INDONESIA INTERNATIONAL SUSTAINABILITY FORUM

ECADIN
ENERGY ACADEMY INDONESIA

BOOK OF ABSTRACTS

Indonesia International Sustainability Forum 2024

Virtual Academic Dialogue

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Indonesia International Sustainability Forum 2024
Virtual Academic Dialogue

BOOK OF ABSTRACTS

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PREFACE

The Indonesia International Sustainability Forum (ISF) 2024 – **Virtual Academic Dialogue** served as a premier platform for scholars, industry experts, and policymakers to engage in intellectual discourse on pressing sustainability and energy transition challenges. This forum was held by the Coordinating Ministry for Maritime and Investment Affairs in collaboration with the Indonesian Chamber of Commerce and Industry (KADIN), with Energy Academy Indonesia (ECADIN) as the knowledge partner. The aim of this program was to showcase research studies or projects by Indonesian students around the world and to serve as a platform for engaging with Indonesia's top officials, world CEOs, and global policymakers.

This Book of Abstracts brought together 27 selected Indonesians from around the world, each sharing their research findings or capstone projects on sustainability and energy transition issues, including recommendations and policies.

This program was held as a 24-hour non-stop live stream over two days on September 5-6, 2024, and was broadcast live on the official YouTube channel of the Ministry of Infrastructure and Regional Development of the Republic of Indonesia.

The thematic areas covered in this dialogue reflected the interconnected challenges and policy considerations necessary to achieve an effective and inclusive energy transition. The research and discussions presented underwent a diligent review process, ensuring academic integrity, relevance, and practical applicability.

Beyond fostering knowledge exchange, ISF 2024 aimed to generate actionable recommendations that would guide policymakers, businesses, and international stakeholders in designing and implementing effective sustainability and energy transition policies. The insights derived from this forum were expected to contribute to policy frameworks, investment strategies, and innovation pathways that support Indonesia's sustainability ambitions.

We extend our sincere gratitude to the authors, reviewers, and organizing team, whose dedication was instrumental in making this program a success. Special thanks to our partners, whose support enabled ISF 2024 to remain a free and inclusive platform for global participants.

As this dialogue concluded, we hoped this Book of Abstracts would inspire transformative actions, catalyze new collaborations, and contribute to the broader sustainability agenda.

On behalf of the ISF 2024 Organizing Team,

Desti Alkano
CEO Energy Academy Indonesia | ECADIN

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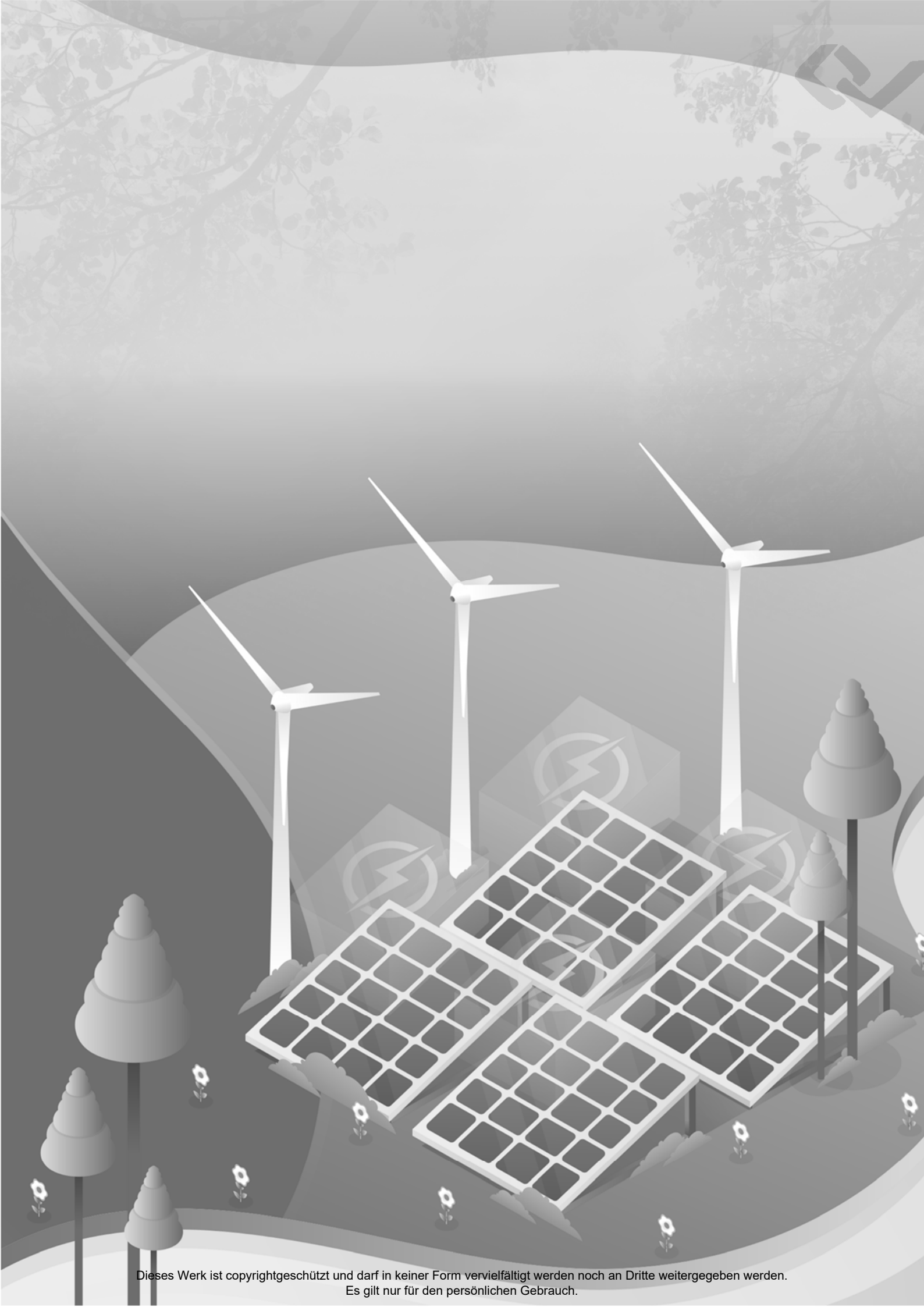

INTRODUCTION

The world faces unprecedented risks and the threat of irreversible damages due to soaring levels of greenhouse gas (GHG) emissions. As a nation, Indonesia has the potential to champion the global climate efforts. With huge renewable potential exceeding 440 GW and substantial reserves of critical mineral for decarbonization including nickel, tin, and copper the country is positioned to foster the development of sustainable industries. **Indonesia also has a diverse ecosystems storing up to 1 Gt CO2, which provides a pivotal role in the global carbon sequestration**.

Against this background, the **Indonesia Sustainability Forum (ISF) was established as a platform to foster collaborations and best practice** sharing across stakeholders in decarbonization actions, ultimately advancing the global concerted effort in pursuing a sustainable growth.

ISF 2023 has emerged as a notable success, drawing a substantial turnout of over 2,500 participants from more than 40 countries. The forum, spanning two days as part of pre-event to the ASEAN Summit 2023, featured 24 plenary and thematic sessions, supported by 12 domestic and international sponsors and 13 knowledge partners. This impactful event resulted in the signing of 8 Memoranda of Understanding (MoUs) and marked the inauguration of Indonesia's inaugural State-Owned Enterprise (SOE) Sustainability Academy. Among the distinguished attendees were over 10 heads of states, ministers, and leaders of international institutions, including the Prime Minister of Papua New Guinea, the Managing Director of the IMF, and the President of the World Bank.

Following from ISF 2023 and the UN 17 sustainable development goals (SDGs), the ISF 2024 shall continue to deepen conversations **around five key levers and the key financial and non-financial drivers needed to achieve sustainable growth**.

100% Renewable Energy Integration in Indonesia

David Firnando Silalahi

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Abstract
This thesis explores a pathway to decarbonize Indonesia's energy system, focusing on solar power and energy storage. Key findings include:1. Indonesia has abundant space for solar power deployment, including rooftops, reservoirs, mining wastelands, and agricultural land. The potential far exceeds future demand; 2. Offshore floating solar PV in calm seas around Indonesia could generate over 200,000 terawatt-hours annually; 3. Indonesia has 321 terawatt-hours of pumped hydro energy storage (PHES) potential, significantly more than needed for a fully renewable system; 4. A solar-dominated electricity system is feasible for Indonesia, with PHES providing overnight and longer storage. Strong inter-island connections are unnecessary; 5. Introducing gas turbines (using hydrogen or synthetic methane) for 1% of generation reduces costs and storage requirements; 6. The levelized cost of electricity for a 100% renewable system is estimated at 77-102 USD/MWh; 7. Solar anomalies during dry seasons are linked to forest fires, incentivizing their prevention. The research contributes: - Assessment of Indonesia's vast solar and PHES potential; - Global mapping of marine floating solar PV potential; - Presentation of premium PHES sites in Indonesia; - A solar heat map for suitable farm locations; - An alternative decarbonization pathway using solar PV and off-river PHES. The study concludes that Indonesia can achieve affordable, reliable, and emissions-free electricity through gradual transition to renewables, primarily solar power with PHES for storage.

Keywords: Solar energy, energy storage, decarbonization

Application of AI and Remote Sensing for Assessing the Impact of Energy Transition on Biodiversity in Indonesia

Prof. Alex Lechner, Dr. Muhamad Risqi U. Saputra, Riska Aprilia Kuswati, Nur Laily, Romadhotul Husna, Vicky Feliren, Alif Ilham Madani

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Abstract
The global transition to renewable energy sources, including wind, solar, and electric vehicles (EVs), is heavily dependent on critical minerals such as nickel, cobalt, lithium, manganese, and graphite. Indonesia, with the world's largest nickel production in 2023 and substantial reserves of copper and cobalt, plays a crucial role in meeting this demand. However, the rapid extraction of these minerals in biodiversity-rich regions like Sulawesi and Maluku poses significant risks to the nation's ecological heritage. This research investigates the ecological impacts of Indonesia's expanding critical mineral extraction within the context of the global clean energy transition. Employing advanced AI and remote sensing technologies, we evaluate the potential effects of mining activities on both terrestrial and marine biodiversity indicators, including Protected Areas (PAs), Key Biodiversity Areas (KBAs), ecoregions, forest cover, threatened species, seagrasses, mangroves, and coral reefs. By analysing spatial and temporal patterns of mining activities, we can forecast their consequences for biodiversity in Indonesia's critical mineral regions. Our findings reveal that critical mineral extraction may lead to deforestation, habitat fragmentation, and pollution, thereby disrupting delicate ecological balances and potentially causing irreversible biodiversity loss. Additionally, we note that Indonesia's approach to decarbonization is increasingly uneven, diverging from the globally advocated 'just' transition. This research provides essential, data-driven insights for formulating policies that foster responsible mining practices to advance global sustainability objectives. While Indonesia's commitment to clean energy is noteworthy, our study emphasises the need for a balanced strategy to ensure that the pursuit of sustainability does not compromise biodiversity, given that Indonesia boasts the second highest biodiversity in the world. Our insights are intended to guide policymakers and stakeholders in the responsible management of Indonesia's mineral resources, aligning with both global energy transition goals and environmental conservation efforts.

Keywords: Energy transition, critical mineral, nickel, biodiversity

Assessing Feasibility of Renewable Energy Integration in ASN 4 Residential Complex at IKN: A Green Building Perspective

Isaac Cornelius

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Abstract
The acceleration of relocating the government center from Jakarta to the proposed capital, "Nusantara," brings forth the need for housing and energy solutions for civil servants. Among the potential residences for government employees in the new administrative hub, the ASN 4 Apartment Complex stands out. Using a statistics approach to reach an accurate load profiling is critical. We consider lighting, HVAC, appliances, and common areas to estimate energy needs. Initially, the design envisioned 100% renewable energy utilization. However, achieving these poses operational challenges for meeting the complex's energy requirements. Our research focuses on photovoltaic (PV) technology. Using simulation tools like PVSyst, we evaluate the potential for electricity generation. To find green building specifications, we integrate several factors, which are efficient HVAC design, water management, and reducing ecological impact. Optimizing HVAC load distribution ensures better cooling results while minimizing energy consumption. Design an alternative HVAC system for a residential building that meets high electricity demand during the day and still provides comfortable cooling at night. Rainwater harvesting and water-efficient fixtures contribute to sustainability. Sustainable materials and thoughtful design mitigate environmental damage. The installation of a photovoltaic system coupled with an efficient HVAC (heating, ventilation, and air conditioning) system in the building renders it self-sufficient. Consequently, the building's electricity consumption no longer burdens the central power grid. Daily electricity needs are met internally, and any surplus energy produced can contribute to powering other buildings. The ASN 4 Apartment Complex can serve as a model for responsible urban living, balancing human comfort with ecological stewardship within Nusantara.

Keywords: Green building, photovoltaics, sustainability

Biochar Subsidies: A Policy Proposal for Accelerating Carbon Removal in Indonesia

Cintya Djayaputra

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Abstract:
Indonesia holds immense potential for carbon removal through biochar, a charcoal-like product derived from biomass. This policy proposal examines the benefits of biochar and advocates for a targeted biochar subsidy program to accelerate its adoption. A. Biochar: A Multi-Benefit Solution. Biochar offers a unique opportunity to address several of Indonesia's environmental challenges simultaneously. It effectively removes carbon dioxide from the atmosphere and stores it in the soil for centuries. Additionally, biochar application enhances soil fertility and moisture retention, leading to increased agricultural productivity. This can empower farmers, particularly in rural areas, by boosting crop yields and reducing reliance on chemical fertilizers; B. Targeted Subsidy for Enhanced Impact. A well-designed biochar subsidy program can significantly accelerate its adoption across Indonesia. By focusing on small-scale producers and farmers, the policy ensures affordability and empowers local communities. This not only promotes carbon removal but also fosters sustainable agricultural practices, contributing to long-term environmental and economic benefits; C. Sustainability and Monitoring. The policy proposal emphasizes the importance of implementing clear sustainability standards for biochar production. This ensures it doesn't contribute to deforestation or soil erosion. Additionally, a robust monitoring system is crucial to track the amount of carbon sequestered through biochar and assess the program's overall effectiveness; D. Conclusion. By strategically promoting biochar through targeted subsidies, Indonesia can unlock a powerful tool for carbon removal and sustainable agriculture. This policy proposal offers a practical and impactful approach to tackling climate change while benefiting rural communities and enhancing soil health.

Keywords: Biochar, carbon removal, sustainable agriculture

Building Foundations for Decolonizing Sustainability Curriculum in Indonesia: Reviving the Coupled System of Land and Sea Perspective

Rifka Fachrunnisa

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Abstract:
Colonialism has profoundly impacted colonized nations, particularly in shaping human-nature relationships. This study offers a new perspective on Indonesian Education for Sustainability (EfS) by exploring precolonial Indonesian connections with land and sea systems. By incorporating these perspectives into educational frameworks, we aim to enhance sustainability, promote biodiversity conservation, and protect habitats. We analyzed eight precolonial manuscripts from various Indonesian cultures using thematic text analysis to uncover the region's environmental identity. Our findings reveal that precolonial Indonesian knowledge embodies a deep harmony between humans and interconnected land-sea systems, reflected through four key relationships: emotional, practical, spiritual, and recreational. Emphasizing these relationships highlights their importance in Indonesia's sustainability curriculum. Our research underscores the significance of reclaiming local knowledge and advocates for a holistic approach to education that acknowledges the diverse dimensions of human experience and environmental interconnectedness.

Keywords: Education, nature, environmental

Challenges and Opportunities of Green Data Centres in Indonesia

Whildan Pakartipangi

University College London, England

Abstract:
Indonesia's surging demand for data centres, driven by its rapidly growing digital economy, underscores the urgent need for sustainable data centre solutions. This is particularly pressing given that data centres are among the most energy-intensive industries and Indonesia's commitment to net zero emissions by 2060. This study investigates the viability of green data centres in Indonesia, focusing on regulatory influences, technological solutions, financial impacts, and competitive advantages. The research method for this study is qualitative, comprising interviews with high-level management from data center providers, regulatory experts, energy suppliers, industry associations, training institutions for data centers, and climate and energy economists. Secondary research involves a comprehensive literature review of research papers, published articles, and industry reports. The proposed solutions emphasise the importance of implementing advanced cooling technologies, adopting renewable energy sources, and utilising energy-efficient servers and Data Center Infrastructure Management (DCIM) tools to reduce carbon emissions. Collaboration with suppliers who comply with green criteria and offer advanced technology is essential. However, the findings reveal significant challenges in transitioning to green data centres. These include limited renewable energy sources, grid technology limitations, and a heavy reliance on coal for electricity. Regulatory gaps and a lack of targeted incentives further complicate the transition. Additionally, high initial capital expenditures (Capex) for advanced cooling systems and generators, coupled with operational expenditures (Opex) for energy and fuel, present financial hurdles. Long-term financial planning that considers the total cost of ownership is critical. Regulations to accelerate the development of renewable energy power plants and incentives for data centre providers are needed to encourage the development of green data centres in Indonesia.

Keywords: Green data centres, renewable energy, sustainability

Cost-Benefit Analysis and Business Proposal Implementing Four Sustainable Development Goals: Case of Jakarta Sinking

Pricilia Vibrani

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Abstract:
This cost-benefit analysis and business proposal address the critical issue of Jakarta sinking, which is occurring at a rate of up to 25 cm annually. The primary cause is groundwater depletion, while the city has only 4.65% of its area designated as green open space, far short of the 20% target. Expanding green space faces two major challenges: limited land availability and the perception that such spaces are not economically viable. This proposal analyses the costs and benefits of increasing green open space, considering the saturated real estate market, the impacts of flooding and the health costs related to air pollution. As Indonesia's capital relocates from Jakarta to Nusantara, many state-owned assets in the old capital have become underutilised, creating an opportunity for alternative asset management. The Ministry of Finance, the key stakeholder acting as both landowner and authority over state budgeting, plans to generate income for the new capital. Under this proposal, 9% of the assets would be leveraged for income production, 21% would remain for internal government use, and 70% proposed to be converted into green space. These underutilized assets are typically located in strategic areas with high land and asset values. To meet the local government's 20% green space target, it is more feasible to use lower-cost land still inside Jakarta's perimeter. Thus, the proposal underscores the crucial importance of a public-private partnership, swapping assets through leasehold agreements to decentralize green space development. This initiative addresses four sustainable development goals: 3,6,11,13.

Keywords: Real estate asset management, stakeholder analysis, sustainable development goals

Determinant of Waste Recycling Through Waste Bank in Indonesia

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Abstract:
Many previous researches have been conducted to analyse waste management in Indonesia. However, many of them still focus on waste management in regional level. This study aimed to examine the correlation between waste recycling through waste bank with factors such as household characteristics, waste bank characteristic and provincial policies of waste management. Fixed effect model regression with STATA software was used to examined the variables. The study use panel data from selected 34 provinces in Indonesia from 2019-2023. The panel data is collected from website of Ministry of Environment and Forestry and Indonesia Bureau of Statistic Website. The result found that recycling facilities, acceptance of waste bank and waste awareness are positively significantly affect waste recycling through waste bank in national level in Indonesia.

Keywords: Waste management, waste recycling, household characteristic

Developing AI for Safe and Efficient Geothermal and Mineral Exploration

Mansur Arief

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Abstract:
Indonesia has vast subsurface reserves of geothermal energy and critical minerals (e.g., nickel), essential for national, regional, and global clean energy transitions. However, extracting these resources requires extensive exploration, complicated by Indonesia's complex geography, uncertain subsurface geology, and limited high-fidelity data. In this talk, I will present an innovative AI-based decision-making framework developed by the Stanford Intelligence Systems Lab and Stanford MineralX to improve the efficiency and scalability of various subsurface exploration efforts worldwide. This framework uses advanced AI techniques and geological data to model subsurface dynamics and noisy measurements. It helps geoscientists and decision-makers optimize exploration efforts, identify optimal drilling sites and sequences, and estimate the risk of induced seismicity. We envision that our research can help unlock Indonesia's significant geothermal and mineral potentials, accelerating the country’s energy transition goals and positioning Indonesia as a role model for other resource-rich nations. By combining AI, geoscience, and strategic energy planning, we can help reduce the overall carbon footprint, achieve energy independence, and contribute significantly to global clean energy efforts.

Keywords: Geothermal exploration, critical minerals, AI framework

Dynamic Analysis of Offshore Floating Solar Panel Structures for a Green Hydrogen Production

Muhammad Abrar Aulia

Technische Universiteit Delft, The Netherlands

Abstract:
Hydrogen demand constantly increases with the increasing population in Indonesia. Green hydrogen is a promising sustainable energy system in making industries, such as fertilizer, methanol, and oil refinery greener, not to mention if it is used as a direct fuel. Having a vast ocean surface offers Indonesia opportunities to promote green hydrogen systems through offshore solar energy system. Offshore solar-powered electricity can be used for hydrogen production technologies, such as electrolysis or methane pyrolysis. The use of electricity from offshore floating solar panels enhances the sustainability of electrolysis or methane pyrolysis. Given the solar irradiance, an electrolysis-based system may be produced offshore nearby existing ports, such as in the vicinity of Surabaya, East Java. A methane pyrolysis-based system may be produced nearby offshore natural gas fields, such as in the neighbourhood of Tangguh, West Papua. Since electricity is critical to optimize the economic value of hydrogen, ensuring a stable offshore operation is of importance. One of the critical part to establish a stable electricity generation is by having a robust offshore structural systems. This study explores the dynamic analysis of offshore floating solar panel structures and their mooring system to provide a robust offshore structural system for a hydrogen production. The integration of offshore solar energy and methane pyrolysis promotes a green hydrogen system and align with Indonesia's renewable initiatives. The findings indicate that offshore floating solar panel structures face some challenges but can be a feasible option.

Keywords: Green hydrogen, offshore solar, methane pyrolysis

Ecological Engineering Solution for Resilient Coastal Cities: Evaluating Construction Materials for Eco-Engineered Seawall

Dinda Mazeda

National University of Singapore, Singapore

Abstract:
Many coastal cities are formulating strategies to reduce the threat of coastal flooding due to climate change. While structures such as seawalls can help mitigate this risk, seawalls also cause ecological fragmentation and habitat loss. Ecological engineering solutions offer an alternative by integrating engineering functions and design approaches that result in biodiversity enhancement. This research evaluates five construction materials for eco-engineered seawalls by considering the physical characteristics, market price and availability, the influence on biodiversity, the environmental impact based on the LCA study, and stakeholder perspectives. The findings highlighted that concrete is cost-effective and offers design flexibility, which was consistently reiterated during the stakeholder's interviews. Concrete with added habitat features also helps increase biodiversity. However, concrete generates a huge environmental impact due to cement production, which can be offset through the utilization of recycled aggregates and pozzolanic materials to reduce its impact.

Keywords: Biodiversity, sustainable materials, climate adaptation

Ecoregion Development in Indonesia

Sidi Rana Menggala

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Abstract:
Ecoregions represent areas with similar ecological characteristics, such as climate, soil, vegetation, and wildlife. Development and policy pathways in ecoregions involve strategies and policies aimed at promoting sustainable development while conserving and managing natural resources effectively. Understanding these distinct regions is crucial for effective environmental management and conservation efforts. The Ecoregion Development Research (EDR) aims to improve one's ability to plan, think, and act at the temporal and spatial scales that are most conducive to the successful protection of biodiversity. The approach proactively advances a commitment to protect the widest spectrum of biodiversity, even though it is novel in its articulation and some of the tools and approaches employed. EDR will be the latest process dedicated to raising the standard of conservation achievement, partnership, and sustainability around Indonesia. It is firmly based on ideologies, principles, and strategies that emphasize good science, stakeholder participation, multidisciplinary partnerships, adaptability, and learning. A participative action research will outline the general course of action that will achieve or contribute to the conservation targets (action plan milestones) as well as the particular steps or activities to carry out that plan (activities) once a conservation plan has been created that lays out a strategy for maintaining an ecoregion's biodiversity. The goals and tasks outlined in an organization's action plan are probably going to be directly impacted by its comprehension of opportunities, risks, and stakeholder interests.

Keywords: Ecoregion, biodiversity, sustainable development

Electrifying Indonesia: A Cost-Benefit Analysis on Implementation of Induction Stove in Nusantara, Indonesia

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This study aims to determine the most cost-beneficial stove implementation project for Nusantara, the new capital of Indonesia, and its newly constructed residential buildings over the next 15 years. A 9-step cost-benefit analysis was performed to compare an electrification project through the implementation of induction stoves to the counterfactual of the implementation of LPG stoves, Indonesia's current status quo for residential cooking. Our data collection approach including secondary data collection, extensive literature reviews, and secondary data analysis to forecast sensitivity analysis towards changing key identified variables. These steps included specifying the set of two alternative projects, identifying the stakeholders and their standing, identifying the negative and positive social impacts, predicting the total impacts quantitatively over the lifetime of the project, monetizing all of the impacts, discounting the costs and benefits, obtaining the net present value of each alternative, performing sensitivity analyses, and summarizing the findings and recommendations. The most significant benefits of the implementation of induction stoves are categorized into environmental, health, government savings, and user cost-savings through energy efficiency, compared to the most significant project costs categorized into capital, installation, and infrastructure costs. The results of this extensive cost-benefit analysis demonstrated a favourable cost-benefit ratio and net present value for the implementation of induction stoves instead of LPG stoves; therefore, the study concluded that Nusantara further advance its net-zero goals by implementing induction stoves in all newly constructed residential buildings starting in 2025 for the benefit of Indonesia and its citizens.

Keywords: Induction gloves, energy efficiency, electrification

Engineering Bioethanol Yeasts for Sustainable Plasticizer Production

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Plasticizers, a key ingredient in numerous plastic products, represent a multibillion-dollar global sector. Currently, isoamyl alcohol, the primary building block of plasticizers, is derived from petroleum, posing sustainability concerns. However, a sustainable alternative exists: yeast naturally produces isoamyl alcohol during fermentation. Therefore, isoamyl alcohol is produced in massive quantities (300 million litres annually!) during industrial bioethanol production. Currently, however, this source of isoamyl alcohol is economically unviable due to the need for an additional distillation step to purify isoamyl alcohol from other yeast-produced fusel alcohols, making prices too high for a commodity chemical. To increase the economic viability of this sustainable isoamyl alcohol, we engineered a *Saccharomyces cerevisiae* yeast strain that generates isoamyl alcohol with a higher yield and purity while maintaining ethanol yield. Our approaches are: (1) screening a vast library of natural yeast variants to select robust chassis strains, and (2) optimizing the isoamyl alcohol biosynthetic pathway. The engineered strain produced 5X more isoamyl alcohol with increased purity from 30% to 60% in the waste stream, without affecting ethanol yield, in synthetic and industry-grade sugarcane molasses. This engineered strain could be implemented as such in an existing bioethanol infrastructure, allowing easy and quick upscaling of sustainable isoamyl alcohol production. More generally, the co-production of bioethanol with other yeast-derived chemicals could boost profitability for bioethanol producers, allowing a decrease in ethanol selling prices to compete with petrol.

Keywords: Sustainable plasticizers, yeast fermentation, bioethanol production

Enhancing CCUS Development in Indonesia: Policy Insights from the US IRA

Benedicto Anggita Prayoga Saragih

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Indonesia's energy landscape, dominated by coal (30.3%) and oil (28.9%) (IEA), has seen CO_2 emissions grow with GDP per capita. To address this, Indonesia established its first CCUS regulatory framework through MEMR Regulation No. 2 of 2023 and Presidential Regulation No. 14 of 2024, targeting net-zero emissions (NZE) by 2060. These regulations only support CCUS in oil and gas blocks and designated Carbon Storage Permit Areas (CSPAs), though coal is the greatest carbon emitter. With CCUS projected to capture 6 Mt CO_2e annually by 2030 and 190 Mt by 2060, it is crucial to Indonesia's NZE pathway. The US Inflation Reduction Act (IRA) includes the 45Q tax credit, offering up to $85 per ton for stored CO_2 and $60 per ton for CO_2 used in industrial processes. Direct Air Capture (DAC) projects receive higher incentives, promoting significant emission reductions by 2035. The IRA's broad eligibility and extended credit claim period support rapid CCUS adoption, highlighting the importance of financial incentives in driving investments in capital-intensive technologies like CCUS. To enhance Indonesia's CCUS policy, robust financial incentives similar to 45Q tax credits are recommended to attract private sector investment and expedite CCUS deployment. A flexible approach to technology procurement is needed, including lowering the 40% domestic composition requirement while boosting domestic industry development. Establishing stringent Monitoring, Reporting, Verification, and Storage (MRV\/S) systems is crucial ensuring CCUS projects' efficacy and integration with future carbon pricing mechanisms. By learning from the US experience, Indonesia can refine its CCUS policy to drive economic growth, create jobs, and meet climate targets. Given Indonesia's coal dependency, alongside efforts to develop renewable energy and decommissioning coal-fired power plants, CUUS is crucial for the coal and oil gas sectors. Embracing these recommendations will help achieve climate goals and position Indonesia as a leader in sustainable development.

Keywords: CCUS policy, net-zero emissions, incentives

Enhancing Coastal Resilience: Applying Decision Support Framework for Nature-Based Solutions

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Abstract:
Sea-level rise and increased rainfall intensity pose significant threats to coastal areas and communities due to climate change. Consequently, it is crucial to develop and implement long-term, cost-effective coastal protection solutions, especially in low-lying areas, particularly in developing countries that often lack adequate disaster protection. However, the proposed solutions primarily involve hard-engineered infrastructure, which may be less adaptable to the uncertainties of climate change scenarios. Nature-based Solutions (NbS) are emerging as an alternative approach for coastal protection and ecosystem restoration, integrating the socio-environmental system. However, there are limitations to their implementation, such as the lack of comprehensive frameworks to support NbS mainstreaming, absence of concrete planning recommendations, and insufficient guidance for assessing and aligning NbS as necessary. To address these challenges, a decision support framework (DSF) has been developed to select the most suitable NbS options in Indonesia. The DSF utilizes a multi-criteria analysis that considers design engineering and existing natural conditions. The development methodology of the DSF includes a literature review of eco-engineering alternatives, mapping potential disaster risks, creating a multi-criteria list, assigning attributes to all relevant alternatives, translating information into the DSF, and conducting DSF testing. The DSF is designed as an interactive platform, providing users with an engaging experience while inputting the assessed criteria. It generates comprehensive alternative solutions based on user inputs. This approach benefits various stakeholders, including the government, coastal managers, and engineers, in designing and developing a masterplan. Additionally, the design scale of the DSF within the NbS model can be adjusted to accommodate different needs.

Keywords: Nature-based solutions, coastal protection, decision support framework

Harnessing Extremely Thermophilic Bacteria to Solve the World's Energy and Environmental Challenges

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Abstract:
In her 2017 collection Quickening Fields, American poet Pattiann Rogers celebrates the wonderment of extremophilic microorganisms, who have "confronted sulfuric boiling black sea bottoms and stayed," and described them as "more mysterious than resurrection, too minimal for death." Within nature's harshest crucibles, extremophiles have evolved a diversity of physiological traits crucial to the renewable energy transition. Extremely thermophilic bacteria, such as Caldicellulosiruptor species (optimal growth at 75 °C), have not only adapted to high temperature environments, but also the ability to degrade and convert biomass from crop residue and agricultural waste into everyday renewable fuels (ethanol, isobutanol) and chemicals (acetone, 2,3-butanediol). Unlike conventional industrial microbes such as baker's yeast, Caldicellulosiruptor species degrade biomass more efficiently and without costly pre-treatment. However, we still know remarkably little about their highly specialized sugar transport mechanisms, or how their internal metabolic pathways can be rewired for synergistic relationships with other microbes. At Princeton University's Department of Chemical & Biological Engineering, our highly interdisciplinary team combines traditional bacterial genetics and metabolic engineering, with modern breakthroughs in machine learning and structural biology, to advance the development of Caldicellulosiruptor species as industrial workhorses for sustainable biomass conversion. Our efforts have elucidated the structural, biophysical, and genetic facets to sugar transport in Caldicellulosiruptor species, expanding opportunities for metabolic pathway engineering. We will also discuss ongoing efforts to better distribute metabolic burden across synthetic Caldicellulosiruptor communities for efficient consolidated bioprocessing of lignocellulose, and develop standardized protocols on high-throughput genetic manipulation of Caldicellulosiruptor species for bioengineers worldwide. Ground zero for climate change-driven extreme heat and rising sea levels, Indonesia must access energy solutions that reconcile sustainability with economic progress. By advancing our fundamental understanding of extremophiles like Caldicellulosiruptor species, we can leverage these microorganisms for efficient biomass-to-fuel and chemical conversion – replacing petroleum-based supply chains and building a more sustainable future.

Keywords: Extremophiles, biomass conversion, metabolic engineering

Harnessing Low-Carbon Hydrogen: National Strategies and Entrepreneurial Opportunities for Equal Energy Access and Lower Environmental Impact

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Abstract:
The urgency of an energy transition in Indonesia is evident due to increasing fossil energy consumption driven by population growth and industrial development. Fossil fuels like oil and coal contribute significantly to greenhouse gas emissions and environmental pollution, with the largest sources of CO2 emissions being exhaust gases from industrial processes and motor vehicles. Indonesia aims to achieve an energy mix of 23% from New and Renewable Energy (NRE) by 2025. Among the promising alternatives, the hydrogen value chain stands out for its potential to reduce greenhouse gas emissions, lower environmental impact, and facilitate a sustainable energy solution. However, the development of green hydrogen technology in Indonesia faces challenges, particularly high production costs. Commercial and Social entrepreneurship plays a crucial role in addressing these challenges by integrating socio-economic actors to devise and implement innovative energy solutions that promote energy equality and accessibility. Energy Investment Management BV developed the Energy Transition Entrepreneurship and Innovations Program with the following three development areas: Business Portfolio Strategy, Business Development Accelerators, and In-depth understanding of regional circumstances. The Indonesian Energy Innovation Challenge 2024 exemplifies this effort, providing a platform for entrepreneurs and students to share ideas, form new connections, and initiate collaborations. Using a descriptive qualitative methodology, this study analyzes the role of commercial and social entrepreneurship in facilitating the transition from fossil fuel economies to hydrogen economies. Key findings highlight the importance of support from the primary sectors of each country and emphasize the role of socially conscious entrepreneurship as a driver of sustainable energy innovation.

Keywords: Energy transition, hydrogen value chain, renewable energy, social entrepreneurship, sustainability, green hydrogen technology, environmental impact, energy equality, Indonesia energy transition, innovation challenge

Mobilizing Youth Expertise: A Crowdsourcing Model for Accelerating Sustainable Development Goals in Indonesia

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Abstract:
This paper explores a crowdsourcing model to engage Indonesian youth in accelerating the Sustainable Development Goals (SDGs) by 2030. With over 20% of Indonesia's population aged 15 to 24, youth represent a crucial yet underutilized resource for sustainability efforts. However, barriers such as limited access to information, educational gaps, and a lack of formal recognition hinder their participation. The proposed crowdsourcing model connects young people with SDG challenges from NGOs, private companies, and the government. This approach fosters inclusivity, representation, and empowerment by allowing youth to apply their skills to specific tasks. Upon completing these challenges, participants receive credentials, certificates, or badges, validating their contributions and improving future employment prospects. Current youth participation in SDG activities is notably low, with only 18.52% of surveyed respondents involved. Educational institutions play a significant role in facilitating participation, while social media remains underused. The study emphasizes that offering accessible information and tangible incentives, such as financial rewards and formal recognition, could enhance youth involvement. The crowdsourcing model presents a promising solution to accelerate Indonesia's SDG progress, empowering young people through structured opportunities and fostering collaboration across sectors to address sustainability challenges effectively.

Keywords: Youth engagamenet, sustainable development goals, crowdsourcing model, empowerment and inclusivity

Net Electricity Load Forecasting in Households with D-PV: A systemic review

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Abstract:
The energy transition is inevitable, with solar energy emerging as a promising renewable source due to falling PV panel prices. In Australia, installed PV capacity now exceeds 30GW, three times the 2018 capacity. Most systems are installed behind-the-meter as a distributed PV (D-PV), causing forecasting challenges for grid operators as they only see the net load, which is the difference between the load and PV generation. Short-term forecasting is difficult due to uncertainties from customer behaviour and solar intermittency. Long-term planning is also challenging with increased solar penetration causing issues like minimum and negative demand. Hence, net load forecasting research has significantly increased in the past five years. Existing literature reveals two categories of net load forecasting models: statistical and machine learning. Despite the introduction of various novel models, there are various issues in the research. First, model robustness is questionable as 70% of studies use non-public datasets, 60% evaluate only on one dataset, and less than 41% compare their models against a benchmark. Second, forecast criteria beyond accuracy, including model interpretability and computational cost, are not considered. Third, over 90% of studies focus on short-term forecasting, leaving room for exploration in mid and long-term forecasting. Lastly, the financial impact of accurate net load forecasting, both short and long term, is yet to be analyzed. In conclusion, despite the rise of D-PV penetration leading to an emerging field in net load forecasting, challenges remain in model robustness, forecast criteria, mid and long-term forecasting, and financial assessment.

Keywords: Net load forecasting, distributed PV, energy transition, machine learning models

Policy Recommendations for Energy Transition in the Draft Law on New and Renewable Energy and the National Energy Policy

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Abstract:
Democratization of Energy Access to Quality Energy Beyond Electrification Ratios. The calculation of basic energy needs in Indonesia still uses a binary approach, focusing only on the presence or absence of electrical connections, measured by electrification ratios or LPG distribution networks. Indonesia's electrification ratio reached 99.78% in 2023, but quality is uneven. The NZmates 2021 report emphasizes the importance of providing energy access in identifying technical and economic potential, involving local governments in preparing Regional Energy General Plans (RUED). By June 2023, 30 out of 34 provinces had established RUED. To facilitate quality energy access, RUED should support regions in achieving national electrification and renewable energy targets. The Indonesian government can adopt the multi-tier framework (MTF) by the World Bank and Energy Sector Management Assistance Program (ESMAP), avoiding biases from simple electrification ratios. For instance, areas like NTB and NTT are still at tiers 1 and 2, unlike Java and other major cities at tier 5. Decentralized energy principles using renewable sources can enhance quality energy access, promoting development and equality across Indonesia.rnrn2. Incentives and Ease of Installing Rooftop Solar PV. Surveys by IESR in Jabodetabek, Bali, Central Java, and Surabaya show interest in rooftop solar PV due to affordability, eco-friendliness, and ease of maintenance. Regulation No. 26/2021 increased net-metering for rooftop solar PV to 100%. However, incentives were removed by Regulation No. 2/2024. The government can reinstate export-import schemes, reintroduce the Sustainable Energy Fund (SEF), and integrate installation requests without biannual limits.rnrn3. Accessible and Attractive Renewable Energy Financing. Renewable energy adoption faces high initial costs compared to PLN electricity or gas refills. Learning from countries like China and Vietnam, Indonesia can implement financing schemes like Feed-in Tariff (FiT) and Renewable Purchase Obligation (RPO). Additional measures include unsecured loans for solar PV or biogas, lease-purchase schemes from EPC companies, or cooperative funding for biodigesters.rnrn4. Regional-Based Renewable Energy Development. With a renewable energy potential of 3,692 GW, Indonesia's installed capacity is only 0.3%. Regulation No. 38/2016 targets electricity provision for underserved areas using renewables. However, its implementation is weak. The government should strengthen regulations, using incentives and penalties, to promote renewable energy in each region, leveraging local potentials to meet regional and national energy needs. These recommendations by the Coalition for a Clean Energy Transition (KIBE) 2050 advocate for comprehensive, localized strategies to enhance energy democratization, provide incentives for solar energy, facilitate renewable energy financing, and promote regional renewable energy development, ensuring a sustainable and equitable energy transition for Indonesia.

Keywords: Energy democratization, renewable energy development, rooftop solar PV, energy financing

Process Modelling and Sensitivity Studies for Integrated Carbon Capture and Conversion with Ionic Liquids

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Abstract:
Closing the industrial carbon cycle is an economically and environmentally attractive solution to decarbonize industrial production. In this context, CO_2 captured from industrial point sources is used as a C1 feedstock and converted to value-added chemicals and fuels. However, the energy penalties associated with the conditioning of CO_2 in conventional, sequential capture and conversion (CCC) processes remain a technological and economical barrier to large-scale deployment. The key innovation of integrated carbon and conversion (ICCC) processes is thus a process intensification approach, whereby the separation of CO_2 from the capture medium is eliminated, lowering the capital and energy intensity of these. Instead, the conversion to a value-added chemical occurs in the capture medium itself, presenting important advantages where the heat of reaction can (partially) offset the heat required for CO_2 separation while CO_2 conversion occurs in the condensed (typically liquid) phase. Motivated by the above, we propose a mathematical modelling and sensitivity study with respect to key material properties for ICCC. In this prototype process, CO_2 is chemically absorbed using aprotic heterocyclic anion ionic liquid solvents (AHA ILs), which were selected due to their superior material properties such as low heat of absorption, improved thermal stability, nonvolatility, and low viscosity of the solvent. Once captured, CO_2 is converted into methanol via a thermocatalytic hydrogenation reaction. Our results indicate that the total duty decreases by 50 % as the reaction approaches complete conversion while holding CO_2 removal constant at 90 %. Our results also point to a massive increase in energy use (by 140 %) when the CO_2 removal rate changes from 90 % to 99 % while holding CO_2 conversion constant at a steady 80 %. We explain these phenomena by considering trade-offs between heating rates and material flow rates (and the associated need to recycle material).

Keywords: Carbon cycle integration, CO_2 capture and conversion, ionic liquid solvents, methanol production

Real Time Control Storage in Constructed Wetland for Sustainability Agricultural Wetland Farming in Indonesia

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Agricultural wetland farming, particularly rice cultivation in paddy fields, is essential for food security in Indonesia as a staple for over 80% of the population. However, sustainability remains a challenge in balancing agricultural development with infrastructure and technology. These factors contribute to low productivity and environmental degradation, specifically wastewater and water scarcity. Wastewater from agricultural wetland farming must be treated to reduce environmental, human health and economic impacts. Constructed wetlands (CWs) have proven to be an advanced, economical, and low-maintenance wastewater treatment solution. CWs utilize natural processes involving wetland vegetation, soil, and microbial communities to improve water quality. Beside improving water quality, CWs detention basin storage can be used as an alternative water source during the dry season and be able to accommodate rainwater to increase water supplies. To avoid water overflow from the reservoir, Real-Time Control (RTC) technology can be applied to the reservoir in the CWs system. The RTC will regulate the outflow from the storage facility in real-time during the intake process. This system can effectively reduce peak flow rates to prevent flooding, and has the potential to reduce peak flows by up to 48% during significant runoff events, such as a 1-in-100-year rainfall event lasting 24 hours. The RTC system can also be set so that it does not actively operate during the inflow phase, so as to ensure that the reservoir is fully filled before releasing water to the outlet. This research aims to utilize constructed wetlands to collect rainwater and agricultural wetland farming wastewater, then recycle it using natural materials. Storage systems with RTC technology, can prevent flooding in the area and reduce water scarcity in drought conditions. This method increases the efficiency of water management and promotes sustainable agricultural wetland farming practices.

Keywords: Indonesia, sustainability agricultural, constructed wetlands, RTC storage, wastewater, water Scarcity

The Implementation of Time of Use for Electricity Customers from The Residential to Industrial Sectors in Indonesia

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Abstract:
The undistributed load and surplus-deficit trade-off load in Indonesia are some concerns in Indonesia's energy transition process. Moreover, these issues affect the national economic growth and energy security both short and long term. Thus, new regulations are required to provide affordable and equal electricity for customers and better profit for providers (PLN and IPPs) in improving electricity quality. The strategies are measured on citizens' ability to use, pay, and act in electricity usage to do several energy efficiencies and solutions that will improve their awareness of using electricity. The Ministry of Energy and Mineral Resources (MEMR) and its stakeholders have a big role in controlling electricity conditions. My recommendation is to Implement Time of Use (ToU) mechanism for customers from the residential to commercial and industrial sectors; this implementation will greatly affect the electricity supply costs (BPP) that need to be issued by PLN (State Electricity Company in Indonesia) and give a clear evident for customers frequently on their electricity usage, removing distrust between PLN and customers. The first alternative option which is in line with the implementation of ToU is to apply electricity cost in Indonesia based on area, leading to electricity justice in Indonesia, this rational solution can help the government to give access to electricity based on the social and economic conditions in Indonesia which are complex. The second alternative is creating a serious plan of decentralized power system based on province, to ensure that each region that has a deficiency could get a guarantee for the accessibility of energy security for their development growth.

Keywords: Energy transition, time of use, electricity justice, decentralized power system, energy security

Tidal Current Energy in Indonesian Waters: List of Potential Sites, Sunda Strait Case Study, and a Synthesize for General Characterization

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Abstract:
Tidal energy has the potential to contribute in diversifying Indonesia's energy mix from the regional to even national levels, helping the nation achieve the 2060 net zero emission target. This research presents a summary of tidal energy potential sites across the Indonesian archipelago, compiled from previous measurement and modelling efforts and also from non-conventional literature. The sites are then classified based on their locations, tidal characteristics, and geographic setting. This research is also followed with a numerical modelling work, with Sunda Strait (a body of water connecting Java and Sumatra) taken as a study case. The ocean hydrodynamics modelling was conducted with aims i) to estimate the available tidal current energy resources and ii) to examine the potential impact of hypothetical tidal turbine farms on the ambient hydrodynamics and the available resources. Further, through a comparative analysis, the modelling results are then used to synthesize the tidal current patterns and the power extraction impacts at several sites in Indonesia. Overall, this research provides additional insight into Indonesia's tidal energy characteristics from the ocean hydrodynamics perspective.

Keywords: Tidal energy, ocean hydrodynamics, energy transition, numerical modelling

Towards Net-Zero Indonesia: Clean Nickel Production

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Abstract:
Nickel is a critical metal for the energy transition. Half of all nickel ore mining and processing globally takes place in Indonesia today. In the last decade, Indonesian nickel production soared more than four times to two million tonnes per annum. With some 9 GW of coal power plants built primarily to power this growth, Indonesia's nickel production is carbon intensive. We are developing methods & modelling tools for assessing decarbonization scenarios and costs for nickel facilities, using Indonesia's Obi Island as a case study. Our work includes (1) estimation of facility-level CO_2 emissions, (2) integration of CO_2 capture and storage (CCS), biomass utilization, and/or renewable power generation with nickel facilities, (3) evaluation of capital investments needed, (4) assessment of coal power assets that could be stranded, (5) estimating the costs of clean nickel production, and (6) estimating industry-specific carbon abatement cost. We found that biomass and CCS are key enablers for net-zero nickel production in Obi Island which could double nickel production cost. Capital investments for 7% to 100% decarbonization are between 0.3 and 1.9 billion USD. Future work is planned to expand the analysis to all of Indonesia's nickel production.

Keywords: Nickel decarbonization, carbon capture and storage, sustainable mining, biomass utilization

Utilizing Waste to Energy Plant Systems to Advanced Circular Economy in Bekasi, Indonesia

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Abstract:
Bekasi is a highly dense city, with a lot of solid waste being generated per day, resulting in problems managing it. Thus, innovation must be made to solve these problems. One way to do it is by reducing the amount of waste in TPA and processing MSW through incineration, pyrolysis, gasification, and so on, then turning it into a valuable commodity such as generating electricity and vitrified slag (which can be used in construction). These commodities can be utilized to earn profit for the operation of the Waste to Energy Plant itself and have the potential to boost the local economy by using a circular economy model. This research prioritizes the processing of the waste, so it does not decrease the quality of its surrounding environment. The profit from the commodity of waste is a secondary priority. In other words, this research is an endeavour to find a sustainable solution to solving MSW problems through a holistic approach combining multiple disciplines such as environmental engineering, environmental science, economy, and social studies.

Keywords: Waste-to-energy, municipal solid waste, circular economy, sustainable waste management