specific challenge to be addressed appropriately. Nonetheless, this does not preclude submission and selection of proposals requesting other amounts.

Project consortium:

Preliminary project consortium, key academic/research partners are:

- EFZN (DE), Wachstumsregion Ems-Achse e.V. (DE);
- Energy Valley (NL), Hanze University (NL), RUG-Rijks Universiteit Groningen (NL), Energy Academy Europe (Netherlands);
- University of Stavanger (UiS)/ CenSE (Norway);
- University of Strathclyde/ Energy Technology Partnership (Scotland); and
- University of Aalborg (DK).

Expected impact:

Support to the scientific underpinning for the implementation of the SET-Plan by strengthening the knowledge base for decision-making concerning feasibility, effectiveness, costs and impacts of related measures and options. The results should assist policy makers in identifying and analysing effective strategies for a transition to an efficient low carbon energy system.

4.2.4. Further proceeding

The preliminary project consortium is mainly composed of academic partners. In order to tackle the project concept elaboration further, a more balanced spectrum of partners is essential, especially for industrial partners coming on-board. Even though the project is about simulation of possible pathways, it is considered indispensable to have the industry's view included when evaluating the possible pathways. Therefore, the project consortium is in the course of acquiring those industrial partners coming from European energy-related companies.

4.3. Green Decommissioning

The financial reservations for decommissioning the various oil and gas platforms and related infrastructure in the North Sea are currently estimated at some €30-50 billion, but experience has learned that such amounts could easily be exceeded as time passes by. At the same time investments in offshore wind and related grid in the North Sea area are estimated to be a multitude of that amount. In other words in the North Sea area during the next few decades investments are likely to be in the order of a few hundreds of billions of Euros. At the same time public acceptance issues of all kind of new energy activity seem to rapidly increasing, which may support the request for offshore rather than onshore new energy activity. This raises the issue if the decommissioning activity on the one hand and the green energy investment on the other hand can be intelligently combined for innovative energy production, conversion (power-to-gas) and large-scale storage activity. This could involve activities such as using existing infrastructure that otherwise would be dismantled for new green energy activity such as combining available CO_2 and H_2 flows into synthetic/green methane, chemical conversion (methanol), storage of gases and chemicals for optimal application at the suitable market conditions, turning residual heat into biomass production (e.g. algae), using tidal and wave energy, combining large-scale chemical storage with hydro storage options and optimal grid management, economic and societal assessment of large-scale chemical storage, etc. This way, traditional platforms for oil and gas exploration could be transformed into modern green energy conversion and storage facilities giving the old platforms a new life. Given the potential savings of such smart combinations it seems logical to investigate the potential of this green decommissioning option with one or a few North Sea international pilots that can be used for not only public illustration, but also for all kinds of joint research and training in which the ENSEA regions collectively have been demonstrated to excel. Green Decommissioning has provided a short project proposal template that can be found in Appendix B.

4.3.1. Teambuilding and management

The lead for coordinating the work in this WG is in the hand of Koos Lok, representing Energy Valley. Working Group members include representatives of most of the current ENSEA partner organisations including:

- Scottish Enterprise, UK represented by David Butler;
- Energy Vally, The Netherlands further represented by Catrinus Jepma and Ingrid Klinge;
- Energy Technology Partnership (ETP), UK represented by Natasha Madeira;
- EFZN, Germany represented by Knut Kappenberg;
- Ems-Achse, Germany represented by Gabriele Krautheim;
- International Research Institute of Stavanger, Norway represented by Astri Kvassnes;
- University of Stavanger, Norway represented by Mohsen Assadi; and

- Scotland Europa, UK represented by Karen Martin Perez.

Although this WG topic has been signalled to be of priority for the ENSEA project, project scope and steps for project development have not yet been formalised. Current activities within this WG have been led by Dutch and Scottish partners in the form of setting up discussions with regional and especially national public and private stakeholders. The primary aim of these activities was to position the ENSEA partnership as a vernicle to further the needs of the (external) stakeholders and build support for further project development.

Although the efforts of ENSEA and the WG members have met very positive reaction from both public and private stakeholders, we are now moving towards a formalisation of the project scope and possible activities. Considering the diverse background of the ENSEA partners and their regional expertise, it is only now that the wider activities for project development can be specified and existing vs. Wished partner competencies can be defined further.

4.3.2. Identification of activities and funding opportunities

The envisioned project entails a radically new way of working for high-level energy stakeholders from the exploration and production (E&P) industry, renewables industry as well as different public organisations. Although the regional nature of the activities/project as well as the ENSEA project mandate allows for such activities, it should be noted that the primary stakeholders for project development are not formally represented within the current ENSEA consortium. For the same reason, it may be stated that funding and financing opportunities for the envisioned project and its activities are currently difficult to define.

During the course of WP4, Scottish Enterprise and Energy Valley have taken the lead in building relations private- and public stakeholders, creating a common understanding of the benefits of initiating a demonstration project for green decommissioning. The activities of a future project entail knowledge transfer from traditional private (oil and gas) stakeholders and their public counterparts to both public and private renewable energy industry stakeholders. Additionally, there are prominent legal and regulatory bottlenecks preventing further implementation activities.

ENSEA efforts in the UK and the Netherlands have aimed to bring the different public and private partners into a discussion about the potential benefits of developing a project within these difficult circumstances. As a results of many informal discussions with these organisations and combined with awareness raising activities about the relevance of this topic on regional and European levels, prominent private-private green decommissioning stakeholders (in UK and NL) have now declared their willingness to further investigate opportunities for further project development while using the ENSEA partnership as vehicle. Additionally, German and Norwegian ENSEA partners have actively supported these activities by informing their public and private stakeholders. There is now a strong basis for further commitment towards opening up different regional and national level funds towards the definition of a project-based implementation of envisioned activities.

In parallel, ENSEA partners have taken steps to further their own insights into the complexity of this potential future project by studying the different variables currently in scope and defining new work packages that need to be initiated together with new stakeholders that can complemented the existing ENSEA competencies. These activities have taken place in the second half of the WP4 timeline and have now taken shape in the form of a new project proposal that has been submitted as an EOI in the INTERREG VB program on 30 June 2015. The EOI has passed the first step and the full application will be submitted before 14th March 2016.

4.3.3. Identification of the relevant call for research proposal

During the course of the ENSEA project, the awareness for/ understanding of the importance of energy system integration as well as development of "cross-sectoral" demonstration projects (to facilitate this) have changed dramatically. As a result, existing EU level stakeholder groups are active on developing opportunities for funding on EU level.

Currently, prominent financing opportunities existing through the European Energy Research Alliance (EERA), who is developing a Joint Programme for Energy System Integration (ESI), aimed at addressing ESI topics.

Although the scope of the activities is still open for debate, the activities defined to cover:

- Modelling;
- Forecasting, aggregation and control;
- Technology;
- Consumers; and
- Finance and regulation.

The JP ESI offers significant opportunities for ENSEA partners to take advantage of the prioritisation of these topics in relation to their integration in existing RTD programme's like H2020. It should be noted however that although individual ENSEA partners are actively contributing to the work in this EERA JP, cooperation between ENSEA and EERA in the realisation of (research) proposals contributing to demonstrating these topics in the context of green decommissioning will require further steps by the ENSEA partners within the coming 6 months.

The current Energy Union developments will allow stakeholder groups to consult the European Commission on so called Projects of Common Interest (PCI). This links green decommissioning project variables related to e.g. licensing and regulatory issues (related to E&P infrastructure and its reuse) to be supported via the Connecting Europe Facility (CEF) and potential new funding opportunities now in development by the European Commission. However, it should be noted that the valorisation of these initiatives would require adherence to existing (lobbying) procedures and governance structures on national and EU level. Additionally, ENSEA partners are required to develop their formalisation process on an interregional level. Discussions with representatives from the EC on these steps are ongoing and have been addressed at the level of Vice-President Mr. Maros Sefkovic.

Finally, both the INTERREG VB North Sea Region and H2020 Energy programme's provide opportunities for furthering different individual aspects of the current green decommissioning project scope.

4.3.4. Further proceeding

ENSEA partners are currently directly and indirectly facilitating the further development of this lighthouse theme by;

- Further discussion with external public and private stakeholders at a national level;
- Further discussion with the European Commission regarding funding opportunities;
- Formalisation and expansion of the ENSEA cooperation as a vehicle to address, validate and implemented the envisioned project activities;
- Project development regarding INTERREG VB;

- Attracting national/regional level funding to co-finance the envisioned project actvities; and
- Define and persue opportunities for cooperation with existing national and EU level stakeholder groups.

4.4. Energy Efficiency & Sustainable Communities

4.4.1. Teambuilding and management

Every partner of the ENSEA consortium has been invited to take part in the Energy Efficiency & Sustainable Communities WG. The interested organizations could enlist themselves and have been involved in the activities of the group. This WG consist of:

- Ems-Achse, Germany represented by Gabriele Krautheim (WG coordinator)
- Ems-Achse, Germany represented by Carolin Schuback (WG coordinator)
- Rogaland County Council, Norway represented by Mette Fossan-Bergem
- University of Stavanger, Norway represented by Farhad D. Rad
- EFZN, Germany represented by Knut Kappenberg
- Energy Valley, The Netherlands represented by Ingrid Klinge, Pauline Kooistra, Koos Lok and Petra Muller
- Scottish Enterprise, UK represented by David Butler and Ben Westland
- Scotland Europa, UK represented by Karen Martin Perez
- ETP, UK represented by Natasha Madeira

As this working group, i.e. Energy Efficiency & Sustainable Communities, covers a very broad topic with a lot of options and different potential subjects, everyone was invited to give his/her input on the themes interesting for their region(s). In this way, the group was able to work target-oriented on different topics simultaneously.

As an example, Germany and Norway have worked on the topic “enhancing the capacity of public authorities to plan and implement sustainable energy policies and measures”. Moreover, Sweden, Finland and Serbia have been identified as potential partners and informed about the ongoing activities of the working group.

4.4.2. Identification of activities and funding opportunities

As a starting point, Ems-Achse proposed four different topics/groups that they would like to focus on, which also represent the quadruple-helix, introduced in the ENSEA JAP, namely:

- Public authorities;
- Consumers;
- Industry; and
- Society.

Funding possibilities have been identified in July 2014 and bilateral talks and meetings have taken place to sort out to inform the working group members about the existing ideas and discuss further approaches. In September 2014, the first concept was introduced to the PMB. The WG coordinators have found four matching energy efficiency (EE) calls, one for each group of stakeholders and they proposed to apply for these calls simultaneously in four different proposals under the umbrella of ENSEA.

It is planned to enhance the ENSEA-cluster from triple helix to a quadruple helix structure, including not only economy, science and local authorities but also society. In the four calls mentioned exactly these main pillars of the so called quadruple helix are specified in the field of energy efficiency:

- EE 07: Enhancing the capacity of public authorities to plan and implement sustainable energy policies and measures
- EE 09: Empowering stakeholders to assist public authorities in the definition and implementation of sustainable energy policies and measures
- EE 10: Consumer engagement for sustainable energy
- EE 16: Organizational innovation to increase energy efficiency in industry

In order to fix responsibilities and to get some inputs from the working group members, the coordinators send “partner input forms” for every call to the group as well as a “confidentiality undertaking letter”. These documents should have served as a basis to start working with different proposals. With the help of the documents, it became apparent that not all of the working group members are interested in every topic. To get an overview of the ideas regarding the future work within this WG, the WG coordinators asked the members for their input and suggested to develop a position paper regarding the significance of energy efficiency with respect to different topics including:

- A successful implementation of the energy transition;
- Energy system integration; and
- Stimulation for innovation in companies.

In addition, the coordinators of the WG visited the EASME Energy Efficiency Infoday in Brussels in December 2014 to gain some insights in the potential energy efficiency calls. The information was summarized for the working group to enable the members to come to a conclusion especially regarding their participation in the preliminary selected four different calls. The summary of information that has been provided to the WG members could be found in Appendix C.

Within the first months of 2015 the topic of energy efficiency became more important to the ENSEA consortium as a whole and therefore to the working group members. It has been discussed during PMB meetings and in conference calls within the group. To clarify who was interested in which topic the coordinators started to itemize the different topics and respective calls the group was talking about and asked the working group members to complement the list. The goal was to get an overview of the interest and the possibilities to work together on different research topics in the future. This resulted in an extensive excel table with 10 topics, calls and ideas (see Appendix D). Since not all of these identified topics and calls have been handled by and within the working group, this report will only mention the topics envisaged at the beginning of this section.

4.4.3. Identification of the relevant call for research proposal

In September 2014, this working group has identified an EU funding opportunity through Horizon 2020 program which had “energy efficiency - market uptake” as the main focus. Four EE research topics, out of 10 announced topics, have been selected as the most relevant topics to the working group as follow:

- EE 07: Enhancing the capacity of public authorities to plan and implement sustainable energy policies and measures – 2,000,000 €

- EE 09: Empowering stakeholders to assist public authorities in the definition and implementation of sustainable energy policies and measures – 2,000,000 €
- EE 10: Consumer engagement for sustainable energy – 1,500,000 €
- EE 16: Organizational innovation to increase energy efficiency in industry – 2,000,000 €

The working group have been communicating with all ENSEA partners to identify who is interested in one or more of the selected EE calls. As a result, the EE07 have been chosen by Germany and Norway as the best possible topic to continue. The selection of EE07 was based on resources availability and interest in both public and private sectors. An example of project template for this working group can be found in Appendix E.

4.4.3.1. EE-07-2015

Topic of the call: "Enhancing the capacity of public authorities to plan and implement sustainable energy policies and measures"

Project idea: "PAGE – Public Authorities Go Energy Efficiency"

The main aim of the project is to empower public authorities to develop, finance and implement ambitious sustainable energy policies and plans in a structured and transferable manner.

For this reason, the consortium wants to enable an effective and aligned implementation of the European Energy Efficiency Directive in local authorities with the help of standardized measures to concentrate European forces and proceed together. In doing so, the PAGE-consortium also wants to mobilize the existing creativity of the different regions.

Scope:

- Raising the capacity of Member States to fulfil their obligation under the new Energy Efficiency Directive.
- Enabling national energy regulatory authorities to address demand issues (e.g. demand response, tariff design, assessment of generation adequacy assessment).
- Capacity building on integrated energy, transport mobility and land-use planning at community and city-level.
- Supporting public authorities in better linking up local, regional and national levels for delivering integrated sustainable energy action planning and projects to achieve synergies and economies of scale.
- Establishing new or exploiting existing networks and other mechanisms to spread knowledge and facilitating the exchange of experiences and best practice on sustainable energy.
- Large-scale capacity building on innovative financing to specific groups of public authorities, such as national, local and regional authorities, energy agencies, structural and cohesion funds managing authorities.
- Defining and implementing standard energy saving packages for households, public sector and industry in particular under Article 7 of the Energy Efficiency Directive.

Consortium:

- Norway – University of Stavanger, Rogaland County Council
- Sweden – Lund University, Skane Energy Agency
- Serbia – Municipality of Temerin

- Germany – Wachstumsregion Ems-Achse e.V.

The PAGE consortium consists of partners who will contribute with their specific expertise to the project. Due to the fact that the implementation of the EED differs a lot from state to state and that Norway and Serbia are not obliged to comply with the directive the consortium itself shows the need to make it easier for local authorities to successfully implement energy efficiency plans. All consortium members acknowledge the important role of energy efficiency, which is also shown in their background and latest activities.

The different initial positions of the partners regarding policy, skills and also constraints and their diverse structure are an advantage for this project. The different backgrounds and stages the partners are in will help to get a clearer picture of what is needed to find a universal solution, which can be adapted to the needs of the different European countries or local authorities respectively. By using the input of the different partners a toolbox can be developed focusing on energy efficiency in all planning for future development in counties and municipalities.

However, the consortium decided to postpone the application because the partners need more time to work on the topic in detail. The consortium will also look for new opportunities to collaborate in other fields.

4.4.3.2. EE-09-2015

Topic of the call: "Empowering stakeholders to assist public authorities in the definition and implementation of sustainable energy policies and measures"

Project idea: "SOMGO - A question of energy – society meets government"

Scope:

- Large-scale capacity building or engagement activities shall be provided to specific groups playing a key role in the definition and/or implementation of sustainable energy policies and measures initiated by public authorities. Implementation of mechanisms ensuring the continuation of the activities beyond the project duration.
- Demonstration of a strong European added value
- Implementation of mechanisms ensuring the continuation of the activities beyond the project duration.

4.4.3.3. EE-10-2015

Topic of the call: "Consumer engagement for sustainable energy"

Project idea: "SOGEE - Society goes energy efficiency"

Scope:

- Changing the behaviour of consumers in their everyday life (e.g. at home, at work, at school), using market segmentation and focussing on 'action', the last step of the AIDA (Awareness – Interest – Desire – Action) framework.
- Equipment responsible for main energy consumption (e.g. heating and cooling, lighting, domestic appliances, and consumer electronics), as well as products from the small-scale renewable energy market, should be addressed in priority.
- Educational activities or tools (such as comparative ones) may be necessary, e.g. to help consumers read and understand their energy bills or labels; to help them take advantage

of ICT devices and tools to monitor and analyse their energy use; to increase trust in individual smart meters or energy audits; or to help them participate in community renewable energy projects (e.g. RES consumer cooperatives, community-owned projects etc).

- The use of social innovations and innovative technologies (e.g. smart meters/appliances/ICT) should be considered when it brings added value, especially when addressing the younger generation. More fundamental activities aimed at a better understanding of consumers' and other stakeholders' perception, motivation and behaviour are part of the scope (e.g. understanding of product labels and building certificates, difference in patterns of consumption for women and men) provided their results can directly lead to improvements in the effectiveness of consumer-driven initiatives.

4.4.3.4. EE-16-2015

Topic of the call: “Organizational innovation to increase energy efficiency in industry”

Project idea: “Taskforce EE - smart solutions for economy”

Scope:

- *Energy management in SMEs and industry*: Improve the availability of skilled energy auditors and energy managers and the diffusion of energy management systems and best practices. Develop instruments to ensure availability of updated, comprehensive and usable information on energy efficiency relevant for industries. Address the issue of access to finance for the actual implementation of energy efficiency upgrades.
- *Human and organizational challenges*: Analysis of motivations, behaviour, perception, and barriers for the involved actors (from decision makers to employees) in the sector. Knowledge about organizational factors influencing energy efficiency.
- *Industrial systems efficiency benchmarking*: Devise methods and tools including ICT to compare and benchmark the energy performance of industrial systems, processes and develop guidelines for tailored measures, in particular in energy-intensive industries. Such methods and tools should be based on existing standards where applicable.
- *Development of sector-specific technology pathways* towards 2050 to target the most energy-intensive industrial sectors

4.4.4. Further proceeding

The working group will extend their work regarding different topics including:

- Enhancing the capacity of public authorities to plan and implement sustainable energy policies and measures;
- Empowering stakeholders to assist public authorities in the definition and implementation of sustainable energy policies and measures;
- Consumer engagement for sustainable energy; and
- Organizational innovation to increase energy efficiency in industry.

In future, some working group menbers want to take the opportiunity to develop proposals for the new working programm 2016/2017 of Horizon 2020.

4.5. Educational Collaboration & Training

4.5.1. Teambuilding and management

This WG includes representative from Scotland, Norway, Denmark, The Netherlands and Germany. Scotland is lead coordinator on the Horizon 2020 innovative training network (ITN) proposal coordination and the engagement with the European Energy Research Alliance's process of developing a new Joint Programme on Energy Systems Integration, and The Netherlands is leading on collaboration with the association of European Renewable Energy Research Centres (EUREC). All partners currently part of the ENSEA initiative are involved in the Horizon 2020 ITN proposal, and any other organisation of interest to the Alliance, may also be involved within the proposal as Associate Partners.

The working group's activities were regularly reported at each PMB meeting and members participated in conference calls and events on EERA and Horizon 2020 ITN. In addition, a number of working sessions/workshops were arranged for ENSEA partners, specifically for Horizon 2020 proposal development, in the Netherlands and in Denmark. The lead proposal coordinator also attended numerous guidance meetings and five half-day Horizon 2020 ITN proposal development and coordination training workshop sessions, organised by the University of Strathclyde, Scotland. Information on working group activities and progress on proposal development was summarised and circulated via a standard ENSEA Project Overview Pro-forma. In addition to the above, coordination of proposal consortia contributions was undertaken via conference calls and circulation of email summaries and action lists.

The complexity of the energy system calls for interdisciplinary and system integration education. Interdisciplinary education is often needed for paradigm shifts in new concept and technology developments. At the same time, diverse energy and other technology systems are becoming more interconnected, requiring strategic planners and managers with a good understanding of core technology themes, but also competent in design and management of complex "systems of systems". In parallel, individual specialists have a need to undergo training in subjects in emerging related disciplines so that they are able to develop and implement solutions that are integrated elements of a complete system.

The current transition in the energy sector also requires the build-up of competent public authorities and an informed civil society. Decision-makers engaged in energy developments at regional and national level need to be informed about new developments in the energy field as well as about their associated opportunities and impacts. An understanding of the different technology fields and the challenges they face would contribute to the development of adequate policies and support schemes. In parallel, service providers and professional end-users need to undergo training when new technology options become available. Civil society and the general public should also be informed about emerging energy solutions, which would contribute to market uptake, deployment and use of new technology.

During WP2 and WP3 activities of ENSEA, all the working group partners provided an overview of their region's education and training profiles and current nature of collaboration with industry. A broad spectrum of competences and skills from a range of disciplines are represented within the cross-sectoral composition of ENSEA partners, and will be further strengthened with other partners from around the North Sea region, and beyond, as appropriate to activities and opportunities for collaboration.

4.5.2. Identification of activities and funding opportunities

4.5.2.1. ESI and the European Context

In preparation for establishing the initiative, ENSEA undertook a consultation, characterisation and evaluation process to gain an insight into the current state of the energy system in the North Sea regions, and potential opportunities for collaboration. The overall impression emerging from ENSEA's review was clear that energy innovation is booming in the four partner regions and growing rapidly.

However, it was evident that joined-up coordination of such activities around the North Sea is still poor and would require greater alignment to facilitate the transition to increased energy system integration. As such, local, segregated, regional/national energy solutions are not sufficient to address the challenges of the energy system as a whole.

The energy transition challenges are becoming so big and already affect Europe, to such an extent, that substantially more collaboration, between energy players from all sectors, will be required to resolve the current energy issues. Navigating pathways for collaborative action, and developing solutions based on international collaboration on energy systems, from local to interregional scales, will be needed to support the North Sea region's energy transition, and provide the EU with a more aligned interregional energy sector, better able to facilitate, support and contribute to EU renewables targets.

The EU Integrated Energy Technology Roadmap replaces the EU Strategic Energy Technology Plan (SET Plan) as the new long-term document setting overall strategic priorities and direction of EU programmes for energy technologies, alongside the new EU Energy Union Strategy. The Roadmap sets out the EU Energy Technology Strategy within five challenges:

1. Active consumer at the heart of the energy system
2. Demand focus
3. System optimisation
4. Secure, cost-effective and competitive supply
5. Cross-cutting social, environmental and economic aspects and international cooperation

For each of the five challenges, there is a potential role for Energy Systems Integration and ENSEA to support the implementation of the Roadmap. ENSEA is taking into consideration the EU challenges within its core activities and incorporating them into the framework for collaborative research, education and training.

The SET Plan Roadmap on Education and Training addresses the human resource challenge for the energy research and innovation sector and constitutes an integral part of the SET Plan agenda. It puts forward recommendations for key education and training activities to advance the provision of adequate human capital and to assist the development of the necessary cooperation frameworks among academia, research institutes and business. The summary of SET plan could be found in Appendix F.

4.5.2.2. ENSEA Collaboration on ESI Research, Education & Training Networks

This working group is collaborating to set up a focused energy research and educational network with the specific aim of jointly carrying out and initiating:

- Research, technological development and demonstration on innovative energy systems integration; and

- Education, training and skills development through research, exchanges and collaborative initiatives.

Based on ENSEA's strategic JAP, ENSEA partners are setting up frameworks and inter-sectoral working groups for increasing collaboration around the North Sea regions through activities relating to:

- ESI of Energy Grid Systems (gas, heat, electricity, infrastructure, operation and management systems, energy-related aspects of water, transport and carbon capture, utilisation and storage)
- ESI Policy, Governance, Economic Development
- ESI aspects of Planning, Modelling & ICT
- Bulk & Distributive Energy Storage to facilitate ESI
- Sustainable Communities & Smart Energy
- ESI Research, Education & Training Networks
- Role of Innovation & SMEs in ESI
- ESI Cluster Development

In June 2014, energy research and education institutes and partnerships from ENSEA regions signed an EOI, as a first step in the process of formalising the Alliance. The signatories intend to set up a strong energy research, education and training network, specifically to carry out and initiate joint energy system integration innovation research, education and training activities aiming at dealing with the challenges for energy transition and integration.

The ambition of the ESI Research and Education Network is to work together to establish an well-recognised North West European energy system integration think-tank that will have the credibility, skills, capacity and critical mass to analyse and address the major challenge of designing future energy systems that are sustainable, reliable and affordable, at the EU-level, and also contribute advances for the international arena. This is to be undertaken through:

- Growing the network and contributors, through associated partnerships,
- Establishing joint-training, PhD, Masters, Internship and staff exchange activities;
- Being scientifically vigorous and independent;
- Covering inter-disciplinary challenges (i.e. technological, economical, legal, societal, ICT, etc.); and
- Focusing on pathways to increased energy systems integration.

Through ENSEA's wider engagement activities, working groups, and the establishment of the Research and Education network, outlined in the EOI, development and demonstration activities will be pursued to focus on a broad range of energy innovation challenges and themes being identified through the ENSEA initiative. Core focus areas include Joint-Research and Education and Joint-training and Skills Development, as summarised below.

Joint-research and education focus

Joint-research development and demonstration activities will focus on a broad range of energy innovation challenges and themes being identified through the ENSEA initiative, and are expected to involve:

- Setting up joint-research projects, including projects in the area of energy system integration modelling, and seeking funding to that end;

- Organising joint activities in research such as joint workshops, network events and conferences;
- Organising the exchange of researchers, PhDs, postdocs, etc. involved in such joint energy system integration projects; and
- Extending and exchanging ideas on setting up more formalised collaboration for joint research, technological development and demonstration activities involving a wider group of key organisations active in the energy sector and located in the North Sea region.

Joint-training and skills development focus

Joint-training and skills development activities are expected to focus on:

- Facilitating student and young professional exchanges for energy related courses and other training activities;
- Setting up joint e-learning activities on energy system integration and its building blocks;
- Setting up and carrying out joint Master and Executive Master programmes;
- Setting up networks for Doctoral Training with academic, industrial and public-sector partners to focus on the pathways to increased energy systems integration; and
- Organising mutual internships on energy issues.

Core Working Group Activities:

To actively seek extension of the scope of partnerships to the ENSEA initiative in the North Sea region, to include other competent energy research organisations that share ENSEA's aims.

to collectively establish a well-recognised North West European energy system integration network that:

- Has the authority, skills, capacity and critical mass to provide significant contributions to solving the major energy challenges recognised at EU-level;
- Is scientifically rigorous and independent; and
- Covers inter-disciplinary challenges (i.e. technological, economical, environment, societal, legal, etc.) of designing future energy systems that are secure, clean and efficient.

There are a number of existing collaborative research, education and training initiatives with which some ENSEA partners already have some form of involvement or association. These are key candidates for which to explore greater ENSEA membership involvement, where appropriate. Some of these initiatives are mainly regionally or nationally based, with potential for collaboration with other regions, and some are interregional. Two of these initiatives with coverage across the EU are EERA and EUREC.

4.5.2.3. EERA Joint Programme on Energy Systems Integration

During 2014 and 2015, EERA has been consulting on establishing and developing a new Joint Programme, on the more technical aspects of ESI, to start later in 2015. ENSEA members have representation on other energy-related EERA Joint Programmes and plans to also to establish representation on this new Joint Programme. Coordinating joint action with existing and emerging collaborations is core to ENSEA's activities and, should the new Joint Programme on ESI become established, this would complement and enhance the current ENSEA activities.

ENSEA members have been involved in the consultation workshops, including presenting at one on ENSEA's ESI-supporting activities and goals for collaboration.

Scope:

The overall goal of the proposed Joint Programme in ESI is to develop the technical and economical tool box that government and industries will need to build the Europe of Energy, and further to export it. As such, it seeks to optimize the energy system by leveraging the synergies between electricity, gas, heat, and fuel pathways at all scales. The energy elements of the water and transport system are also included in ESI as is the enabling data and control network that enables the optimization. The control variables in this problem are technical, economic and regulatory. Therefore, its scope is potentially vast (Figure 2) but it is first and foremost focused on the interfaces where the coupling and interactions are strong and represent a challenge and/or an opportunity. Examples include integrated planning and operation of gas and electricity networks, and the increased coupling between electricity transmission grids and local heat networks via the concept of virtual storage. This joint programme is structured along a number of well-defined sub programmes that span the disciplinary range.

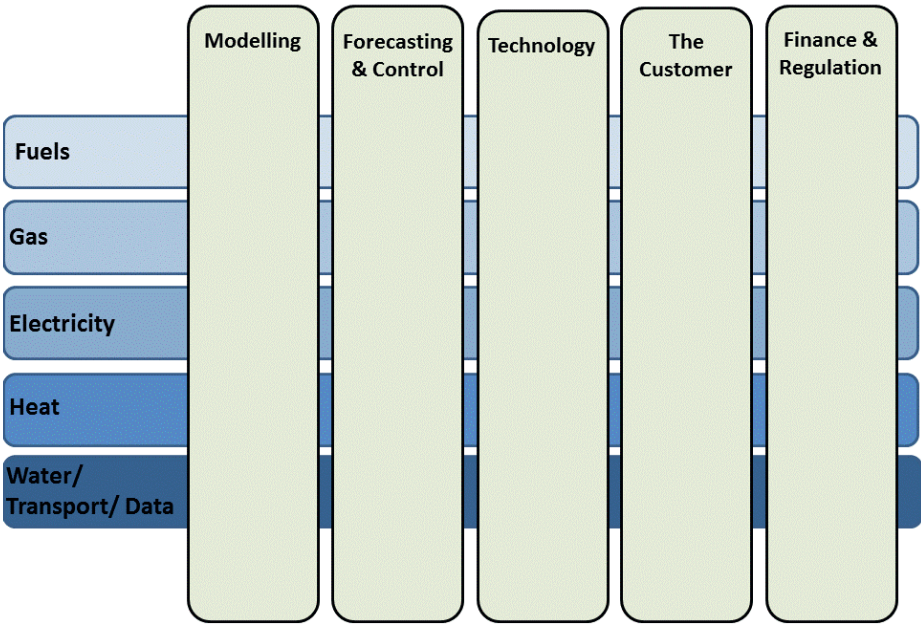

Figure 2: Scope of EERA Joint Programme on Energy Systems Integration

4.5.2.4. European Renewable Energy Research Centres

EUREC is the association of European Renewable Energy Research Centres, whose membership is composed of research centres and university departments active in the area of renewable energies and related enabling technologies.

EUREC is developing a new European Master in Energy Systems and is keen to align activities and explore collaborative opportunities with ENSEA, where of mutual benefit. To this end, EUREC and ENSEA representatives are investigating input from ENSEA partners into the new European Master. Talks with Scotland are in process and will proceed to other WG partners.

4.5.2.5. Regional/National Funding:

Scottish and UK Funding:

There are a number of coordinated funding streams and organisations specifically for supporting innovative energy research, education, training and skills development in the UK and Scotland. These include:

- Energy Technology Partnership (Funded by SFC, Scottish Government and Scottish Enterprise and 12 Scottish Universities)
- Scottish Funding Council
- UK Energy Research Centre
- Scottish Enterprise
- Scottish Government
- Skills Development Scotland
- Scottish Government Energy Skills Task Force
- Carbon Trust
- National Environment Research Council
- Innovate UK
- Highlands & Islands Enterprise
- Research Council UK Funding including:
- Biotechnology and Biological Sciences Research Council (BBSRC)
- Engineering and Physical Sciences Research Council (EPSRC)
- Economic and Social Research Council (ESRC)
- Natural Environment Research Council (NERC)
- Science and Technology Facilities Council (STFC)

Some of the funding streams and organisations in the Netherlands include:

- SNN
- RVO
- Kamer van Koophandel
- Noordelijke ontwikkelingsmaatschappij (Nom)
- Waddenfonds
- Ministry of economic affairs (TKI Energy)
- Innovativ actieprogramma Groningen
- Innovativ en duurzaam MKB (sustainable sme)
- Participatiefonds duurzame Energie Noord-Holland
- Stimulering duurzame Energieproductie (SDE)
- Borgstelling MKB (BMKB)
- Some fiscal funds (such as WBSO and Innovatiebox)

4.5.2.6. EU Funding

EU Funding streams relevant to the working group theme include:

- ERDF (European Regional Development Fund)
- INTERREG VB
- Horizon 2020
- Life (perhaps in the future)

Of the above EU Funding streams, in February 2014, the working group identified an EU funding opportunity through Horizon 2020 programme which had ‘innovative training of new researchers’ as the main focus. The Marie Sklodowska-Curie Actions Innovative Training Network (MSCA-ITN) fits very well with the aim of extended collaboration around the North Sea on energy education and research training. The ITN supports competitively selected joint research training and/or doctoral programmes, implemented by partnerships of universities, research institutions, research infrastructures, businesses, SMEs, and other socio-economic actors from different countries across Europe and beyond.

There are a number of ITNs but the two most relevant are the European Training Network (ETN) and the European Industrial Doctorates (EID). These are explained further, below.

4.5.3. Identification of the relevant call for research proposal

4.5.3.1. Horizon 2020 - Innovative Training Networks

Calls for Marie Skłodowska-Curie Actions Innovative Training Networks (H2020-MSCA-ITN-2016) which are relevant to ENSEA are:

1. ETN – Joint research training networks with cross-sectoral partnerships, involving 15 researchers in 4-10 Member States. Each researcher can be hosted by one sector, in one Member State and must spend around 30% of the time based in one or more other Member States, through secondment to one or more research partners, drawn from any sector.
2. EID – Joint research training networks through partnerships between research institutions and industry, involving 5 researchers in a minimum of 2 Member States. Each researcher must be hosted by an academic and industrial sector partner on a 50% time split in different Member States.

The ITN funding lasts for 4 years (with 3-year researcher contracts within that period). The same, or modified, Consortia may re-apply for further rounds of funding each year, so that the cohort of researchers continues year after year (subject to successful award). There is no limit to reapplication for this funding. About €4 million funding is provided for employment of 15 researchers, 1 administrator, networking and training activities, and overheads to host and secondment organisations.

The Innovative Training Networks (ITN) aim to train a new generation of creative, entrepreneurial and innovative early-stage researchers, able to face current and future challenges, and to convert knowledge and ideas into products and services for economic and social benefit.

ITN should be designed to raise excellence and structure research and doctoral training, extending the traditional academic research training setting, and equipping researchers with the right combination of research-related and transferable competences. It will provide enhanced career perspectives in both the academic and non-academic sectors through international, interdisciplinary and inter-sectoral mobility combined with an innovation-oriented mind-set.

Each ITN programme should have a clearly identified supervisory board co-ordinating network-wide training and establishing active and continuous communication and exchange of best practice among the partners to maximise the benefits of the partnership.

The programme should exploit complementary competences of the participants, and enable networking activities, the organisation of workshops and conferences to facilitate sharing of knowledge, new skills acquisition and the career development of researchers.

Training should respond to well identified needs in defined research areas, with appropriate references to interdisciplinary fields. It should be primarily focused on scientific and technological knowledge through research on individual, personalised projects.

In order to increase the employability of the researchers, the research training should be complemented by the meaningful exposure of each researcher to the non-academic sector and by substantial training modules addressing key transferable skills common to all fields (e.g. entrepreneurship, management and financing of research activities and programmes, management of intellectual property rights, other exploitation methods of research results, ethical aspects, communication, standardisation and societal outreach). The training follows the EU Principles for Innovative Doctoral Training. An example of project template with respect to MSCA-ITN can be found in Appendix G.

4.5.3.2. The ITN Relevance to ENSEA:

The ITNs are a perfect fit for the working group theme of Education, research and training collaboration for the North Sea region as it is aligned with ENSEA objectives, including the ITN four core focus areas of:

1. Innovation
2. Interdisciplinary
3. Inter-sectorial
4. International

What is new and innovative about the proposed project is the core theme and focus of the project to support Energy Systems Integration around the North Sea Region. The changes the proposed project would bring to the North Sea Regions is the gradual development and growing body of collaboration, expertise and research intensity in the field of Energy Systems Integration and also in the North Sea region. This collaboration should also have wider impact for the rest of the EU and international levels, both in innovation, entrepreneurial activity and research collaborations.

4.5.3.3. Identification of resources needed & researcher topics

The European North Sea Energy Alliance (ENSEA) proposes to set up an Innovative Training Network based on increasing Energy Systems Integration between, and within, regions around the North Sea. ENSEA seeks to increase collaboration on Energy Systems Integration for demand-driven research, skills development and training, as part of a host of network activities with regional, European and International dimensions. Initial focus is on development of a European Training Network although, in doing so, seeking opportunities to expand potential research partnerships into a more detailed and focused European Industrial Doctorate.

The proposed research themes for the ESI European Training Network (ETN) are drawn from a breadth of inter-related and inter-dependent factors which relate to the whole energy system and those systems and processes which interact with it. Increasing integration of energy systems will necessitate exploring, evaluating and accommodating complex interdisciplinary and inter-sectoral dimensions. The benefit of the ETN structure and composition is that these elements of enquiry and investigation will naturally fall out of the research pathways for the researchers and the network-wide activities. Moreover, the ETN itself will essentially become a mechanism by which ENSEA can achieve its aims; to expand and strengthen collaborative working on ESI, for stimulating ESI innovation, and for nurturing development of a body of inter-disciplinary knowledge, expertise and skills capable of addressing the challenges for energy transition.

Through review of ENSEA reports, conference calls, workshops and meetings, a summary of proposed ENSEA Collaboration Goals for Energy Systems Integration was developed. These goals form the basis for the proposed ITN Framework and have been further detailed into specific research goals under three research themes. An overview of the key questions and coverage of the three research themes proposed for the ITN Framework, and the over-arching goals is provided in the tables, below.

Table 2: Over-arching ENSEA collaboration goals for energy systems integration

	ENSEA COLLABORATION GOALS: GENERAL ESI SUPPORT
1	To explore and further understand Energy Systems Integration and the interrelationships between associated systems and cross-cutting issues.
2	To develop the knowledge, research and technological base to support establishment of better integrated, flexible, stable, secure, efficient, effective and smart energy systems for the North Sea regions.
3	To develop a generation of well-trained, skilled, interdisciplinary 'knowledge carriers' to support cross-sectoral research, development and innovation in ESI and for energy transition.
4	To support implementation of the EU SET Plan and Energy Union Strategy goals (including; education, training, skills development, innovation, etc.)
5	To expand, and further reinforce, the academic-industrial-public sector collaboration model of ENSEA to support innovation in ESI for the North Sea Regions.
6	To engage community groups and all levels of the education sector in energy-related initiatives or activities to inspire them to become more involved in energy issues, management and professions.
7	To explore approaches to spanning the bridge between centralised and decentralised energy production/ consumption at national and regional levels.
8	To facilitate cooperation between SME's and researchers for TRL levels 1-9 (via living labs, test centres, etc.).
9	To support Smart Specialisation strategies and interregional cooperation in order to develop a specialisation in the North Sea region as a whole.

Table 3: Collaborative research themes, key questions and coverage

ENSEA research collaboration schemes	Key questions	Theme coverage
Theme A: Innovative Technologies for Sustainable Energy Systems	What technological developments or innovations are required to support energy transition and greater integration of renewables?	Innovative technological developments which could support a sustainable, smart, whole-systems approach to increasing integration of the energy system, incorporating gas, electricity and heat alongside appropriate storage systems, systems optimisation, modelling, balancing supply, demand-side management, energy efficiency and developing more sustainable communities.
Theme B: Infrastructure and Facilities for ESI	What infrastructure or facilities are required to be developed or adapted to support energy transition and greater integration of renewables?	The relationship between systems integration and physical infrastructure, looking at smart energy grids, developing, re-purposing or adapting existing and future energy and storage infrastructure and facilities.

Theme C: Cross-cutting issues for the wider Energy System	What is required to create and support a suitable operating environment for energy transition and greater integration of renewables?	The areas surrounding the energy sector which will shape systems integration in the North Sea region. It will examine the suitability of finance, markets and regulation to support energy transition. It will assess the impacts of up-coming and existing EU, UK & regional policy, planning and governance and their implications for adapting education, training, skills and consumer behaviour.

4.5.4. Further proceeding

The energy sector is an evolving field, which creates new job opportunities but at the same time requires the development of new skills and competences. The challenges for the education and training institutions and their legal frameworks will be to ensure a workforce flow of researchers, engineers and technicians who are able to generate new knowledge and to meet the requirements of evolving technologies and labour markets.

Addressing these challenges with partners around the North Sea is the best way of developing new knowledge and collaboration in addressing common challenges for the Energy transformation.

The SET Plan Roadmap on Education and Training addresses the human resource challenge for the energy research and innovation sector and constitutes an integral part of the SET Plan agenda. It puts forward recommendations for key education and training activities to advance the provision of adequate human capital and to assist the development of the necessary cooperation frameworks among academia, research institutes and business.

This working group prepared a draft proposal, which is structured based on the European Commotion proposal template. The draft proposal includes research and training objectives and collaboration with industry and public authorities. At this stage, the research team are working on the template to develop and finalize it before the next MSCA-ITN deadline.

Solid base for development of increased collaboration within energy education around the North Sea addressing necessary for achieving the goals set in the 2050 goals of a more sustainable energy system in Europe. This will be addressed in a proposal for MSCA-ITN. Collaboration in education related to system integration around the North Sea will also be important in establishing ENSEA as a permanent organization. Therefore, a crucial part of the future ENSEA collaboration could be developed in the area of Education.

4.6. Innovation and SME's

To accelerate innovation performance, ENSEA wants to create an action plan for improving framework conditions and access to finance for demand driven RTD by creating synergies between regional, national and European funding. In doing so, it is important to build on existing potential for high value dynamism between large and small enterprises operating within the respective regions. To accelerate innovation ENSEA wants to stimulate focused knowledge exchange by increased (social) network interaction within and between regions. Project development has been undertaken to position ENSEA as a central connector or broker to strengthen the regional connections between SME networks allowing access to valuable resources (banks, suppliers, customers, financial and trading institutions etc.) while facilitating transnational links to discover new business opportunities. This will allow access and mobilisation of resources to enable the pursuit of the identified opportunities for large- and small enterprises.

4.6.1. Teambuilding and management

The lead in this WG has initially been taken by Robbin van der Linde of Energy Valley. Later project development was coordinated by David Butler of Scottish Enterprise. The WG for this ENSEA topic consist of the following ENSEA partners:

- Energy Valley, the Netherlands represented by Robbin van der Linde and Ingrid Klinge
- Scottish Enterprise, UK represented by Bruce Ainsley
- Scottish Enterprise, UK represented by David Butler
- Rogaland County Council, Norway represented by Hilde Uppstad
- Ems-Achse, Germany represented by Carolin Schuback
- University of Stavanger, Norway represented by Kyrre Aas

A weekly telephone call was arranged in the 6 week run up to the INNOSUP 1 bid that was submitted on 30th April 2015 (the ENSEA-SME bid). A new organisation Energie und Resourcen (Goslar) was recruited into this bid to provide a link to Lower Saxony because Emse Achse withdrew from participation in this bid. It is expected that the tempo of these calls will now reduce to 1 every 2-4 weeks now.

4.6.2. Identification of activities and funding opportunities

ENSEA partners wish to "Create an SME friendly environment and business opportunities" by:

- Accelerating innovation through knowledge exchange/interaction within and between regional SME networks;
- Facilitate SME access to valuable resources (banks, suppliers, customers, financial and trading institutions etc.);
- Facilitating transnational links to discover new business opportunities;
- Positioning ENSEA as central connector in SME innovation networks;
- Promoting effective collaboration within strategically important cross-sectoral and/or cross-border networks; and
- Promoting strategic restructuring measures within the regions for innovative capacity to develop.

As the above goals have obtained increased attention of regional, national and EU policy developments, financing and subsidies program on a level of aggregation offer possibly to align regional innovations infrastructures between the different ENSEA regions and for the whole of the ENSEA geographical area. As such, ENSEA partners have been pursuing opportunities to develop their regional innovation infrastructures and linking them by making use of the COSME programme.

Firstly, Dutch, German and Scottish partners have developed and submitted a project proposal with the overall objective to strengthen cluster management in the consortium as a way to provide more professional business services to European SMEs. This project was the first concrete action in the framework of the Cluster Excellence Programme referenced in the ENSEA application and was supported under COSME. It aimed to promote cluster excellence in the ENSEA region and entailed actions that will assist cluster organisations, business networks and their managers to provide high quality services to SMEs in different areas, including access to foreign markets. The project proposal directly build on ENSEA efforts relating to strategic industry-driven collaboration with respect to Energy System integration.

Secondly, ENSEA partners have joined developed and submitted an additional project in under COSME in relation to promoting and directly facilitating new industrial value chains around the

North Sea regions. A project proposal was submitted where the development, integration and demonstration of SME innovation projects through cross-sectoral collaboration (e.g. use smart specialisation strategies) was described. Additionally, the project entailed a validation process for cross-sectoral SME innovation project ideas as well as mentoring/coaching activities as well as innovation and technical assistance vouchers.

Finally, different region partners have developed new SME related programmes and projects that contribute to establishing a regional innovation system that can directly contribute to the goals and above-mentioned activities. As an example of these activities, it should be noted that Energy Valley has joined the EU Cluster of Excellence Initiative and have joined the European Enterprise Network together with a regional consortium of different cross-sectoral cluster organisations.

4.6.3. Identification of the relevant call for research proposal

There are and will be numerous possibilities for funding given the focus on SMEs in Horizon 2020 (such as ERA-Net, H2020 programs and calls like INNOSUP). The decision on which to target was and is based on achieving a consensus from partner regions. An example of project idea concerning INNOSUP call can be found in Appendix H.

4.6.3.1. ENSEA_SME INNOSUP call

The programme would have involved regional economic development agencies and cluster organisations from Norway, Denmark, Germany, Netherlands and the UK that have a common ambition to creating a new European Energy Region of Excellence. Rogaland County Council from South West Norway (which has managed several large EU funded projects) will be the project coordinator with assistance from the International Research Institute of Stavanger (IRIS), which will coordinate the cross-border project brokerage activities and provide techno-market expertise to the consortium.

The 30 month ENSEA-SME programme will assist the economic development agencies realise their energy-related smart specialisation objectives and enable the development of globally competitive value chains in response to the need for 'secure, clean and efficient energy'. Central to this will be the exploitation of synergies between the cluster support organisations and encouragement of cross-sector collaboration by innovative SMEs. The programme will also leverage additional internationalisation and innovation support from other regional, national and transnational programmes and the private sector. It will, therefore, foster economic growth and support the strategic goals of the ENSEA partnership to make North Sea energy industries and value chains globally competitive, resource efficient and sustainable.

To maximise opportunities for collaboration, project partners will not only recruit from their own strong SME networks, but actively seek out SMEs, and other innovation actors, from other European regions to work with their regions' SMEs. Projects will be driven by North Sea regional smart specialisation priorities in new and emerging markets such as bioenergy, offshore renewables, geothermal, novel storage technologies, smart grids and energy system integration.

A bid writer was selected to assist produce the bid and based on his drafting and input from the partners a final version (version 7) was submitted at the end of April on the EU's bid portal. The timescale was tight – an invitation to quote as the bid writer was issued on 19th March. Optimat of Scotland was selected around 25th March 2015 with the cost split between Scotland and Norway. The bid then went through several redrafts with the partners' involvement through a series of weekly telephone calls.

Emse-Achse withdrew from the bid process around 21st April and fortunately we had assistance getting another Lower Saxony development agency - Energie und Resourcen Goslar involved at very short notice. This gave us representation of all the ENSEA regions in the bid.

4.6.4. Further proceeding

Dutch and German partners have detailed project plans for supporting innovation in SME's by up scaling a pilot cross-border voucher system between Northern Netherlands and Northern Germany. It should be noted that this project proposal is likely to be submitted by the partners by the end of 2015 and is complementary to the larger project proposal for cross-sectoral value chain development submitted under the COSME programme in April 2015. It should be mentioned that Energy valley (Northern Netherlands) has received a bronze label for this activity.

4.7. ENSEA Cluster (formalisation)

The central focus of ENSEA objectives and activities is on the coordination and exploitation of energy research to foster innovation and economic growth. Coordination of high quality research is assured through different drivers. The research-driven clusters involved in the project all have complementary strong academic bases in energy RTD themes relevant to system integration. Coordination between these clusters proposed in ENSEA will help improve the quality of the research and the potential for exploitation of research results, by identifying and attracting more and more diverse funding opportunities. By sharing and building on successful policy measures within the different regions involved partners set up an advanced common framework for stimulating innovation in research-driven clusters with strong energy RTD.

This will be a strong basis for cluster growth and consolidation within the regions as well as the collaboration with the region Sichuan (China) and other possible international clusters. The framework developed in the project can be transferred to other research-driven clusters within the North Sea region, allowing other energy clusters to benefit from the project results thus enhancing the European added value of the ENSEA collaboration.

4.7.1. Identification of activities and further proceeding

The ENSEA project brings together energy expertise and to align research programs around the North Sea. This project will end by September 30, 2015. Meanwhile the complexity of the energy systems around the North Sea has further increased, transnational linkages have intensified, and in the light of the proposed further integration of European energy systems in the Energy Union the need for coordination and cooperation in the North Sea region has become more evident. Accordingly, various ENSEA members have expressed their interest to continue their cooperation, and have discussed options to take this cooperation to a next level. Precise decisions on the way forward, the goals to be achieved, and the scope of this intensified cooperation have not yet been taken. Various partners have proposed to formulate a roadmap for ENSEA 2.0, which should outline the goals, scope and legal status to be achieved in ENSEA 2.0, and the strategy to achieve these. In general;

1. ENSEA partners intend to continue their cooperation in 'ENSEA 2.0.
2. Partners consider to formalise their cooperation under European law.
3. Partners choose to take a structured approach to the formulation of the roadmap for ENSEA 2.0, agreed upon by key players. This memo offers a first proposal for a strategy to the formulation of this roadmap.

4. The current ENSEA network consists of too many partners to effectively formulate a roadmap in plenary meetings. Therefore, a smaller group of key players will prepare a roadmap proposal to be presented to the ENSEA partners.
5. Formulation of the roadmap to ENSEA 2.0 is a transparent process, in which the interest of the regions around the North Sea and the different stakeholders to the North Sea's energy system are considered.
6. Work for the project proposals (INTERREG, Marie Curie, INNOSUP) continues parallel to the discussions about the ENSEA 2.0 strategy. Discussions about the ENSEA 2.0 strategy do not focus on the day to day progress of these project acquisitions.

Step 1: Line up key players and agree on approach

1. Gain support for below outlined approach from ENSEA network. Present a summary of the approach at PMB in Brussels. Ask for support and identify key players to be involved in the roadmap formulation.
2. Establish a Steering Committee of high level representatives of the key players;
3. Arrange day to day support for the Steering Committee in a working group;
4. Approval by Steering Committee of process towards the roadmap as outlined below.

Step 2: Formulate ambitions for ENSEA

1. Analyse the key projected developments in the energy system of the North Sea region, and formulate the role ENSEA wants to play therein. *(working group, input by Steering Committee)*
2. Analyse the synergies between participating regions. Where do the strengths and weaknesses of the regions, analysed in the FP7 project, provide opportunity for intensified cooperation? *(working group)*
3. Identify the rationale, scope and goals for ENSEA 2.0. What do we want to achieve on the medium and long term? *(working group, input by Steering Committee)*
4. Study the options for formalization of ENSEA 2.0. What are their requirements, pros and cons? Which resources do they require? What are realistic time frames? What do different options require from organizational structure and governance? Contact the European Commission for input. *(working group. Introduction to European Commission by Steering Committee, further contact by working group)*
5. Research current formalized European partnerships. Learn from the experience of these partnerships their best practices, do's and don'ts along the way. Contact established joint undertakings. *(working group)*
6. Formulate a strategy to achieve the desired levels of formalization. *(working group)*
7. Write proposal outlining rationale, role, scope and goals of ENSEA, as well as appropriate formalization options, their pros and cons, and the strategy to achieve them to be presented to Steering Committee. *(working group)*
8. Decide on the proposal. *(Steering Committee)*

Step 3: Propose vision about ENSEA 2.0 to ENSEA partners

1. Present proposal to ENSEA partners in plenary teleconference. *(Steering Committee)*
2. Gather input from ENSEA partners. How do they feel about the set goals and formalization options for ENSEA 2.0? Do they want to continue with ENSEA 2.0? Do they have suggestions about stakeholders to be considered in step 5? *(Steering Committee and working group)*

3. Adjust proposal according to the outcome of discussions. (working group prepares document, Steering Group decides on final document)

Step 4: Identify key stakeholders to incorporate and/or consult

1. Analyse which expertise, or partner types are missing in the ENSEA partner network to achieve formulated objectives. *(working group)*
2. Analyse which leading/excellent organizations in industry and academia are active in each region of the NS area, who could strengthen the cooperation. *(working group)*
3. Select organizations to involve in the formulation of the roadmap to ENSEA 2.0. *(Steering Committee)*
4. Formulate a strategy to include these stakeholders. Which stakeholders should be added to the ENSEA network now? Which stakeholders can be possible partners to the network later? Which stakeholders can be associated to the network? Which of them need to be consulted in the formulation of the roadmap? When should the partners be approached, by who, and with which message or question? *(document prepared by working group, decision by Steering Committee)*
5. Report updates to ENSEA network

Step 5: Involve the key stakeholders on the formulated goals of ENSEA

1. Approach parties identified in step 5 who could benefit ENSEA at this stage to join the partnership. *(Steering Committee and working group)*
2. Organize meeting with Steering Committee and possible new partners.
3. Consult parties who's input is desired for the success of formalization (e.g. local governments, European Commission, key industries). *(working group, in some cases Steering Committee)*
4. Report on the position of various stakeholders, and the key points to consider in the roadmap for ENSEA 2.0. *(working group)*
5. Incorporate new partners in Steering Committee and working group. *(Steering Committee and working group)*

Deliverable: report on the position of various stakeholders and the key points to consider in the roadmap of ENSEA 2.0

Step 6: Formulate a roadmap for ENSEA 2.0

NB: The organization of ENSEA roadmap formulation will possibly change in this phase. Possibly industry will take the leading role.

1. Prepare a governance structure for ENSEA 2.0. *(working group)*
2. Prepare a communications strategy to ENSEA 2.0. *(working group)*
3. Prepare a work plan to execute the roadmap. *(working group)*
4. Prepare, based on the documents of previous steps, a roadmap for ENSEA 2.0. *(working group)*
5. Input from Steering Committee on the roadmap. *(Steering Committee)*
6. Present roadmap ENSEA 2.0 to ENSEA partners. (preparation by working group, presentation by Steering Committee)
7. Adjust roadmap ENSEA 2.0 according to outcomes of discussions with ENSEA partners. *(working group)*
8. Finalize roadmap ENSEA 2.0. (working group. Final approval by Steering Committee)

4.8. Large-Scale Storage

Large-scale energy storage, for synchronization of electricity production and consumption and for effective usage of the electricity generated by intermittent renewable energy sources has become more crucial by growth of the share of intermittent renewable energy integrated to the grid. One of the main storage alternatives is hydropower. Replacing the electricity provided by hydropower by electricity from wind and solar energy, keeping the water in the reservoirs provides the cheapest and immediate solution. Pump-hydro storage, where the excess electricity from intermittent renewable is used to pump up the water back into the reservoirs is another storage option using hydropower. However, certain additional investments and construction work is needed to establish pump-hydro storage. Non-hydropower based storage in terms of power to gas, where excess power from intermittent renewable is used for hydrolysis and hydrogen production, followed by methanation where hydrogen and CO_2 are converted to methane, batteries, etc. are among other options where access to hydropower is limited or not possible.

The EU has long been a driving force in international negotiations and tangible measures on energy policies and climate change. The European Parliament, therefore, adopted the plan on climate change on December 2008 (EU "20-20-20"). The package of measures focuses on emissions cuts, increased use of renewable resources and substantial improve in energy efficiency.

It has become commonly understood worldwide that measures on climate change carries a cost, but doing nothing would be far more expensive in the end. Moreover, investing in those green technologies that cut emissions will also secure the supply, boost the economy, create jobs and strengthen Europe's competitiveness in a globalized world.

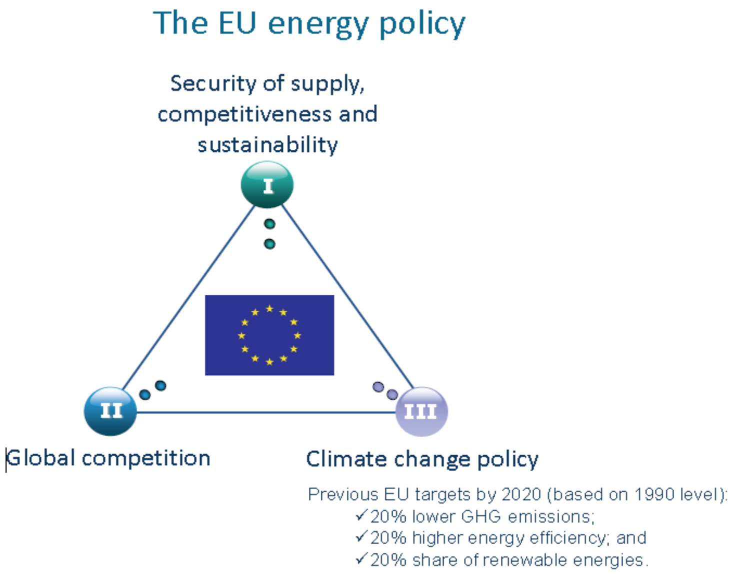

Figure 3: The EU energy policy

(Courtesy of Mohammad Mansouri Majoumerd's artworks)

Furthermore, in 2009, the European Council conclusions called upon all parties to embrace the objective of the International Panel for Climate Change (IPCC) to limit climate change to 2°C in 2050 by drastically reducing greenhouse gas emissions (GHG). The target for developed countries is considered to be 80 to 95% reduction of GHG below 1990 levels by 2050. In 2011, the European Council asked for an elaboration of a 2050 low-carbon strategy. The European Commission responded shortly after by releasing three roadmaps throughout 2011, and as a result, the transition towards a low-carbon energy future is increasingly debated in Europe.

In a shared effort to reach the EU "20-20-20" climate and energy goals as well as the 2050 energy roadmap, energy industry developments will undergo vast and radical transformation in the coming years. This energy transition means movement from a fossil and nuclear energy dominated world to usage of more sustainable and environmentally sound alternatives. The participating research and industry partners within the proposed project "Pumped Hydro Europe" with their multidisciplinary approach are at the forefront of these energy developments.

Facilitating the transition from the use of large-scale fossil and nuclear energy resources to this preferred state demands an integrated energy system. Such an integrated system has to balance the use of a diverse set of sustainable energy.

Increased attention is currently being paid to energy storage. As the shares of fluctuating renewable energies (mainly wind and solar power) increase in the total power supply, it becomes more and more difficult to balance power demand and supply. This is also linked to the facts that the share of controllable fossil power generation is decreasing (production) and, at the same time, the typically highly regionally concentrated renewable energy production is limited by the capacity of the power grid (distribution).

Therefore, energy research has begun focusing on grid-connected energy storage systems such as pumped hydropower energy storage (PHES). PHES produces power to supply high peak demands by moving water between reservoirs at different elevations. Turbines are used to capture the kinetic energy of water by converting it to power as the falling water spins the turbine. Hydropower is a renewable, efficient, and reliable source of energy that does not directly emit greenhouse gases, e.g. CO_2, or other air pollutants, and that can be scheduled to produce power as needed. It currently provides the lowest cost and commercially most important means of large-scale grid energy storage.

4.8.1. Teambuilding and management

The lead for EFZN to coordinate the work concerned with the hydropower project within ENSEA was agreed between the two research institutions EFZN and University of Stavanger. The idea behind the project were recent ministerial talks between EU and Norwegian officials about the future role of Norway in Europe's future security of supply architecture. Right from the start, it was emphasized that industrial participation and financial commitment from industry is vital for the success of the project. Therefore, talks with leading European energy companies and energy-related global companies were held as well with power plant engineering companies, hydroelectric power business suppliers and electricity transmission system operators. Several meetings were held with the core group consisting of four partners that were in closed contact with the respective industrial players stated above in order to shape the project in terms of aims, scope, duration, business case evaluation and preliminary estimation of overall cost including investment.

4.8.2. Identification of activities and funding opportunities

Horizon 2020 reflects the policy priorities of the Europe 2020 strategy and addresses major concerns shared by citizens in Europe and elsewhere. As security of energy supply is a major societal challenge of the European Union, one focus lies on secure, clean and efficient energy. Based on that work programme, low carbon technologies are important to develop and bring to market affordable, cost-effective and resource-efficient technology solutions to decarbonize the current energy system in a sustainable way - i.e. by using hydropower. Furthermore, the activities shaped in the project core group, with the input from industrial partners, showed from a very early stage that this project is not "just a normal R&D project", but instead a major, complex and particularly costly innovation-related activity including R&D, piloting, demonstration and preparation for market uptake which calls for a pan-European approach. An example of filled project template within the ENSEA project with respect to Large-Scale Storage can be found in Appendix I.

4.8.3. Identification of the relevant call for research proposal

The call H2020-LCE-09-2015 has been identified as the most relevant call for research proposals.

Topic of the call: Large scale energy storage

Type of action: Innovation Actions

In the following, please find an extract from the call text[1] in detail:

Specific challenge:

The high penetration rates of variable renewable energy resources entail the need for large scale energy storage to balance the production and consumption of high quantities of electricity and during longer time periods. Demonstration activities in this topic will aim to progress large scale energy storage and reduce the barriers associated with new storage concepts. An important market uptake challenge is to reduce the barriers (technological, economic, regulatory, environmental, social and other acceptance, etc.) associated with the deployment of existing or new storage concepts.

Scope:

Activities should focus on storage systems that reached already TRL 5 and bring them to TRL 6-7 (please see part G of the General Annexes). This would include anticipation of potential market and regulatory issues with due consideration to the environmental and socioeconomic aspects and improved models to demonstrate energy storage systems.

Activities should pursue direct electricity or indirect storage (electricity with other energy vectors). The activities must address the interfaces for integrating storage in grid management. Where appropriate, synergies between electricity grid, other energy grids, storage and final energy use must be taken into account.

The priorities are demonstration and validation of:

- Pumped hydro storage in new locations such as underground storage concepts aiming at GWh scale;
- Retrofitting of existing hydro dams with pumped hydro or other storage to enable flexible operation, large scale balancing and storage, while applying environmentally friendly design and operation;

[1] http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/1149-lce-09-2015.html#tab1

- Integrated management of existing or retrofitted pumped hydro storage (with variable speed pumps/turbines) also across national borders (e.g. smart grid concepts across alpine (or other) borders and enclosing many existing facilities); and
- Linking such storage projects with the development of the Northern Seas and other trans-European grid infrastructure concepts

Demonstration proposals should include market uptake measures for integrating energy storage in the electricity network and power system management. They shall focus on a limited set of specific issues that currently prevent an up-scaling or the realization of the concept. They should also include research on environmental, economic, legal, societal and public acceptance issues and recommendations for future energy policy by the industrial stakeholders involved. These results should be compared with the results of research oriented projects on the same or similar topics.

All projects will have to perform a detailed cost-benefit analysis and operational optimization of storage.

Expected impact:

- A wider use of storage technologies in the energy system through validation of solutions with reduced cost, increased efficiencies, and lower environmental impact.
- Provision of services for increased renewable energy integration, resulting, among others, in a reduced need for curtailment of wind, solar and other variable renewable energy resources.
- Deferred investment for transmission grid reinforcements and lower societal costs associated with high penetration of variable renewable energy resources.
- Integration with ICT tools for the control and management of electricity networks.

The impacts are expected to be linked to either energy balancing or improved grid congestion management at transmission level.

4.8.4. Further proceeding

The project has been shaped and all partners showed serious interest. Therefore, the project consortium is in the course of acquiring further industrial partners coming from European energy-related companies, especially in Norway and Germany.

4.9. Heat & Biomass

4.9.1. Teambuilding and management

In light of the increased emphasis on heat as part of the energy mix and the fact that generating heat accounts generally for some 50% of energy costs in the EU, this area has gained importance over the past number of months within the ENSEA project even though it was not initially selected as one of the lighthouse themes. This WG was representative of three partners in ENSEA including Scottish Enterprise, Energy Valley and the University of Stavanger. The sub-group meetings were organised over an intensive period of information gathering and additional exchange of information between different related establishments in each of the three geographies represented.

Alan Liddle of Scottish Enterprise has taken the lead in this WG and the working group for this ENSEA topic consists of the following ENSEA partners, whose remit was to look for new projects under heat for EU applications:

- Scottish Enterprise, UK represented by Alan Liddle (coordinator), Jamie Robinson and David Butler
- Energy Valley, the Netherlands represented by Ingrid Klinge
- University of Stavanger, Norway represented by Mohammad Mansouri and Mohsen Assadi

4.9.2. Identification of activities and funding opportunities

There was extensive dialogue amongst partners, using a set up conference call facilities along with follow up e-mails, to agree which activities to choose for Horizon 2020 funding application(s).

4.9.3. Identification of the relevant calls for research proposal

The decision was informed by an Expression of Interest form (see Appendix J) that sent out to partners to collate potential projects for support. This was encouraged to be disseminated widely to stakeholders and in Scotland for example, the Heat Network Partnership – a Government Partnership set up to develop district heating policy, was included

Whilst an application had been submitted, which was unsuccessful, under the EE 18 area (new technologies for heat recovery), the consensus in the working group was to examine possibilities under EE13 (Technology for District Heating and Cooling), after this process of wide dissemination of the possible heating project opportunities. This bid area closed on 4th June 2015 along with LCE 3 – Demonstration of renewable electricity and heating/cooling technologies, which closed on 5th May 2015.

The process was expected to pull in viable projects but in terms of working them up, the projects when explored further were still at a premature stage for a viable application to these rounds. However, the process of seeking bids helped to understand how projects were being developed, (in both Scotland and the Netherlands, through other means such as the Scottish Local Energy Challenge Fund and potential interest in a new Scottish Government led Low Carbon Infrastructure Transition Programme). Instead using contacts to further disseminate the activity under the call, awareness was raised of ENSEA and an opportunity for another project, which was not being led by ENSEA but led by a Dutch Research Institution was put out for interest amongst contacts, which resulted in at least an EOI from Edinburgh University to be involved in it. An example of a filled project template within the ENSEA project with respect to different appropriate calls for this WG can be found in Appendix K.

4.9.3.1. EE-18-2015

As mentioned earlier, the topic of heat was not initially selected as one of the lighthouse themes. However, due to increased importance of this topic some of the partners of the ENSEA project decided to submit a proposal for EE-18 "New technologies for utilization of heat recovery in large industrial systems, considering the whole energy cycle from heat production to transformation, delivery and end use". The link between Scotland (UK) and Rogaland (NO), which has been established by ENSEA, helped to prepare the proposal and to establish the consortium. In addition to the ENSEA partners involved in the bid, several other ENSEA partners have expressed a keen interest in this project due to the high level of industrial activity in the partner regions such as Ems-Achse (DE) and the Energy Valley (NL). In order to make a consistent and well-coordinated proposal, many individual and group conference calls have been arranged by Scottish Enterprise beyond the ENSEA framework.

The main objective of this proposal "SMART-HEAT" was to overcome barriers to industrial waste heat recovery and therefore increase EU industrial competitiveness and sustainability. This would involve four different industrial sites across Europe (in Belgium, Greece, Italy and the UK) and include:

- Realisation of underexploited economic and environmental opportunities by addressing both the technical & non-technical barriers and mobilising multi-stakeholder partnerships
- Enabling new and emerging technical solutions for each site to be evaluated and taking advantage of the 'living lab' opportunity to develop and demonstrate a new, modelling tool for wider replication

The other specific objectives of this research and innovation project were to:

1. Develop, and seek to implement, appropriate technical solutions and business models to recover at least 15% of the waste heat that is exhausted from four diverse process industry sites in different European countries;
2. Explore short and longer term opportunities for enhanced waste heat recovery based on the exploitation of novel technologies (TRL4-7);
3. Develop a suite of modelling and planning tools that can be used for the assessment of different technical and economic options for waste heat recovery from industrial process plants;
4. Validate the modelling tool in association with another 10 process plants in Europe; and
5. Proactively communicate the case-based evidence to relevant stakeholders across Europe to encourage replication.

The four industrial sites includes processing plants that manufacture cement, chemical, glass and steel products and industrial companies that have multiple European sites. Central to the project was a multi-stakeholder framework that has the broad range of technical, commercial and regulatory competence to carry out the work programme around the four industrial sites, which would be the focus for the research & innovation action.

Unfortunately, although a very good proposal with an excellent consortium have been submitted, SMART-HEAT could not get support from EU. It turned out that actually the final proposal evolved into something, which ended up not being a perfect fit and not well enough aligned with that particular call topic. This could be primarily due to the fact that the research topics identified were not at an advanced stage in that the evaluators had not identified the specific innovative technologies that would be implemented in different industrial sites. This meant that SMART-HEAT was unable to bring in specific technology providers into the consortium although it was planned to do so during the project and this uncertainty was too great for the evaluators to score the application highly, despite the strong consortium.

4.9.4. Further proceeding

Given that there is an appetite for heat projects across Europe to demonstrate technologies in this field, it is envisaged that project ideas will be generated and wider discussions opened up again. The potential for future EU bids in this field, especially under the envisaged new round of Horizon 2020 funding, depending on published topic areas matching requirements will be examined.

Appendices

APPENDIX A: An example of project template for North Sea Power Ring

APPENDIX B: An example of project template for Green Decommissioning

APPENDIX C: Summary of information provided to WG Energy Efficiency and Sustainable Communities

There are three groups of EE-calls including:

1. Buildings and Heating & Cooling (Calls: 05,06,02,13,14)
2. Finance and Public Authorities (Calls: 19,21,20,07,09)
3. Industry, Products and Consumers (Calls: 10,11,15,17,16,18)

EE-07: Public authorities

Public authorities play a key role in the reduction of EU energy consumption and the increase of renewable energy capacity (National level & Sub-national level). This requires:

1. Multidisciplinary skills
2. Skills to engage stakeholders
3. Skills to secure funding

It was made clear that for this call the participation of local authorities or networks of such are essential. The number of stakeholders reached has to be very high. An example of a former project was given:

"Gathering 7 large capital cities across Europe, coherent upgraded solutions will be designed for each participating city in integrative urban energy planning. Implications of innovative technical solutions will be identified for governance processes. The project is expected to increase the capacity of 100 city administration staff, 400 stakeholders from utilities and 180 stakeholders from other large cities"

EE-10: Consumers

Changing the behaviour of consumers in their everyday life using market segmentation and focussing on "action", the last step of the AIDA (Awareness – Interest – Desire – Action) framework

Sub-topics

1. Educational activities or tools to help consumers read and understand their energy bills or labels;
2. To help them take advantage of ICT devices and tools to monitor and analyse their energy use;
3. To increase trust in individual smart meters or energy audits;
4. To help them participate in community renewable energy projects.

Each million € of EU support expected to deliver annual energy savings of around 10% for at least 5,000 households.

EE-09: Public authorities

Overcome capacity gap to ensure full involvement of private stakeholders and civil society in energy planning and policy.

1. Large-scale capacity building or engagement activities for specific stakeholders (utilities, NGO's, consumer associations etc.)
2. Who play a key role in the definition and/or implementation of sustainable energy policies and measures initiated by public authorities.
3. Demonstrate strong European added value and ensure continuation of the activities beyond the project duration.

Hundreds of stakeholders playing a key role in the definition and successful implementation of national, regional or local policies and as a result, thousands of final consumers impacted.

EE-16: Industry

Removing market barriers, in particular lack of expertise and information on energy management; Mechanisms to secure funding for energy efficiency investments & facilitate the continuation of activities beyond project lifetime

1. Uptake of cross-cutting innovative technologies
2. Total-site energy management schemes and system optimization
3. Prioritise energy-intensive industries.
4. Four specific areas: Industrial system efficiency benchmarking: sector-specific technology pathways towards 2050; energy management in SMEs & industry; human & organizational challenges

Capacity building projects: increase the skills of hundreds of people working in the sector, resulting in savings of at least 25 GWh per year. Improved competitiveness; larger investments; energy savings; better implementation of policies.

APPENDIX D: Calls and ideas on Energy Efficiency

Call	Call Title	Lead partner	wants to be a partner	proposed by
EE2	Buildings design for new highly energy performing buildings		Scotland	Scotland
EE5	Increasing energy performance of existing buildings through process and organisation innovations and creating a market for deep renovation		Scotland	Scotland
EE6	Demand response in blocks of buildings			Scotland
EE6	Demand response in blocks of buildings			Energy Valley
EE 07	Enhancing the capacity of public authorities to plan and implement sustainable energy policies and measures	Germany	consortium is already defined: Norway, Sweden, Serbia	Germany & Norway
EE 09	Empowering stakeholders to assist public authorities in the definition and implementation of sustainable energy policies and measures			Energy Valley
EE 10	Consumer engagement for sustainable energy		Scotland	Scotland
EE 10	Consumer engagement for sustainable energy		Energy Valley	
EE 11	Empowering stakeholders to assist public authorities in the definition and implementation of sustainable energy policies and measures		Scotland, Germany	Scotland
EE-16	Organisational innovation to increase energy efficiency in industry		Energy Valley	Energy Valley

APPENDIX E: An example of project template for Energy Efficiency & Sustainable Communities

APPENDIX F: SET Plan Roadmap: Networks of Universities with links to Business and Research

The overall goal of the networks of universities and other relevant higher education institutions is to address knowledge, skills and competences needs and gaps via building networks, pooling capacities and allowing quick and wide replication. As such, they have the following guiding objectives:

1. To establish a flexible framework for developing new and upgrade of existing curricula in the respective evolving technology field, including blue-sky research, and involving of a broad range of experts from academia, research organisations and business.
2. To speed up the process of implementing such curricula within and outside the networks by helping higher education institutions to structure their studies along the developed programmes.
3. To facilitate the development of joint degree programmes among different universities via the envisaged streamlining and integration of curricula, teaching materials, teaching and learning methods at EU level.
4. To create links to relevant research and industrial infrastructure(s) in order to provide access for training of students and staff.
5. To encourage skill-led strategies for education, providing students and professionals with the latest technology trends.
6. To develop a new generation of professorships and trainers in fields where expertise is lacking.
7. To create a forum for relevant stakeholders from research, higher education institutions, industry and the public sector to exchange information on educational needs and share knowledge and experience.

The networks should gather stakeholders along the technology value chains, including a core network of universities and other higher education institutions, relevant research institutes, industry/business associations, and companies in the field. They should support lifelong learning and contribute to mobility across the EU. Furthermore, they should seek to have a global approach, and create links to relevant universities and quality organisations outside the EU.

APPENDIX G: An example of project template for Educational Collaboration & Training

APPENDIX H: An example of project template for Innovation and SMEs

APPENDIX I: An example of project template for Large-Scale Storage

APPENDIX J: An Expression of Interest form for Heat Calls

APPENDIX K: An example of project template for Heat & Biomass

Partners:

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Energy Systems Integration: The Agenda for the Future
Policy Brief

As the European energy landscape develops, the need to integrate our energy systems is increasingly recognised. Integration enables greater security of supply, higher levels of new and renewable low-carbon energy sources, reductions in the cost of energy, and requires increased deployment of low-carbon infrastructure. It compels us to create a system reflective of our changing energy use, and the changing energy landscape.

What is not as clearly understood, however, is how best to achieve the integration required. To be successful it must occur at all scales and in all sectors. It demands a holistic approach and coordinated, long-term policy commitment.

The European North Sea Energy Alliance (ENSEA), an EU-funded project looking at Energy Systems Integration (ESI) around the North Sea regions, has brought together experts in the field to discuss key issues and priority actions for enabling ESI across Europe. We present our priority actions below.

There are many organisations across Europe which could pursue these actions, however for the purposes of this report the actions are addressed primarily to the European Commission and the Directorate Generals for Energy, Climate Action, Enterprise and Growth, Digital Agenda and Consumers.

Definitions

Energy Systems Integration (ESI) describes the optimisation of the design and performance of the supply of all forms of energy (electricity, heat, transport fuels and others) at all scales (consumer, community, regional and inter-regional).

Quadruple-helix approach refers to bringing together academia, industry, the public sector and civic society to work together.

The benefits of integrated energy systems

Integrating our energy systems brings multiple benefits to different players – from generators and consumers to system operators.
We outline below how bringing our energy systems together can have positive effects on the three pillars of the energy trilemma.

Security of Supply: Bringing together different areas of our energy systems reduces our dependence on particular sources of energy. Variable generation is better managed in an integrated system and actively managed networks reduce the likelihood of outages and grid constraints. Energy systems integration creates resilient energy networks encompassing a wide range of technologies. Crucially, it reduces the need for imports from outside the EU and reduces the need to use finite energy sources.

Cost savings: Integrating our energy system drives efficiencies. Consumption can be reduced and smart systems mean less wasted energy. These energy efficiencies equate to cost savings for both businesses and consumers. By minimising reliance on hydrocarbons, consumers are protected from their volatile costs.

Low-carbon generation: Energy systems integration enables better use of our low-carbon generation capacity. For example, integrating wind power with energy storage, or converting excess renewable electricity to hydrogen for alternative uses, means that more of our generation can be low and zero-carbon. Energy systems integration supports energy efficiency measures, heat networks and decarbonised transport, helping to integrate renewable generation into the energy system.

The Vision

Our energy system is locked in a 'trilemma' as we try to balance the need for secure energy supplies, low-carbon sources, and affordable consumer costs. If we are to tackle the energy trilemma we need to see an integrated energy system where:

1. There is a holistic approach to energy systems policy-making and governance
2. Integration is achieved through cooperation between the 'quadruple helix' of academia, industry, civic society and the public sector
3. The public is educated and engaged, with 'pro-sumers' a key element of our demand and generation profile
4. Policy aims to harmonise markets and frameworks for integration across Europe
5. Infrastructure that facilitates integration between different energy sectors is prioritised
6. Ambitious EU-wide R&D programmes underpin continual technology development
7. Data are shared and Active Network Management occurs at scale

Key Barriers and Recommendations

Significant changes need to be made before our current energy system can resemble the holistic system we need to create. We outline below what we consider to be the key barriers to creating an integrated energy system across Europe within the four (overlapping) areas of *Technology; Infrastructure; Policy, Governance & Markets*; and *Consumers*.

Through detailed stakeholder engagement across the 'quadruple helix', ENSEA has identified a series of priority actions to help overcome these barriers.

Principal Recommendation

Establish an Energy Systems Integration Forum to address in a holistic way the issues of Policy and Governance, Technology, Infrastructure, and Consumer Engagement.

The relevant Directorates of the European Commission should work together to seek new models of cooperation to encourage quadruple helix, cross-discipline and cross-sector collaboration.

Technology

We welcome the European Commission Communication "Towards an Integrated Strategic Energy Technology (SET) Plan" and the inclusion of energy demonstration projects in the Horizon 2020 programme. However further action is necessary to fully and holistically address systems integration and to get genuine commitment. This includes the following action areas.

Action Areas:

1. Ensure continued R&D funding is made available for technology development and system integration research.
2. Encourage uptake of EU-level frameworks and guidelines which can support long-term stability and comparability of national support schemes.
5. Create a pan-European Energy Systems Integration demonstration roadmap, mapping existing demonstration projects as well as potential future projects. This requires establishment of a cross-discipline, cross-sectorial technology grouping.
6. Create a pilot 'Energy Island' which is connected to a national energy network to test theoretical ideas in a location which isn't isolated. This would prove/disprove the feasibility of various technologies.
7. Involve SMEs working in the field through engagement programmes to ensure coordinated approaches to technology development.

Infrastructure

Long lead times for energy infrastructure mean there is a need for strategic planning. Existing infrastructure needs to be better utilised, with priority infrastructure projects identified and network design improvements coordinated.

Action Areas:

8. Conduct gap analyses and determine top priority European infrastructure projects.
9. Launch a project turning selected existing assets into test-beds for new and smart systems.
10. Conduct a series of projects scaling-up the injection of hydrogen and bio-methane into the grid.

11. Analyse the energy performance of cities using future cities technologies for integrated energy systems.
12. Develop auditing tools and frameworks for zero carbon zones and communities.
13. Develop a ‘smart-neighbourhoods’ project focussed on district heating, assessing roll-out potential from existing demonstration projects.
15. Coordinate an approach to develop all scales of storage solutions
16. Develop a feasibility study and/or test cases for infrastructure synergies and Intelligent ICT pilot programmes.
17. Create a pan-European network design roadmap, mapping existing infrastructure projects as well as potential future projects.
18. Conduct a SWOT analysis of discrete energy networks that have been designed latterly to identify strengths and weaknesses, and assess potential replicability.
19. Conduct an infrastructure ownership assessment and drive results into policy and regulations.

Policy, Governance and Markets

While we welcome the Energy Union strategy we recognise that further efforts are required to implement a holistic European approach to policy, governance and markets. Climate change considerations must be central to the European energy strategy: ambitious and binding targets need to underpin a multidisciplinary approach to projects, and regulatory landscapes and market mechanisms should be synergised.

Action Areas:

21. Establish binding targets and a strong governance framework for carbon reduction targets out to 2050 and energy efficiency incentives to create an appropriate investment climate into clean-technology development.
22. Assess the policy initiatives in the Energy Union strategy which can aid the facilitation of Energy Systems Integration.
23. Encourage uptake of EU-level frameworks and guidelines which can support long-term stability and comparability of national support schemes.
24. Develop frameworks for, and implement, zero-carbon zones in areas across member states, which are linked to technology demonstration zones and integration-enabling infrastructure projects.
25. Require all EU-funded energy projects to have a steering committee in place with a quadruple helix structure.
26. Develop an EU-wide position paper on principles for local governance of integrated, low-carbon, energy systems.

Consumers

The Commission’s ‘New Deal’ for consumers initiative, and focus on consumer savings, choice and protection is welcome, particularly with regard to tackling fuel poverty. However, the role of the consumer within a more integrated energy system will change. Consumers will become ‘pro-sumers’, both generating and consuming energy. Appropriate structures to facilitate this transition for consumers (and communities, through the democratisation of energy governance) need to be developed.

Action Areas:

21. Encourage national and/or regional governments to consider suitable local approaches for community-level engagement in energy projects

Conclusion

The energy system Europe needs looks very different from our system today. To tackle the energy trilemma – ensuring secure and cost-effective energy supplies while reducing carbon emissions – we need to integrate all parts of our energy system at all scales. This report has presented the barriers to reaching that vision and sets out what we believe to be the priority actions required to overcome those barriers.

Our findings are based on three years of stakeholder engagement with all energy sectors, academia, the public and private sectors, and community energy specialists across Europe and internationally – from grass-roots activity through to representatives from the European Commission and DG Energy. Our research is thus some of the most comprehensive on the topic and we would strongly encourage our recommendations be given full consideration in future policy development.

The European North Sea Energy Alliance Project Partners

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