



Table of content

Abstract	ix
Kurzfassung	xi
List of illustrations	xiii
List of tables	xv
Part A Theoretical work foundation	1
1 Motivation	3
1.1 Energy system decarbonization	4
1.2 The operational flexibility challenge	5
1.3 Liberalized market environment	9
1.4 Research question	12
2 State-of-the-art methodologies and research gap	14
2.1 Flexibility in the literature - a review of assessment methodologies	14
2.2 Specification of the solution approach	23
2.3 Research gap and contributions	26
3 Unit commitment for product valuation	28
3.1 A map of the unit commitment world	28
3.2 Best suited unit commitment problem for the assessment of individual power plant's operational flexibility	29
3.3 Planning and scheduling, a vast world of approaches	30
4 Part conclusion	34
Part B Methods and concept development	35
1 On the importance of the power plant model	37
1.1 Flexibility parameters	39
1.2 The optimization problem formulation	45
1.3 Sensitivity of the optimal dispatch to the power plant description	46



1.4	Section conclusion.....	50
2	Event-based optimization	51
2.1	Theory	51
2.2	Model validation and valuation	60
2.3	Implementation	66
2.4	Section conclusion	68
3	Assessing flexibility incentives in interdependent markets	70
3.1	Markets incentivizing operational flexibility	71
3.2	Frequency control capacity reservation - an opportunity costs approach	73
3.3	Quantitative assessment of arbitrage opportunities in the intraday market	83
3.4	Combined heat and power plants	87
3.5	Market-dependent value of flexibility improvements.....	90
3.6	Section conclusion	92
4	Applicability of the study assumptions	94
4.1	Merchant plant operating in forward and spot markets	94
4.2	Power plant technical description	96
4.3	Intraday lead time	97
4.4	Fleet effects.....	97
4.5	Stochasticity	98
4.6	Section conclusion	98
5	Part conclusion	100
Part C	Case studies	101
1	Introduction	103
2	Case study catalog	105
2.1	Power plant selection	105
2.2	Operational flexibility options.....	111



2.3 Country and market selection	114
3 Case study results	121
3.1 Market analysis.....	121
3.2 Operational flexibility retrofits	140
3.3 Answering the research questions.....	156
4 Conclusion and outlook	161
Appendix: Power plant description	167
References	175