Technical University of Denmark

DTU

Flex4RES

Flexibility for Variable Renewable Energy Integration in the Nordic Energy System

Nordic Energy Research Flagship project
September 2015 - March 2019

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DTU Management Engineering
Systems Analysis Division

NEF Flagship project, NER 21 September 2015

DTU Management Engineering
Department of Management Engineering

Project summary

Integrating a high share of variable renewable energy through enhanced energy market interaction

The Flex4RES project investigates **how an intensified interaction between coupled energy markets, supported by coherent regulatory frameworks, can facilitate the integration of variable renewable energy (VRE)** in turn ensuring stable, sustainable and cost-efficient Nordic energy systems.

Through a holistic system approach based on coupled energy markets, we **identify potentials, costs and benefits of achieving flexibility** in the Nordic power market created by the heat, gas and transport sectors as well as by power transmission and production.

We **develop coherent regulatory frameworks and market designs** that facilitate market interactions, which are optimal for the Nordic conditions in an EU context.

Objectives

The primary objective of Flex4RES is to

> **Identify and assess regulatory and technical pathways towards coherent Nordic energy systems** in 2050 based on strong interaction between different energy markets that ensure resilience, sustainability and efficiency.

The secondary objectives are to:

a) **Estimate the potentials and costs of flexibility** in the Nordic power market created by the coupling of and increased interaction between different energy markets (electricity, heat, gas and transportation). Estimate the need for flexibility in the future Nordic power market.

b) **Identify regulatory and technological barriers** to intensified market interaction. Develop coherent regulatory frameworks and market designs that facilitate energy market couplings that are optimal for the Nordic conditions in an EU context.

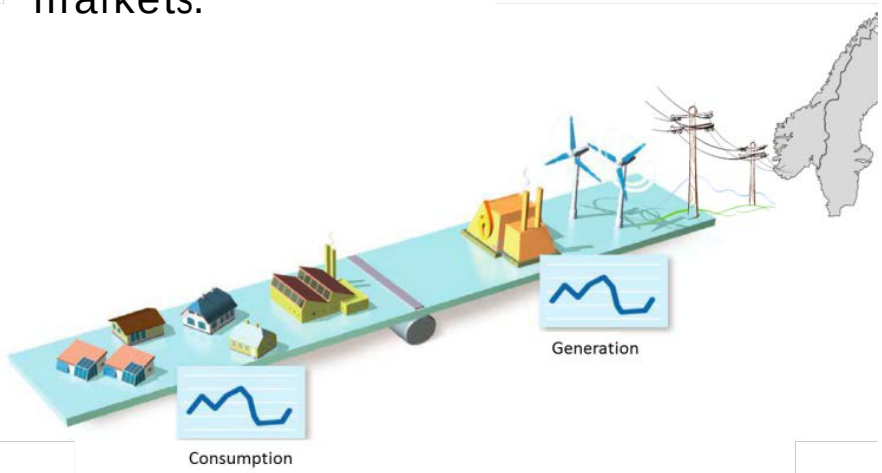
c) **Adapt a high-resolution Nordic energy market model** covering heat, power and transport for quantification of the impacts of different market couplings, regulatory frameworks and market designs. **Estimate the cost and benefits** of a coherent energy system framework.

Hypotheses

There is a **comparative advantage of combining different energy markets**, both with respect to flexibility, but also with respect to synergy and economics.

The Nordic power market is well functioning despite a few technical challenges. **With the right coupling to the underlying national and local energy markets for heat, gas, and transport fuels, enough flexibility can be generated** in a cost efficient way and so embrace a larger amount of VRE.

The project has a holistic system approach to the Nordic Energy system with **flexibility obtained across energy markets** with respect to flexibility at the power markets.



Analytical and practical approach

Flex4NES develops a **robust method of defining the flexibility potentials** in order to compare potentials from different energy sectors. Flexibility potential cost curves are estimated via data collections in the various Nordic countries and energy sectors. The outcome is a technology catalogue for flexibility potentials and costs in the Nordic countries.

The **need for flexibility** is estimated via the CorWind model (DTU Wind) that simulates wind and PV variability.

The needed **changes in regulatory frameworks to obtain the flexibility** of coherent Nordic markets are analysed via regulatory economics.

Together with the flexibility potential cost curves this is **analysed via the energy system modelling tool Balmorel**. The model is open source and is already used widely within the Nordic and Baltic countries and by several Flex4RES partners. E.g. Balmorel is used in the NETP (Nordic Energy Technology Perspectives 2016) project. Flex4RES builds on the findings and recommendation found in previous projects and the model is adapted further in-depth in order to cover heat, power, and transport for quantification of the **impacts of different market couplings, regulatory frameworks and market designs**.

Finally, the project sets up **regulatory and technical pathways** towards future stable, sustainable and cost-efficient Nordic energy systems with high shares of VRE.

The results of the project are **disseminated continuously** yearly, mid-term, and final in an interactive and dialog-based process with a broad range of stakeholders.

Work Packages

WP1: Flexibility need and potentials

Task 1.1 Review and Method development

Task 1.2 Flexibility potential cost curves, Technology catalogue

Task 1.3 Flexibility need, uncertainty and impact on reserve need

WP2: Framework conditions

Task 2.1 Review of existing framework conditions

Task 2.2 The Nordic energy system designs

Task 2.3 Market integration, frameworks, and market designs

Task 2.4 Coherent market scenario set-ups

Task 2.5 Pathways to a flexible Nordic energy system

WP3: Energy system analysis of integrating energy systems

Task 3.1 Model update / adaption

Task 3.2 Market coupling analyses

Task 3.3 Analytical results: comparison and interpretation

WP 4: Policy recommendations

Task 4.1 Economic impact of VRE and flexibility

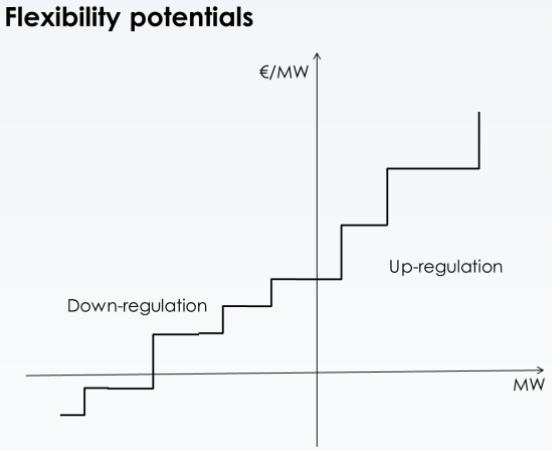
Task 4.2 Creating a sustainable and stable Nordic energy System

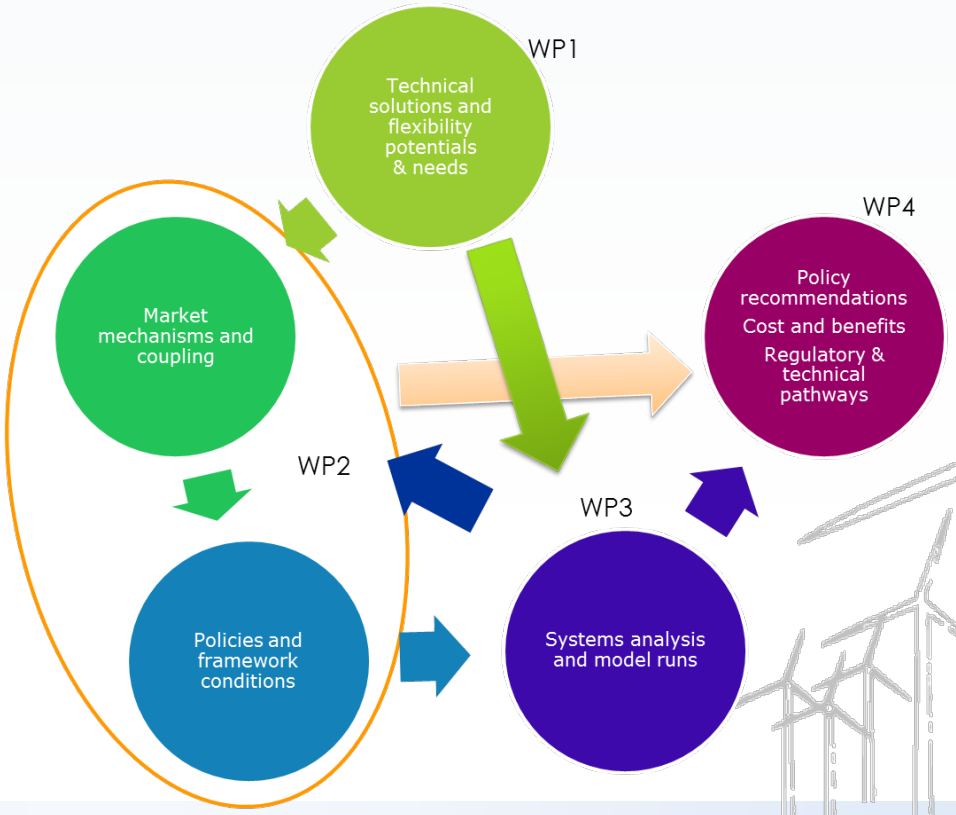
WP 5: Dissemination and capacity building

Task 5.1 Website, LinkedIn, and Newsletter

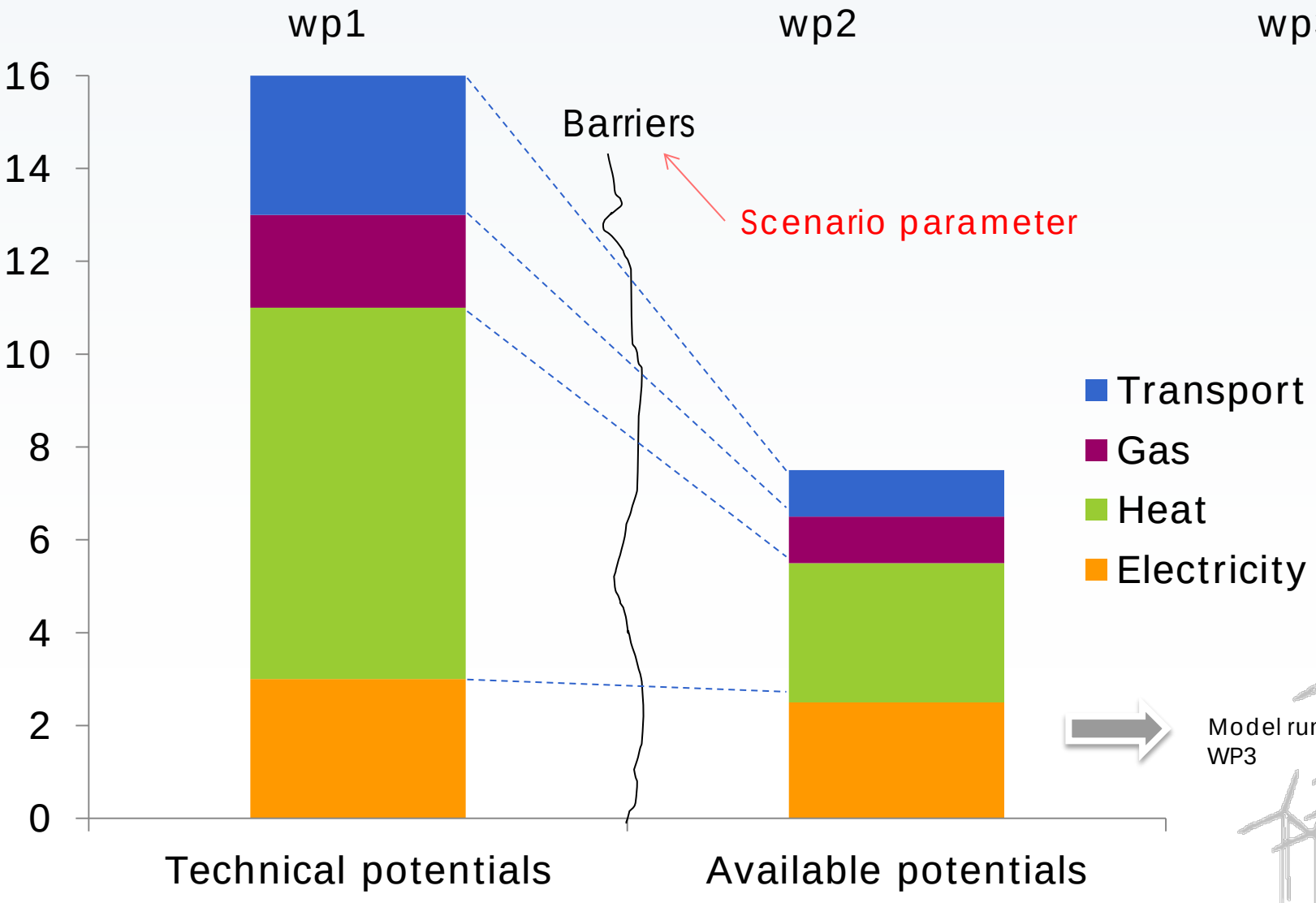
Task 5.2 Advisory board meetings

Task 5.3 Workshops/Seminars

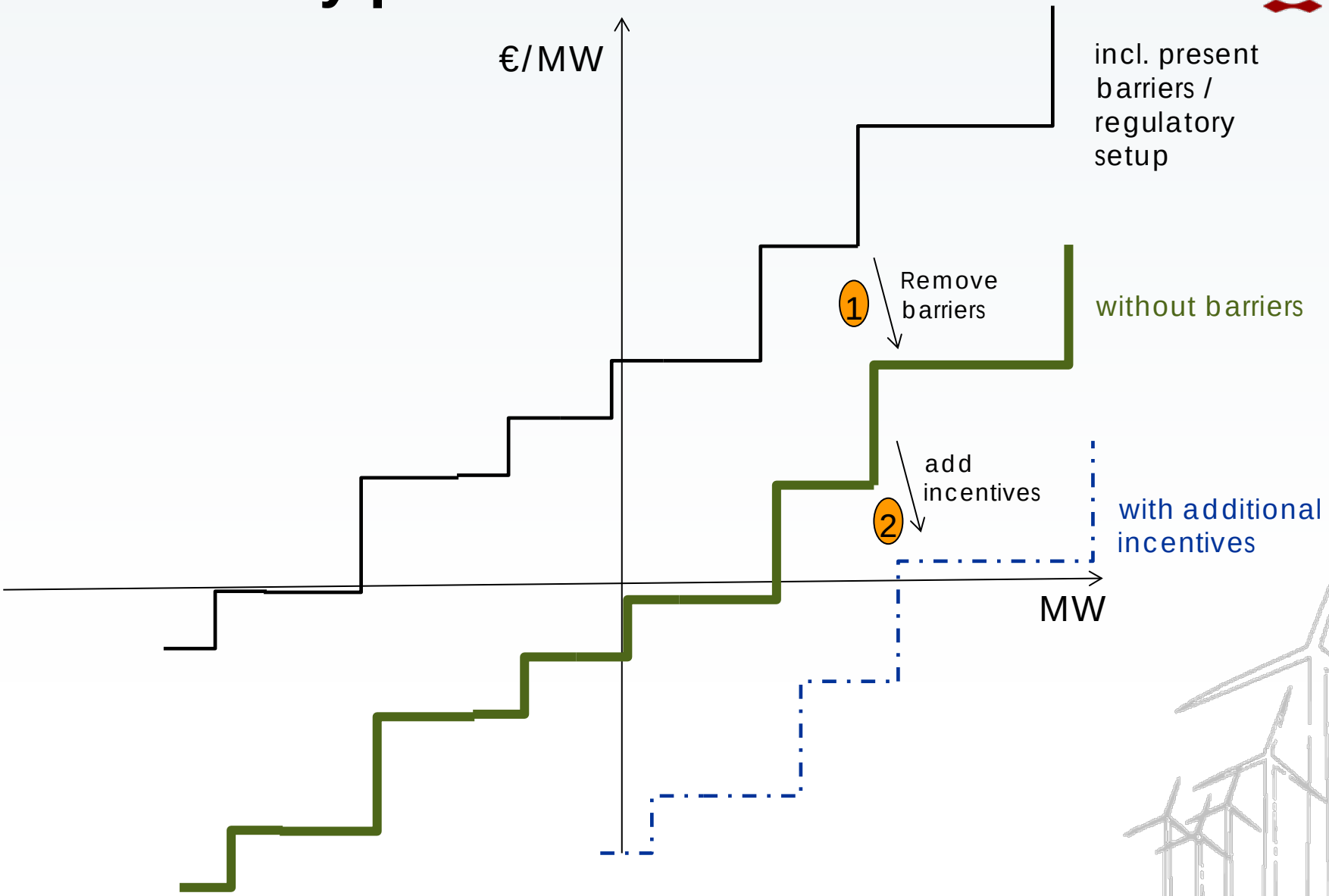




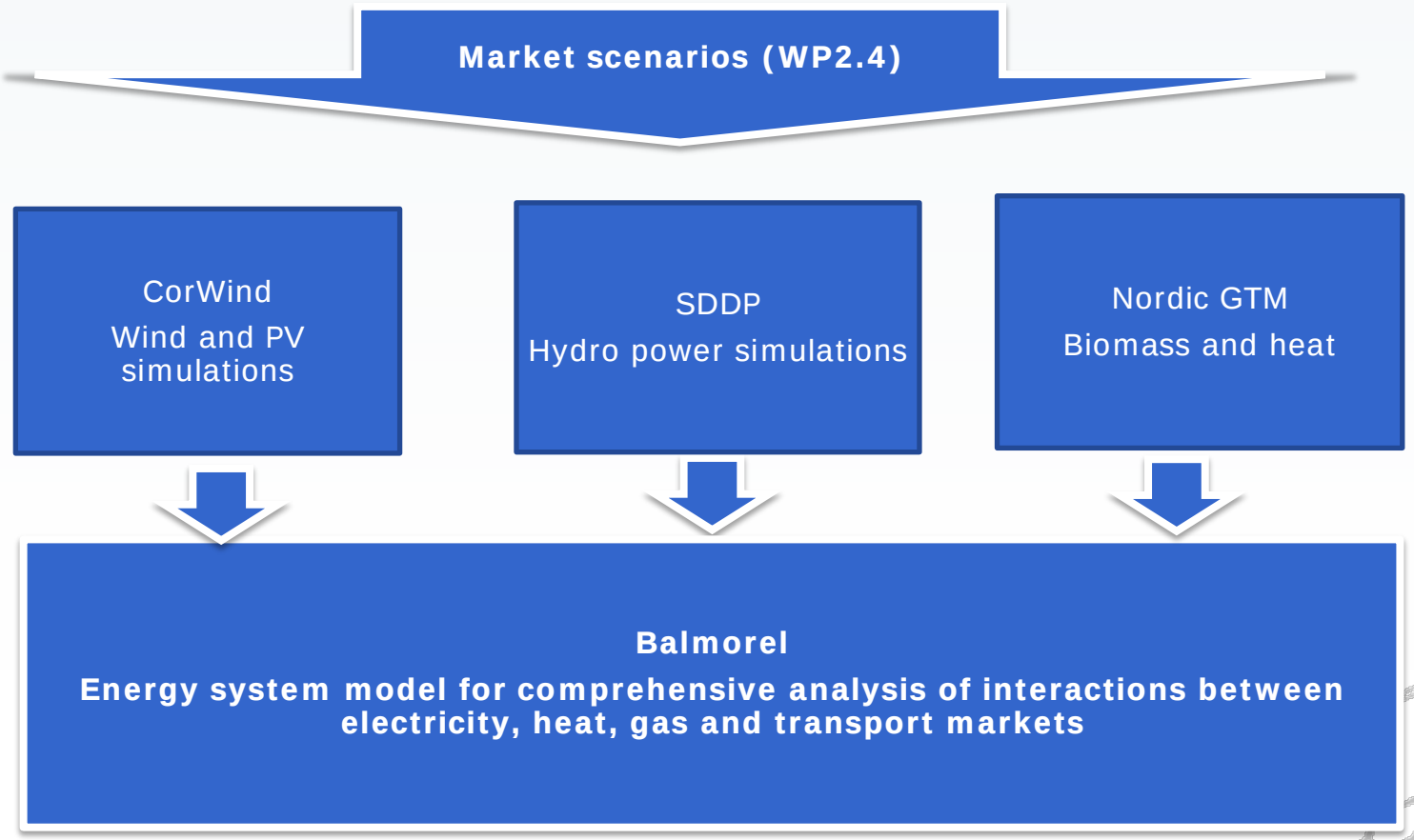
From technical to available potentials



Flexibility potentials



Model set-up


Market scenarios (WP2.4)
CorWind
Wind and PV simulations
SDDP
Hydro power simulations
Nordic GTM
Biomass and heat
Balmorel
Energy system model for comprehensive analysis of interactions between electricity, heat, gas and transport markets

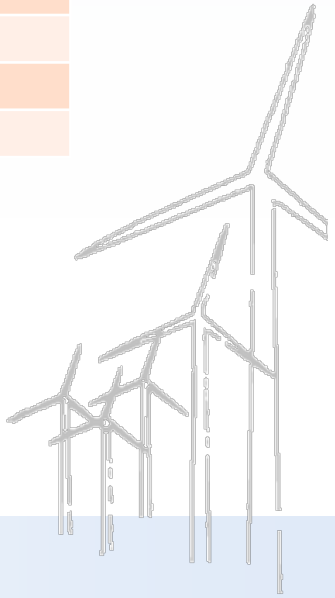
Research partners

Organisation / Institution	Country
DTU, Management Engineering, Systems Analysis	Denmark
NMBU, Institutt for Naturforvaltning	Norway
KTH, Electric Power Systems	Sweden
Aalto U, Applied Physics / New energy techn.	Finland
Riga Technical U, Energy Systems & Env	Latvia
DTU, Wind Energy	Denmark
RAM-løse edb, Hans Ravn / Balmorel.com	Denmark
NIFU	Norway
Stockholm School of Economics	Sweden
Tallinn University of Technology	Estonia

Advisory board - confirmed partners

Organisation	Country
NEPP / Energiforsk	SE
Statkraft	N
Statnett	N
Danish Energy Association	DK
DONG Energy	DK
Energinet.dk	DK
Energistyrelsen	DK
Dansk Fjernvarme, District Heating Ass	DK
Enova	N
AGORA Energiewende	D
Energimyndigheten, Swedish Energy Agency	SE
Cleen Ltd	FIN
Elering, TSO	EE
GASUM	FIN

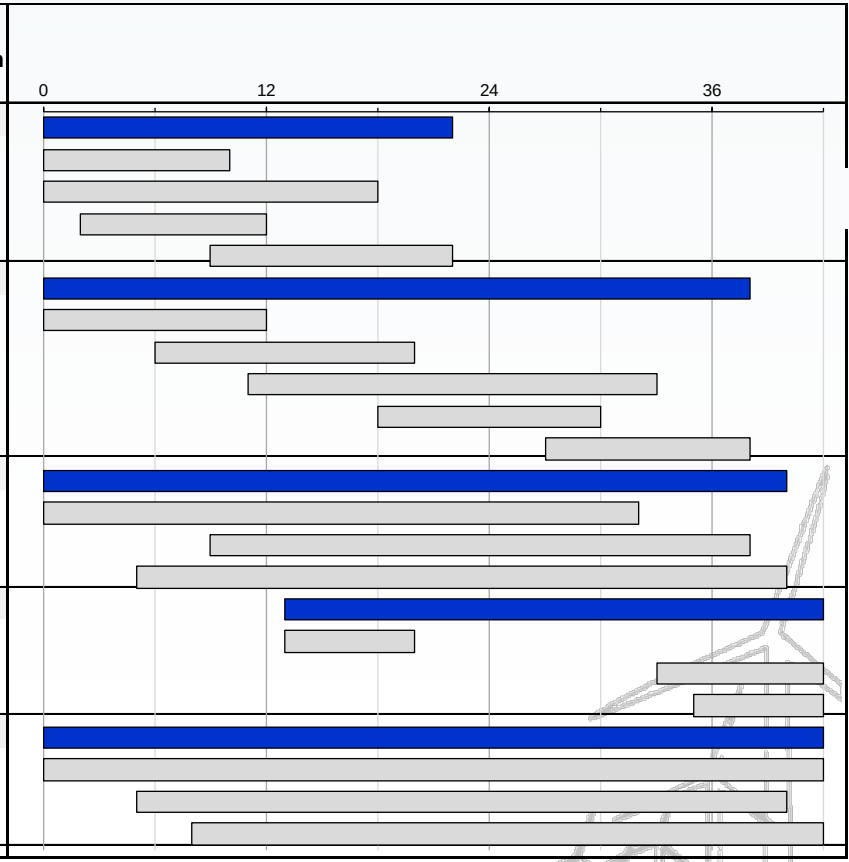
+ More partners to be confirmed in the start-up phase



Gantt chart

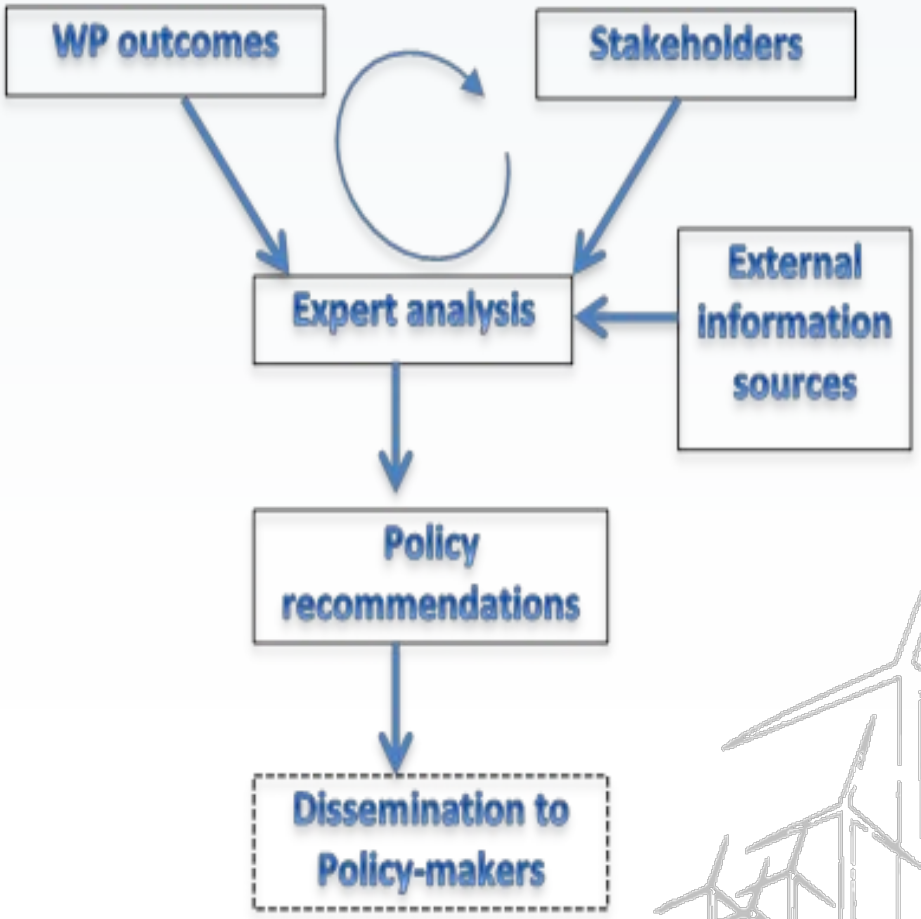
3,5 years - September 2015 - March 2019

WORK PACKAGES AND TASKS	Lead	Start month (beg. of)	End month (end of)
WP1 Flexibility need and potentials	**KTH**		
Task 1.1: Review and Method development	KTH	1	10
Task 1.2: Flexibility potential cost curves & Technology catalogue	RTU	1	18
Task 1.3: Flexibility need, uncertainty and impact on reserve need	DTU Wind	3	12
Task 1.4: From technical to realisable potentials	DTU MAN	10	22
WP2 Framework conditions	**DTU MAN**		
Task 2.1: Review of existing framework conditions	RTU	1	12
Task 2.2: Barriers for an intensified coupling	KTH	7	20
Task 2.3: Market integration, frameworks, and market designs	DTU MAN	12	33
Task 2.4: Coherent Market Scenario Set-Ups	NMBU	19	30
Task 2.5: Pathways to a Flexible Nordic Energy System	Aalto	28	38
WP3 Energy System Analysis of integrating energy systems	**NMBU**		
Task 3.1: Model update / adaption	NMBU	1	32
Task 3.2: Market Coupling Analyses	DTU MAN	10	38
Task 3.3: Analytical Results: Comparison and Interpretation	KTH	6	40
WP4 Policy recommendations	**Aalto**		
Task 4.1: Potentials of and Barrier for VRE and Flexibility		14	20
Task 4.2: Economic Impact of VRE and Flexibility		34	42
Task 4.3: Creating a Sustainable and Stable Nordic Energy System		36	42
WP5 Dissemination and capacity building	**DTU**		
Task 5.1: Website, LinkedIn, and Newsletter		1	42
Task 5.2: Advisory board meetings		6	40
Task 5.3: Workshops/Seminars		9	42

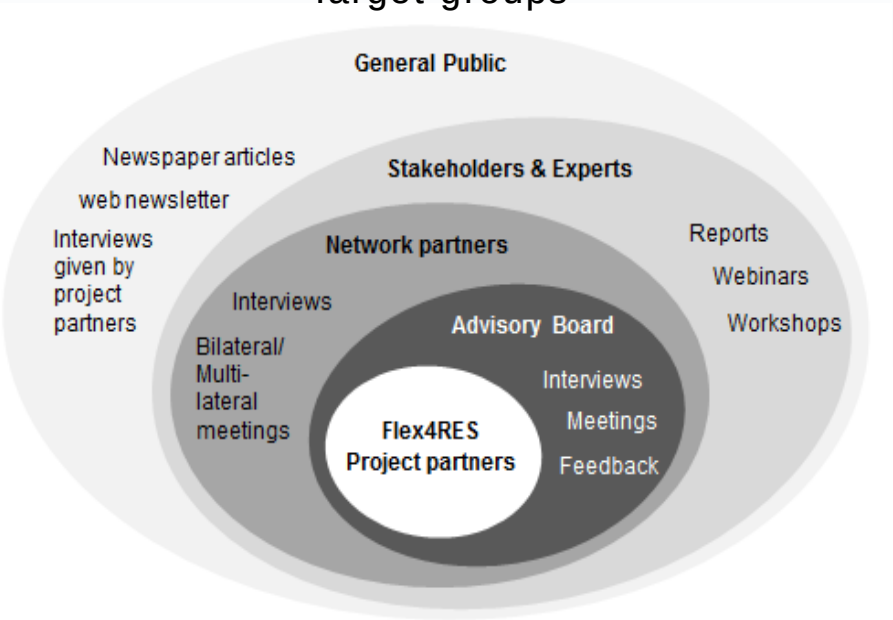


Stakeholder involvement & Dissemination

Science-policy approach involving key Nordic stakeholders



Target groups



Thank you for your interest

Questions ?

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