# Estonian long-term energy scenarios

Kick-off meeting

Tallinn, 4 December 2012

Ea Energy Analyses

# Agenda

1. Welcome and presentation of all participants
2. Background for the scenario project
   - Estonian long-term energy strategy
   - Current energy policy debate
3. Introduction to project (Ea)
   - Ea Energy Analyses
   - Introduction to scenario analyses
   - Balmorel and Stream
   - Case: Energy Policy Strategies of the Baltic Sea Region for the Post-Kyoto Period
4. Discussion of relevant scenarios
5. Next steps
   - Activities, deliveries and responsibilities
   - Interaction with expert groups

# Estonian long-term energy scenarios

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Ea Energy Analyses

Ea Energy Analyses

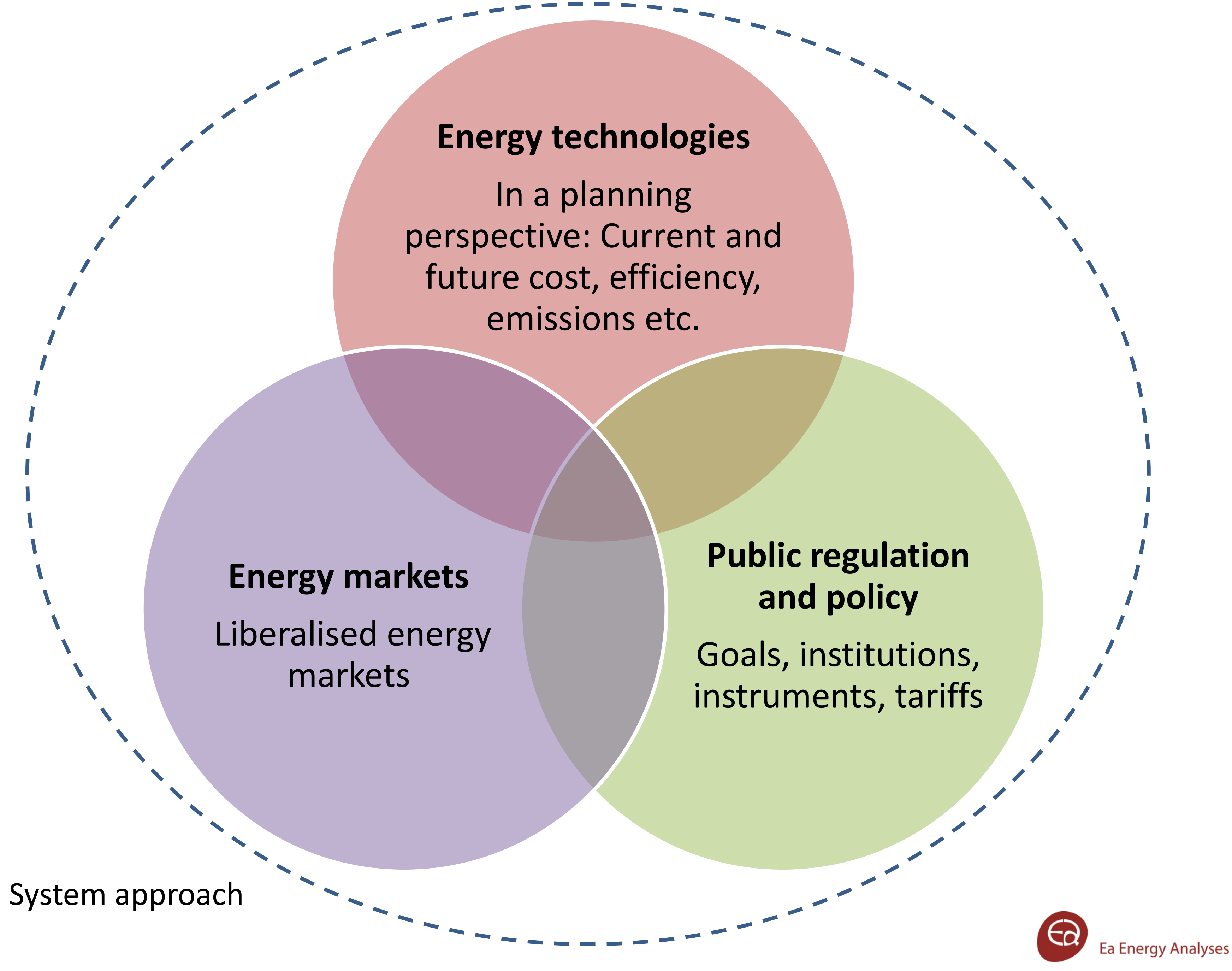
# EA ENERGY ANALYSES

# Ea Energy Analyses

- Started in 2005
  - With a background:
    - Elkraft (Transmission System Operator. Today: Energinet.dk)
    - Danish Energy Agency
    - Research
- 30 employees
- Customers (Danish and international)
  - Authorities
  - International organisations
  - Energy companies and trade organisations

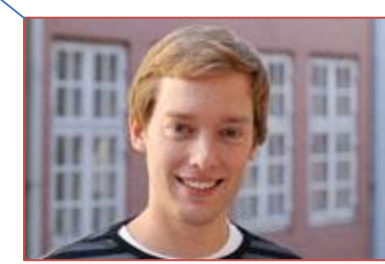
# Our profile

- Our products: Analyses of energy systems
  - Independent
    - Often with a societal perspective
  - High quality reports
    - Relevant, creative, critical, advanced methods if needed
  - See www.eaea.dk for reports in English
- We like to make a difference
  - Policy oriented
  - Future oriented (2020, 2030, 2050)
    - Consultant for Danish Commission for Climate Change Policy
  - Best possible interaction with stakeholders


Energy technologies
In a planning perspective: Current and future cost, efficiency, emissions etc.
Energy markets
Liberalised energy markets
Public regulation and policy
Goals, institutions, instruments, tariffs
System approach
Ea Energy Analyses





| Expert competences of relevance to the proposed project | Mikael Togeby (MT) | Kirsten Dyhr-Mikkelsen (KDM) | Anders Kofoed-Wiuff (AKW) | Jesper Werling (JW) | János Hethey (JH) | Anders Larsen (AL) |
|---|---|---|---|---|---|---|
| Design and analyses of scenarios | ● | | ● | ● | | |
| Model expert (Balmorel and STREAM) | | | ● | ● | ● | ● |
| Energy demand | ● | ● | | | | |
| Generation techniques | | | ● | ● | ● | ● |
| Transport | | | ● | | ● | |
| Electricity system, transmission lines | ● | | | ● | ● | ● |
| Stakeholder/expert consultations | ● | ● | ● | | | |
| Project management | ● | ● | | | | |

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# 2. BACKGROUND FOR PROJECT

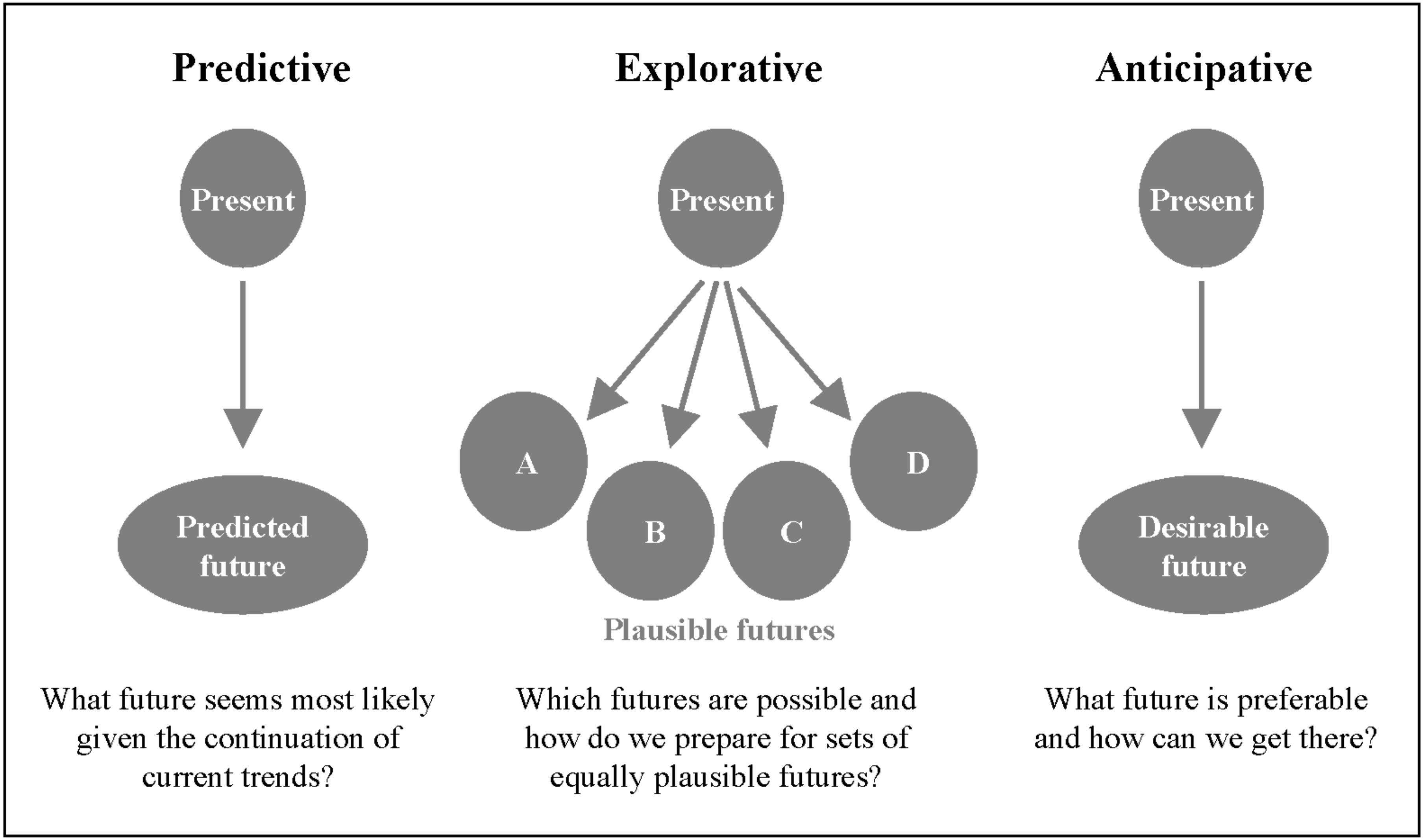
# 3. INTRODUCTION TO PROJECT

# Agenda

3. Introduction to project
   – What can scenarios be like?
   – Balmorel model
   – Stream model
   – Case: Energy Policy Strategies of the Baltic Sea Region for the Post-Kyoto Period
4. Design of Estonian long-term energy scenarios
5. Next steps

# SCENARIOS

# How to use scenarios?




- IEA reference scenario
- EU Commission reference

- Shell
- Energinet.dk (Danish system operator)

- EU energy road-map
- IEA 450 PPM scenario
- Danish Climate Change Commission

# Scenario analyses for long-term energy policy development

- Define part of the future
  - GDP, fuel prices, demand growth etc.
  - Nuclear, hydro
- Define options
  - Generation technologies (conventional; renewable), transmission capacity…
- Use models to compute consequences:
  - Costs, benefits, emissions and risk exposures of alternative pathways

Transparent objective

- Use of models:
  - Ensures that assumptions are consistent and quantifies impact
  - Results will often challenge preconceptions

# How to define scenarios?

- Focus on areas …
  - That are discussed
  - That are uncertain
- Make different scenarios exploring the selected areas
- Important with your input here!
  - Good examples?
    - Future $CO_2$ price?
    - Future for oil shale?
    - Natural gas infrastructure (LNG)?
    - Role of renewable energy?
    - Energy efficiency?

# Three types scenarios

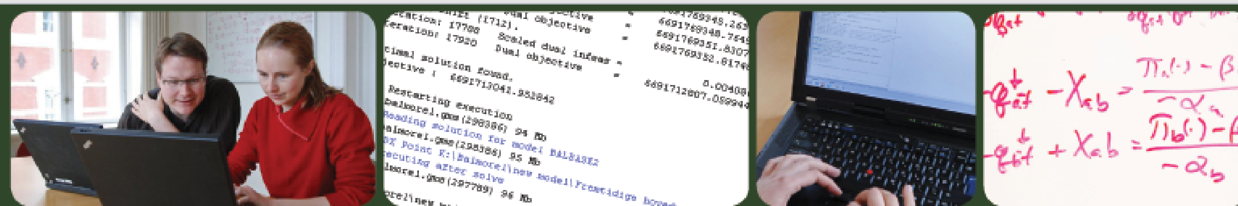
- Business-as-usual (BAU)
- Single-track-scenarios
  - High/low in selected areas
- Combination scenarios

# THE BALMOREL MODEL

balmorel.com

# Balmorel

*Energy system model*



Home

The Balmorel concept

Activities

Publications

Download model

Users

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## Balmorel

### What is Balmorel?

Balmorel is a model for analysing the electricity and combined heat and power sectors in an international perspective. It is highly versatile and may be applied for long range planning as well as shorter time operational analysis.

The model is developed in a model language, and the source code is readily available, thus providing complete documentation of the functionalities. Moreover, the user may modify the model according to specific requirements, making the model suited for any purpose within the focus parts of the energy system.

### What can Balmorel be used for?

The Balmorel model has been applied in projects in Denmark, Norway, Estonia, Latvia, Lithuania, Poland, Germany, Austria, Ghana, Mauritius, Canada and China. It has been used for analyses of, i.a., security of electricity supply, the role of flexible electricity demand, hydrogen technologies, wind power development, the role of natural gas, development of international electricity markets, market power, heat transmission and pricing, expansion of electricity transmission, international markets for green certificates and emission trading, electric vehicles in the energy system, environmental policy evaluation.

See Cases and Publictions for description of ongoing and past projects using the Balmorel model.

### Who can use Balmorel?

### News

- First international Balmorel User Group meeting - January 2011
- Balmorel course in January 2011
- Environmental alternatives for district heating in Aarhus
- Wind power in Estonia
- System Analyses of Compressed Air Energy Storage

# Balmorel

- Analysis for planning of power system development
  - Generation, transmission, electricity and heating demand
  - Overall optimisation of operation and investments
  - Public regulation

**Technical system development**

- New transmission lines
- New power plants
- New wind farms or solar power expansion
- Demand response

**Market and regulatory development**

- New tariffs, taxes, subsidies
- Market design
- Policy targets
  - $CO_2$-reduction goal
  - Goals for renewable energy
  - Phasing out nuclear

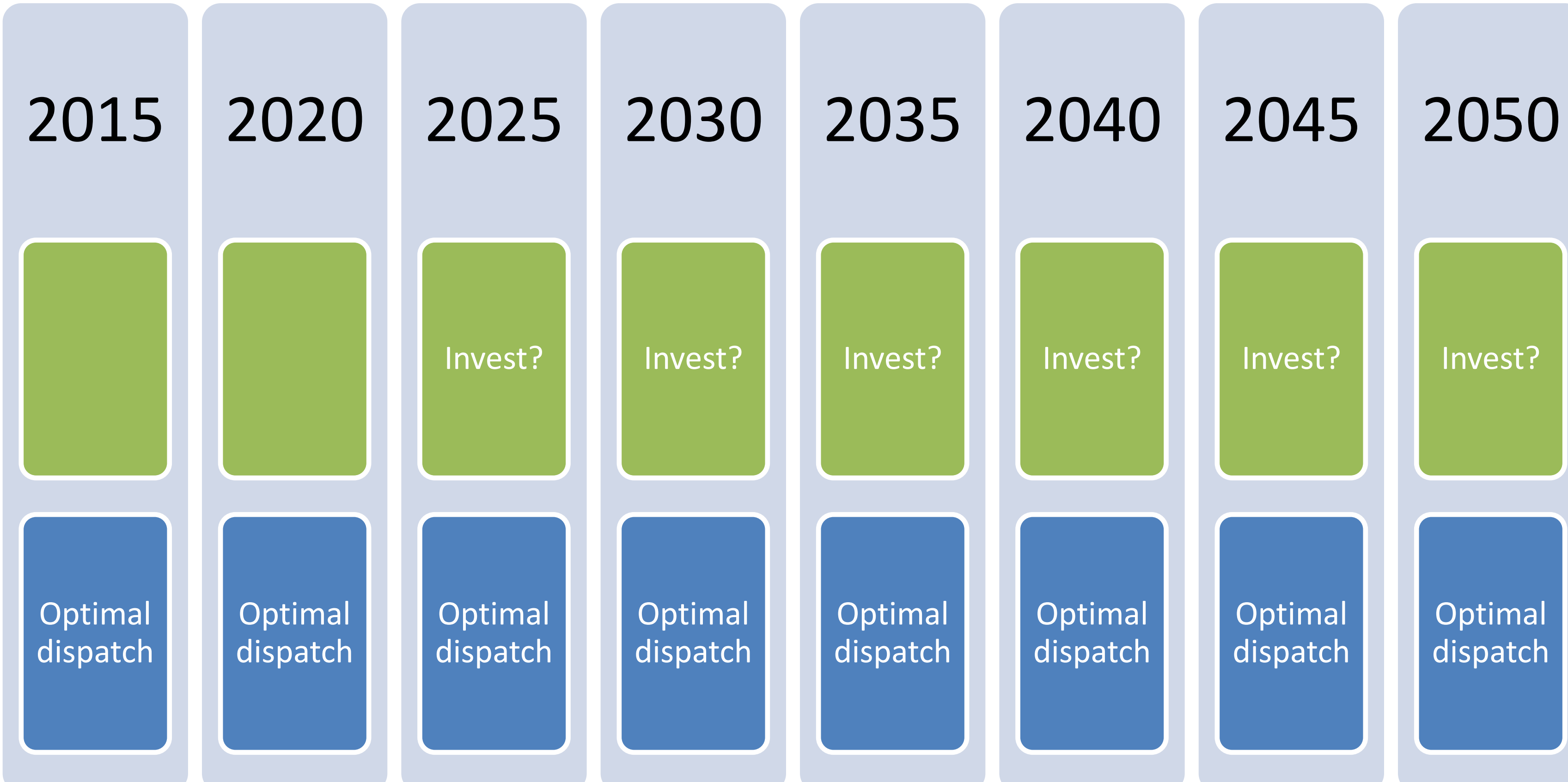
# Applications for the Balmorel model

- Market design analyses
- Policy implications/regulatory design
- Technical & economic
- Cost-benefit / feasibility
- Market/economic projections
- Operational simulation
- Scenario analyses

# Different modes of model use

- Operational perspective: Optimal dispatch
  - Defined fuel prices and defined system
    - Demand
    - Generation plants
    - Transmission capacity

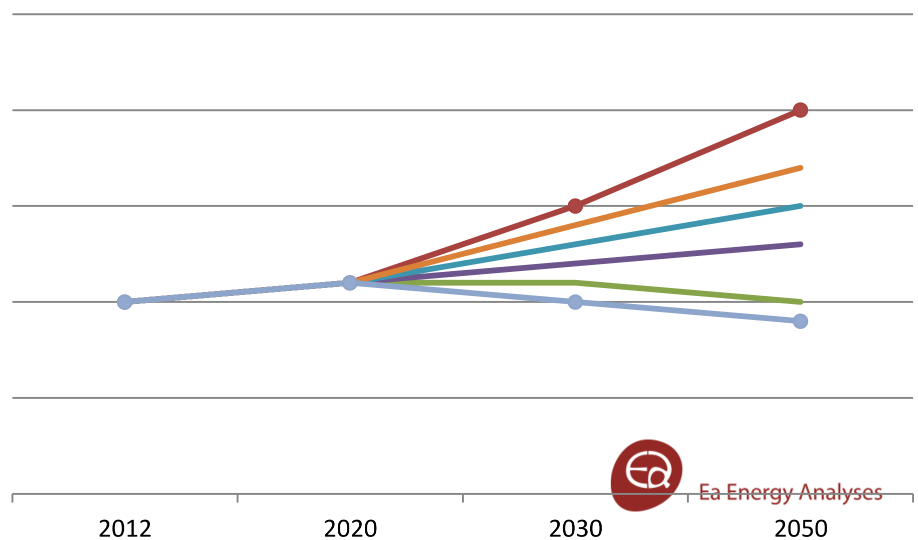
- Investment perspective: Model based investments
  - Generation
  - Transmission capacity
  - Based on catalogue of technologies




Investment in generation and transmission if profitable (use of technology catalogue)
Existing power plants produce if marginal price in lower than the price
Economic life time may be shorter than technical life time

# Balmorel results

- (2012-2020)-2030-2050
  - Computation for every five years
- Model based investments
  - Generation
  - Transmission and generation



# Input -> Results

- Input data
  - Demand for electricity and district heating
  - Fuel prices
  - Technology catalogue
    - Generation
    - Transmission
  - Fixed input
    - Nuclear
    - LNG

- Results
  - Investments
  - Operation
  - €
  - Prices (€/MWh)
  - Emissions
  - Import/export
  - Results per country

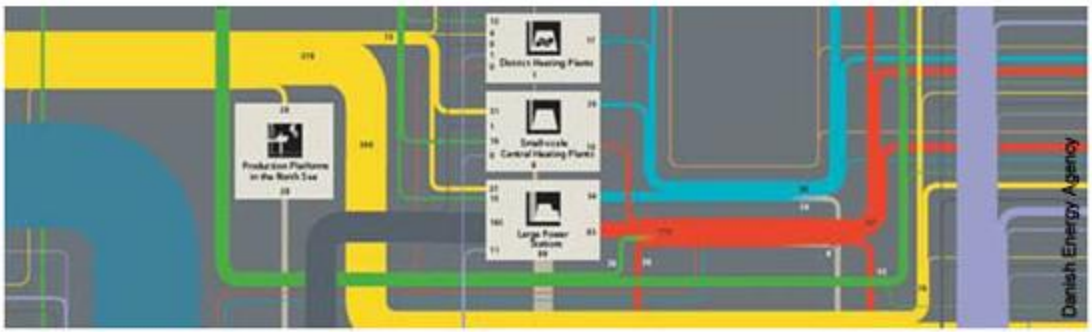
Kirsten Dyhr-Mikkelsen

# STREAM MODEL

# www.streammodel.org

## STREAM - an energy scenario modelling tool

Home | Model | Downloads | Cases | Contact




### About the STREAM modelling tool

The STREAM modelling tool provides a quick insight into the different potential energy mixes not only for the whole of Europe, but also for defined regions or countries. The model allows planners, politicians, students and others to be able to create scenarios on demand.

Moreover, the databases used can be periodically updated (through Eurostat for example) making this tool and the results more realistic and adaptable. Different potential policies or projections can also be incorporated providing an overview of the proposed scenario.

### Cases

Scenarios and analyses of policy measures for the Danish Commission on Climate Change Policy »

The Future Danish Energy System »

Scenarios for the Danish energy system in 2020 and 2050»

Gas market study for Poland »

Future European Energy Systems »

Sustainable Energy Scenarios for the Baltic Sea Region »

# Application examples

- Originally developed for “Future Danish Energy System” (2004-07)
  – Danish Board of Technology in conjunction with some of the most important Danish stakeholders in the energy sector
- Regional analyses
  – Sustainable Energy Scenarios for the Baltic Sea Region
  – Future European Energy Systems
- National analyses
  – Gas market study for Poland by 2035
  – Scenarios for the Danish energy system in 2020 and 2050
  – The Future Danish Energy System
  – Scenarios and analyses of policy measures for the Danish Commission on Climate Change Policy
- Numerous municipal scenario analyses

# How the STREAM model works

**Demand for energy services**

- Electric end-uses e.g. light
- Heat
- Process energy
- Transport, person-km, tons-km

**Conversion at end-user**

- Engine
- Boiler
- Etc.

**Final energy demand**

- Electricity, heat, oil, gas, biomass, etc. delivered to end-users

**Conversion**

- Electricity generation
- District heating production
- Production of transport fuels

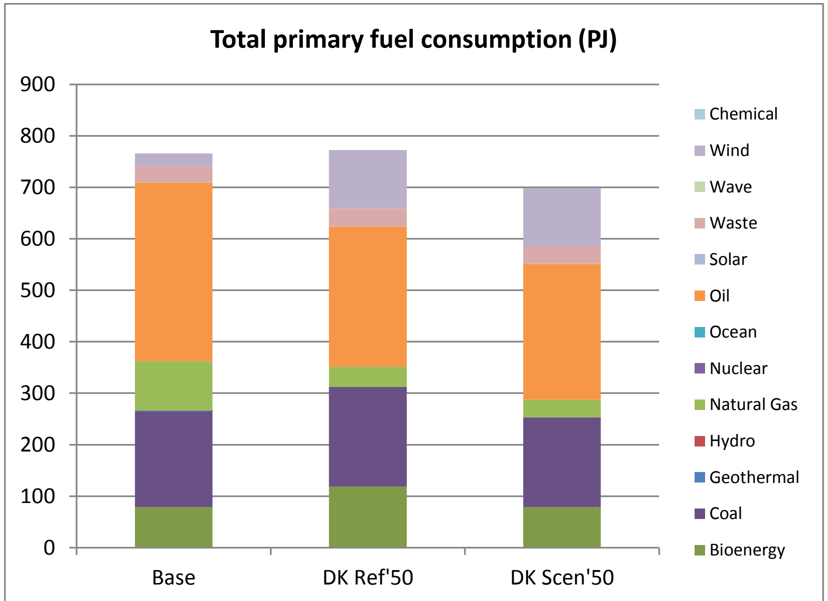
**Primary energy demand**

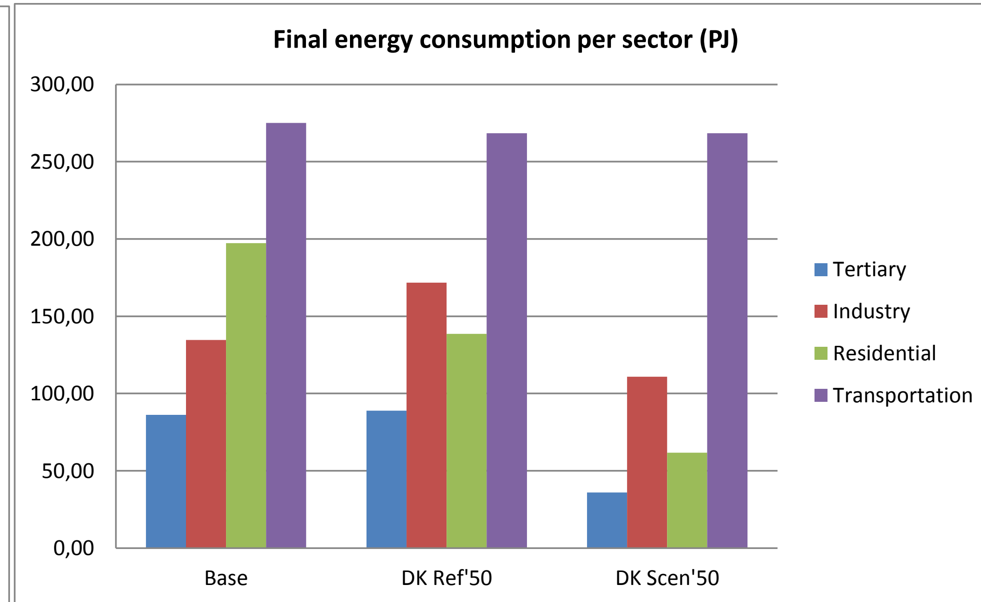
- Total demand for energy for conversion and end-users

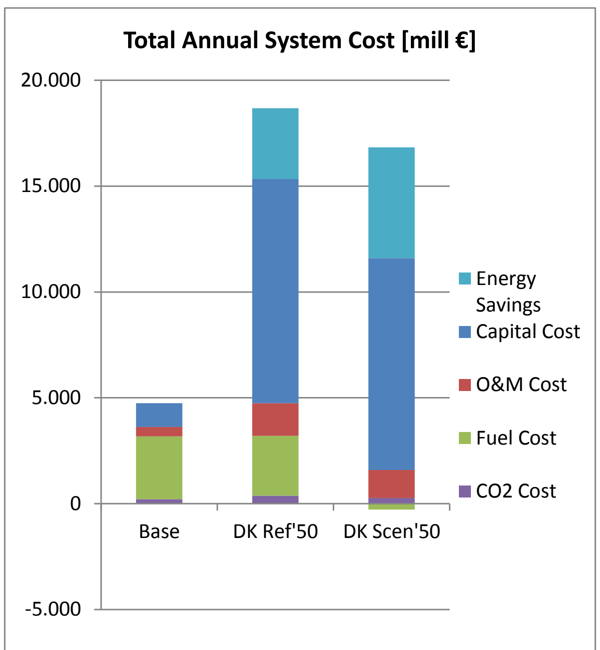
# Strengths

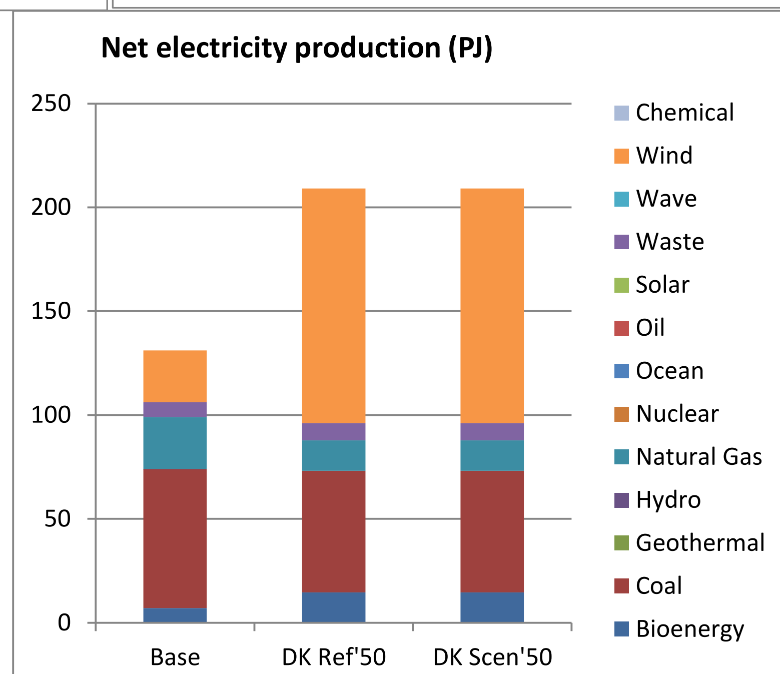
- Can facilitate dialogue on complex issues
  - All energy types
  - Both supply and demand side measures
  - Easy to change parameters and see impact
    - Targets and measures
- Overall understanding of interactions before commencing with more complex models
- Required input moderate
  - Aggregated figures

# Examples of output graphs

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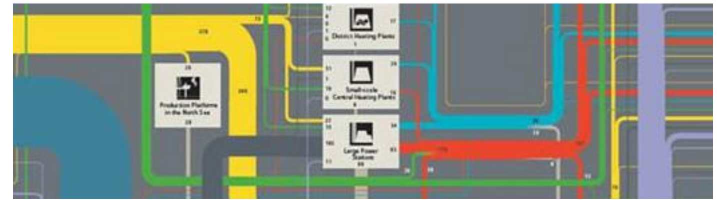
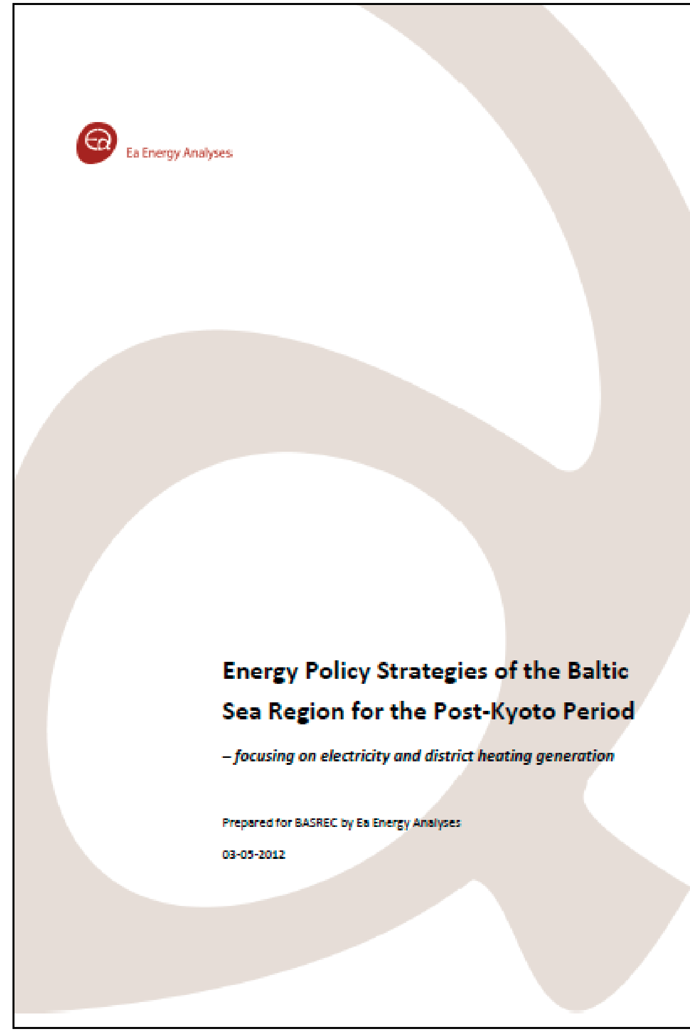
# Model tool box



Soft links

- STREAM
  - Covers the whole energy chain
  - Spread sheet model – based on user decision
  - Scenarios for demand development
    - Based on GDP, demand technologies etc.
- Balmorel
  - Electricity market (and district heating)
  - Optimisation of both investments and operation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Energy Policy Strategies of the Baltic Sea Region for the Post-Kyoto Period

*– focusing on electricity and district heating generation*

Prepared for BASREC by Ea Energy Analyses

03-05-2012

Case study

# ENERGY POLICY STRATEGIES OF THE BALTIC SEA REGION FOR THE POST-KYOTO PERIOD



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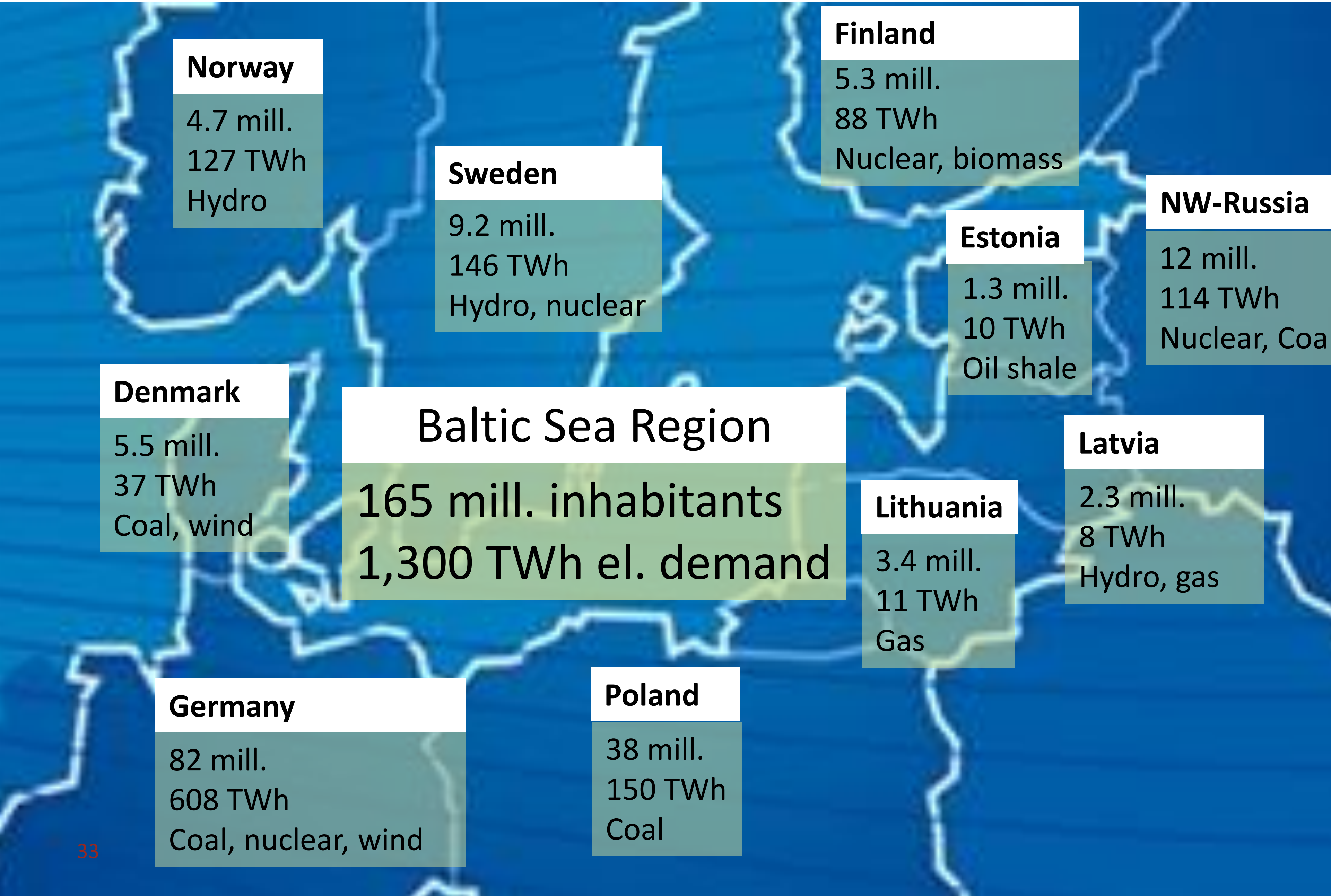
# Inhabitants and electricity demand

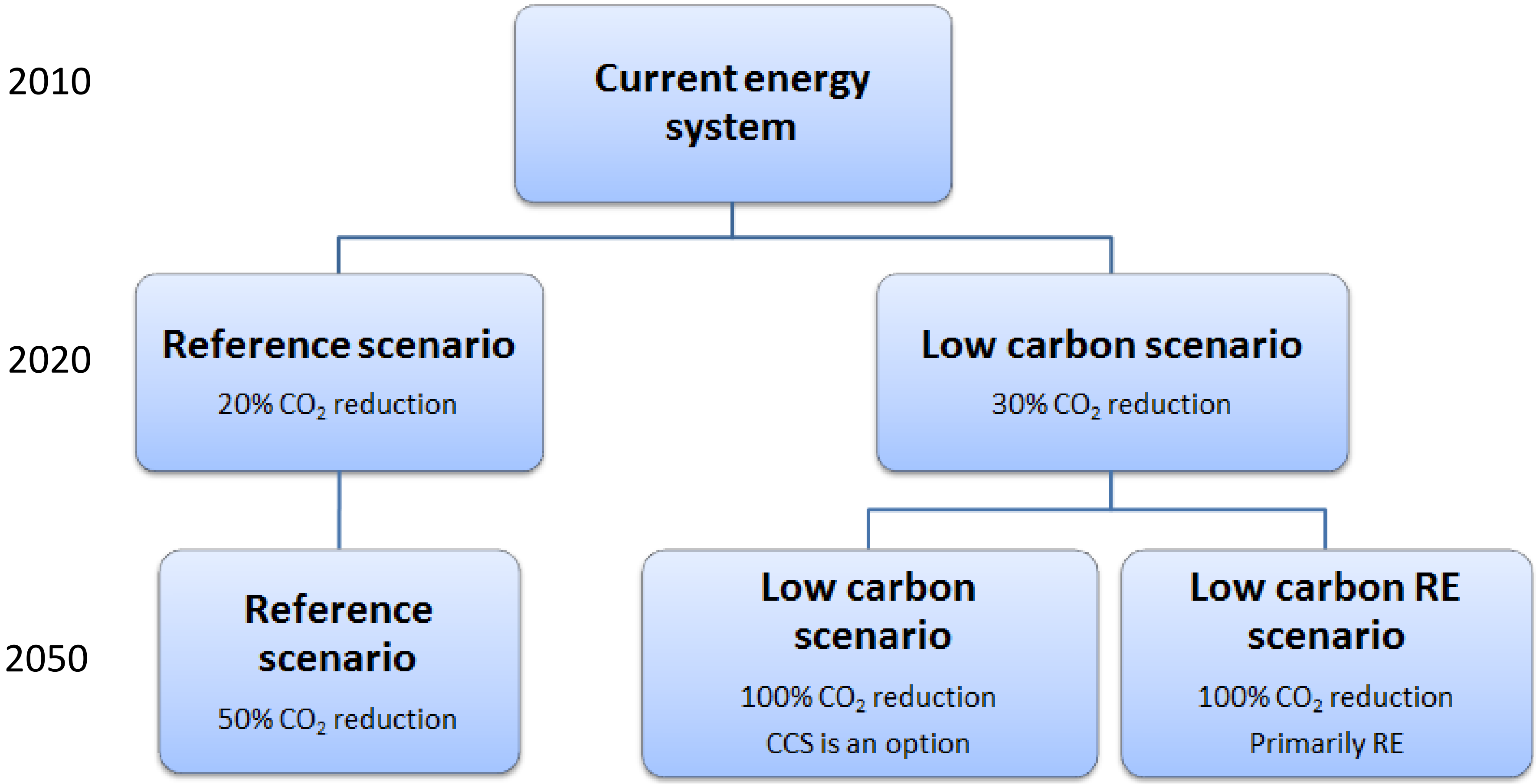


# Research questions addressed

- Can the Baltic Sea Region become $CO_2$ neutral by 2050?
- What is the additional cost of achieving 30% $CO_2$ reduction in 2020?
- What are the benefits of a coordinated planning and expansion of the electricity transmission grid?

Focus: Electricity and district heating systems

# Project scenarios



# Model setup for the study

- Least cost optimisation
- Model decides new investments in
  - Generation capacity
    - Except nuclear and hydro power
  - Transmission capacity

# Nuclear development

- Specified nuclear development assuming
  - German phase out by 2022
  - New nuclear generation capacity in Finland, Lithuania, Kaliningrad and Poland
  - Stable development in Sweden

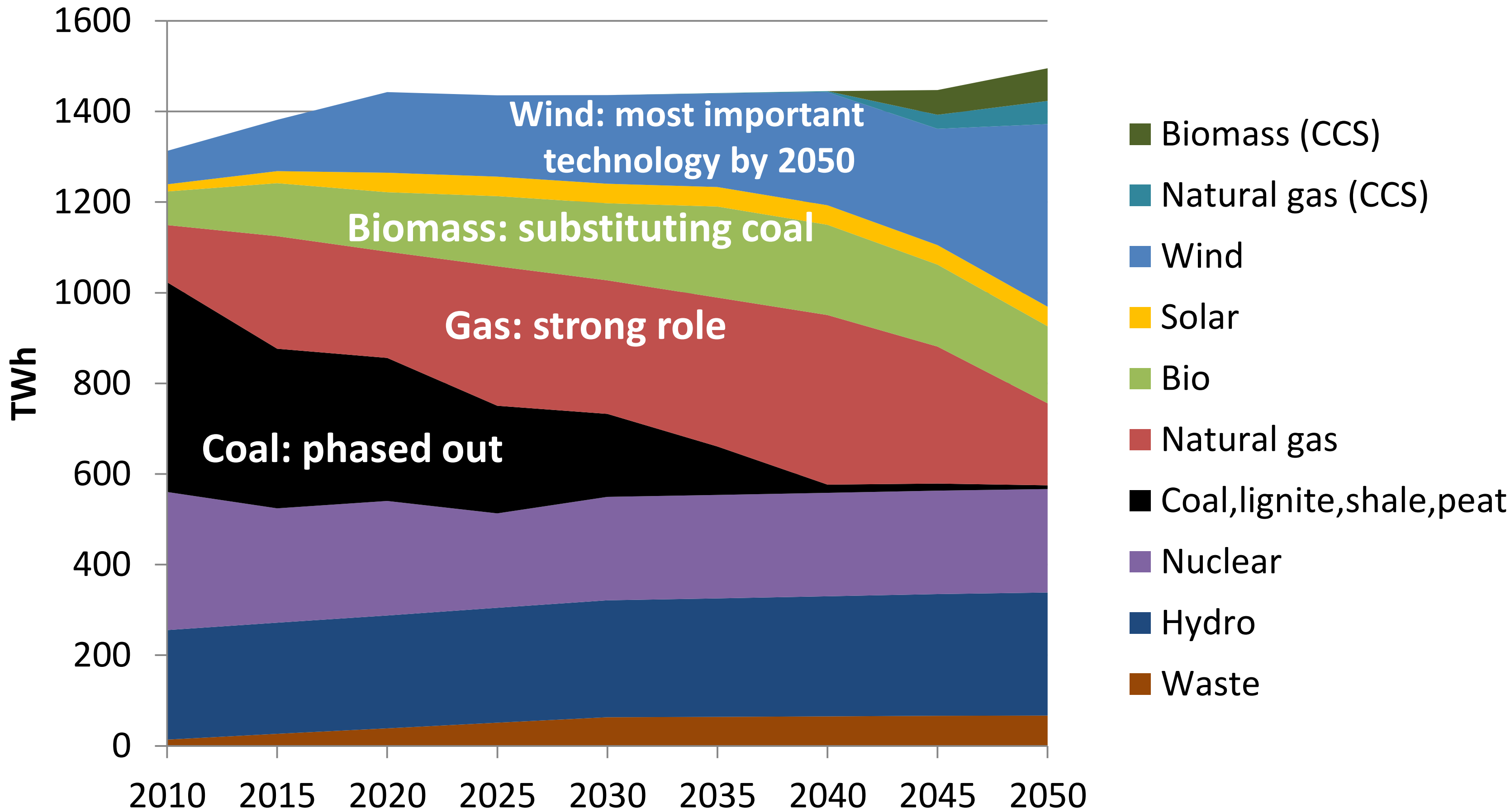
| [MW] | FINLAND | GERMANY | LITHUANIA | POLAND | RUSSIA | SWEDEN |
|---|---|---|---|---|---|---|
| 2010 | 2,691 | 20,339 | | | 5,760 | 9,372 |
| 2015 | 4,291 | 12,003 | | | 5,760 | 9,782 |
| 2020 | 4,291 | 8,052 | 758 | 1,515 | 6,842 | 9,782 |
| 2025 | 5,691 | | 1,515 | 2,776 | 6,842 | 9,782 |
| 2035 | 7,191 | | 1,515 | 3,699 | 6,842 | 9,782 |
| 2050 | 7,191 | | 1,515 | 3,699 | 6,842 | 9,782 |

# Technology data

| Technology type | Fuel type | Investment cost (mil. €/$MW_{el}$) | Fixed O&M (€1000/$MW_{el}$) | Variable O&M (€/$MWh_{el}$) | Electric efficiency *Condensing mode* | Electric efficiency *CHP mode* | Total efficiency *(Elec. + heat)* |
|---|---|---|---|---|---|---|---|
| Condensing | Coal | 1.5 | 22 | 3.6 | 44-50% | - | 44-50% |
| Condensing | Wood pellets | 1.5 | 22 | 3.6 | 43-49% | - | 43-49% |
| Condensing | Natural gas | 1.0 | 37 | 0.8 | 46% | - | 46% |
| Condensing with CCS | Coal | 2.6 | 59 | 16.7 | 41% | - | 41% |
| Condensing with CCS | Wood pellets | 2.6 | 59 | 16.7 | 40% | - | 40% |
| Extraction CHP | Coal | 1.5 | 22 | 3.6 | 44-50% | 36-44% | 87-90% |
| Extraction CHP | Wood pellets | 1.5 | 22 | 3.6 | 43-49% | 35-42% | 87-90% |
| Extraction CHP | Natural gas | 1.0 | 37 | 0.8 | 46% | 37% | 90% |
| Extraction CHP | Wood | 1.7 | 24 | 3.3 | 46.5-48.5% | 36-39% | 103-107% |
| Extraction CHP with CCS | Coal | 2.6 | 59 | 16.7 | 41% | 33% | 84% |
| Extraction CHP with CCS | Wood pellets | 2.6 | 59 | 16.7 | 40% | 32% | 84% |
| Condensing CC | Natural gas/biogas* | 0.5-0.6 | 15 | 1.9 | 56.5-60% | - | 56.5-60% |
| Condensing CC with CCS | Natural gas | 1.4 | 39 | 6.4 | 51% | - | 51% |
| Extraction CC | Natural gas/biogas* | 0.5-0.6 | 15 | 1.9 | 56.5-60% | 52-56% | 88-90% |
| Extraction CC with CCS | Natural gas | 1.4 | 39 | 6.4 | 51% | 46% | 80% |
| Backpressure | Natural gas/biogas* | 1.1 | 7 | 8.4 | - | 43-47% | 92% |
| Backpressure | Straw | 4.0-5.0 | 8-10 | 1.4-1.7 | - | 30% | 90% |
| Backpressure | Municipal waste | 5.7 | 160 | 22.8 | - | 24-26% | 97-99% |
| Backpressure | Biogas | 3.2-3.5 | 93 | 15.5 | - | 42-47% | 92-93.5% |
| Onshore wind | Wind | 1.4-1.6 | 28-29 | 2.9-3.1 | - | - | 100% |
| Onshore wind LCI | Wind | 1.8-2.0 | 31-32 | 2.9-3.2 | - | - | 100% |
| Offshore wind (low**) | Wind | 1.6-2.0 | 49-52 | 3.6-4.1 | - | - | 100% |
| Offshore wind (mid**) | Wind | 1.9-2.3 | 49-52 | 3.6-4.1 | - | - | 100% |
| Offshore wind (deep**) | Wind | 2.3-2.8 | 49-52 | 3.6-4.1 | - | - | 100% |
| Solar PV | Solar | 1.0-2.0 | 12-33 | - | - | - | 100% |
| Wave power | Wave | 2.7-8.9 | 58-116 | 3.6-7.2 | - | - | 100% |

Based on DEA and Energinet.dk technology catalogue

# Low carbon case: Electricity generation



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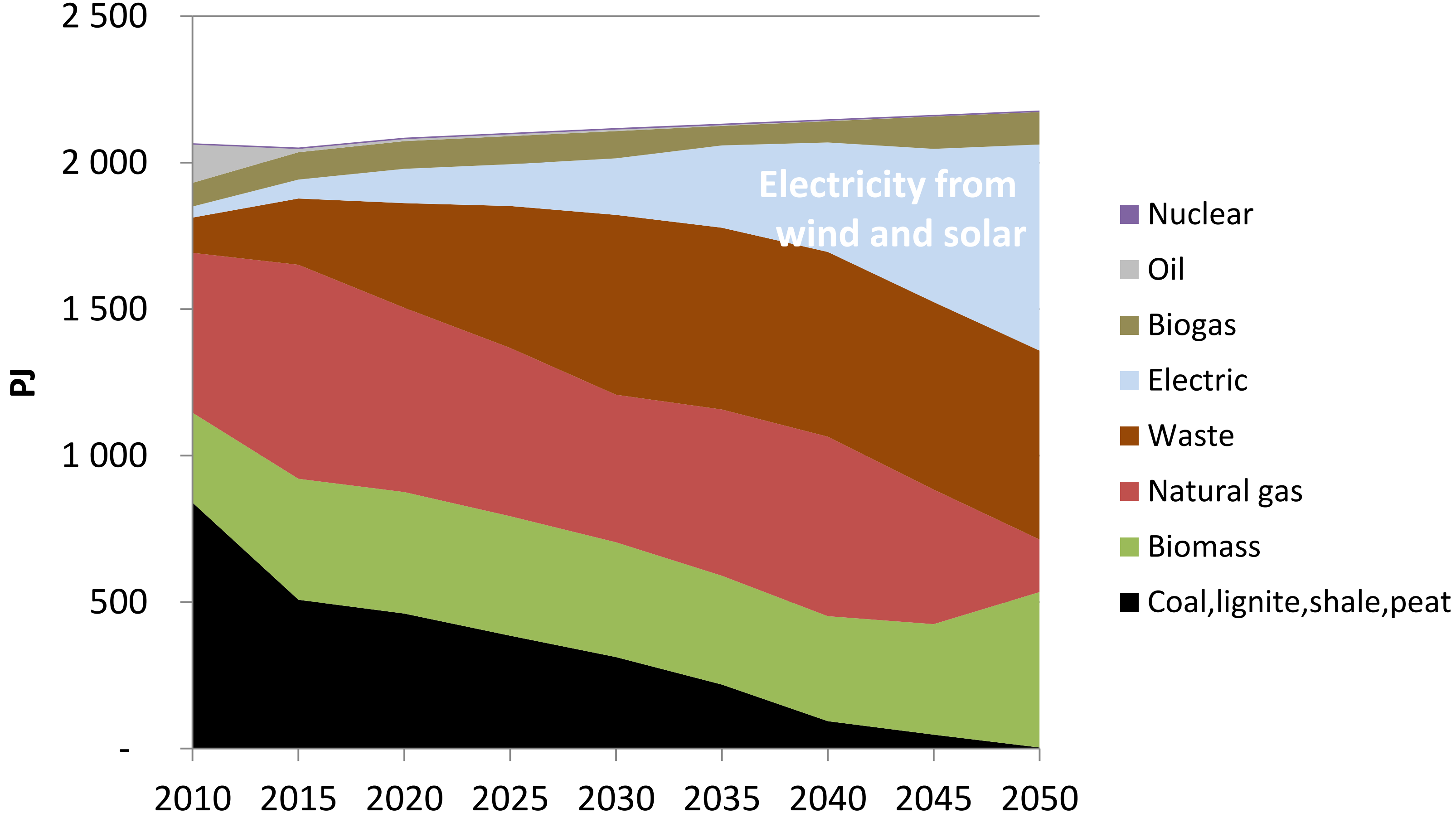
# Low carbon RE case: District heating generation



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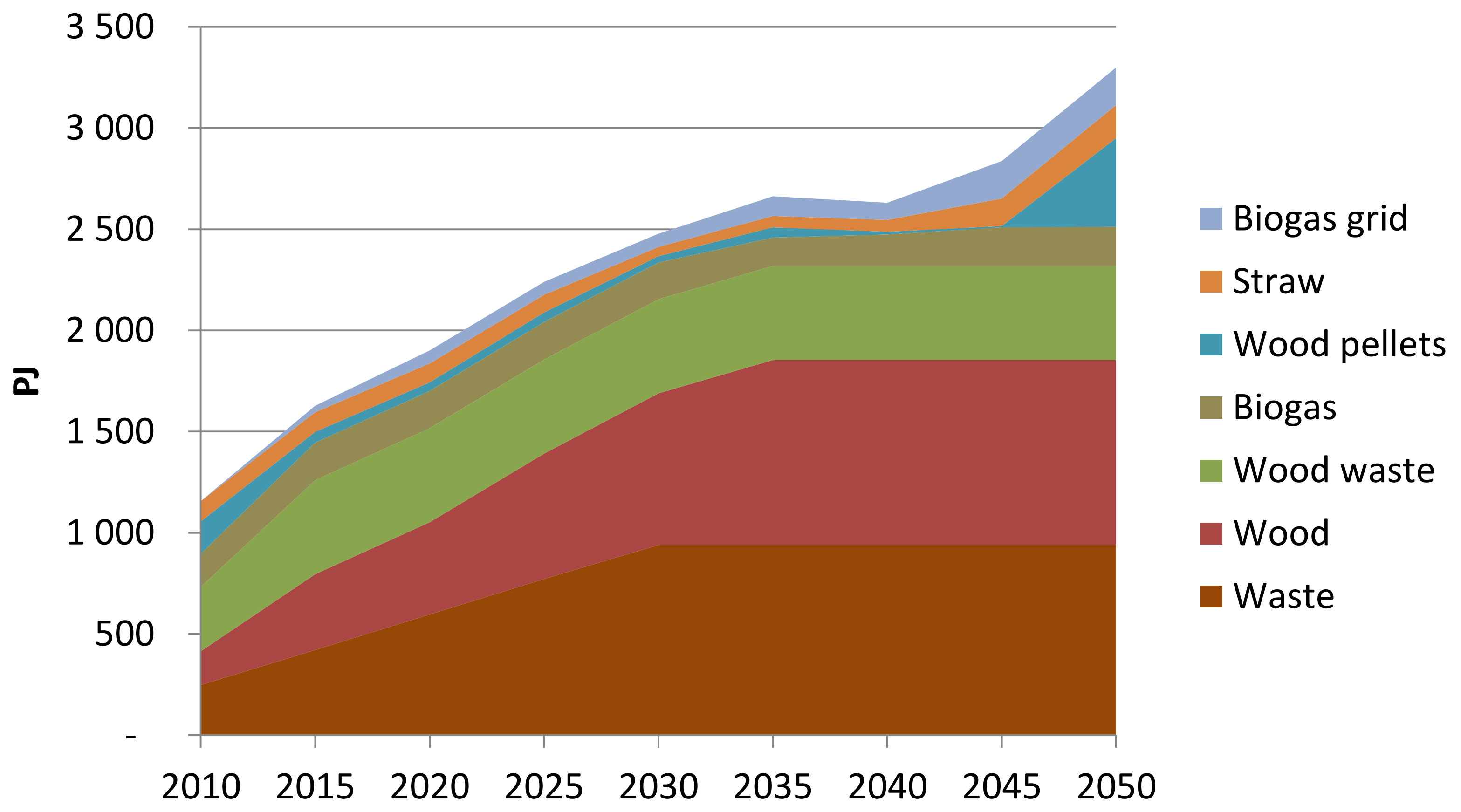
# Utilisation of biomass resources



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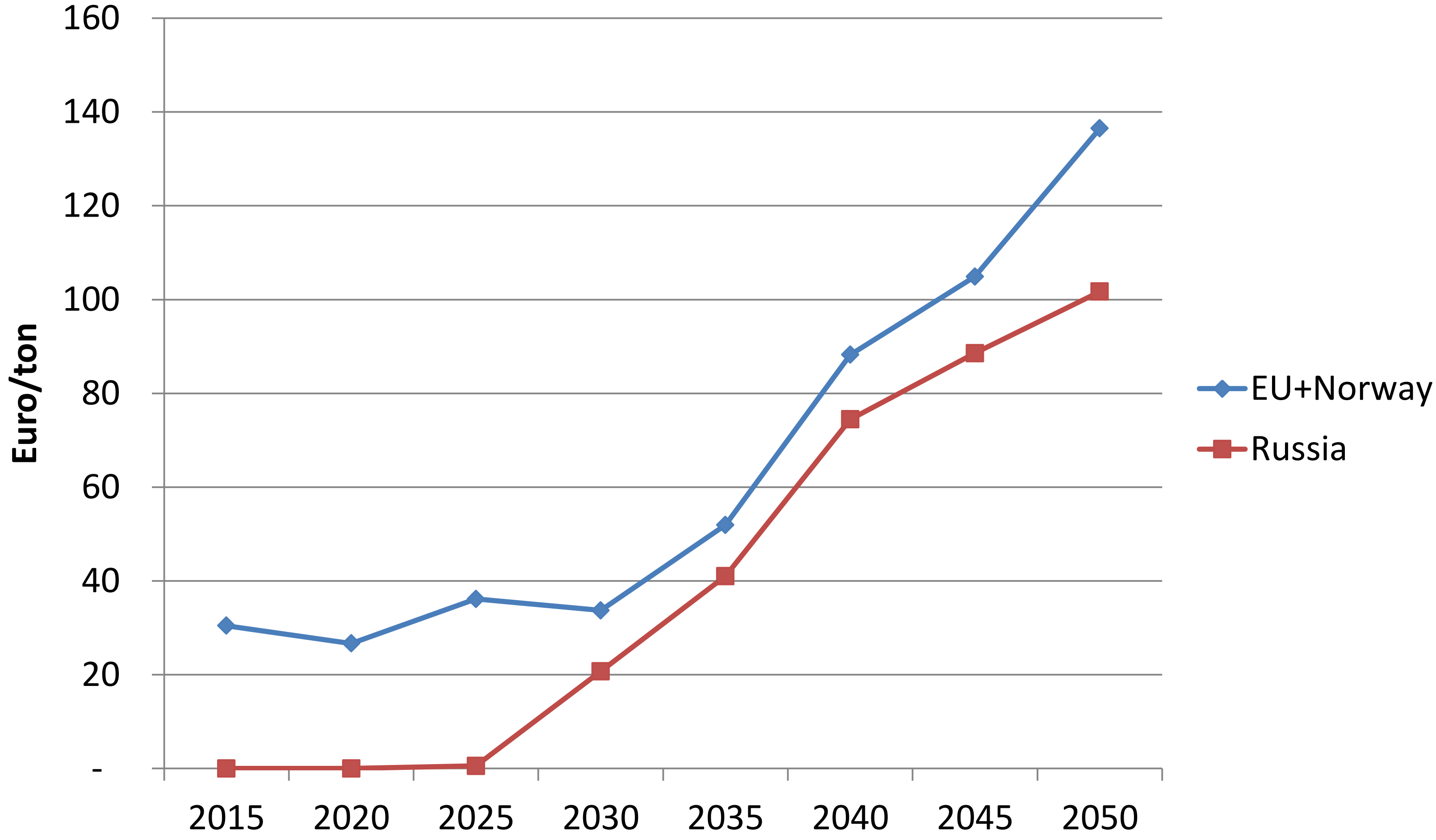
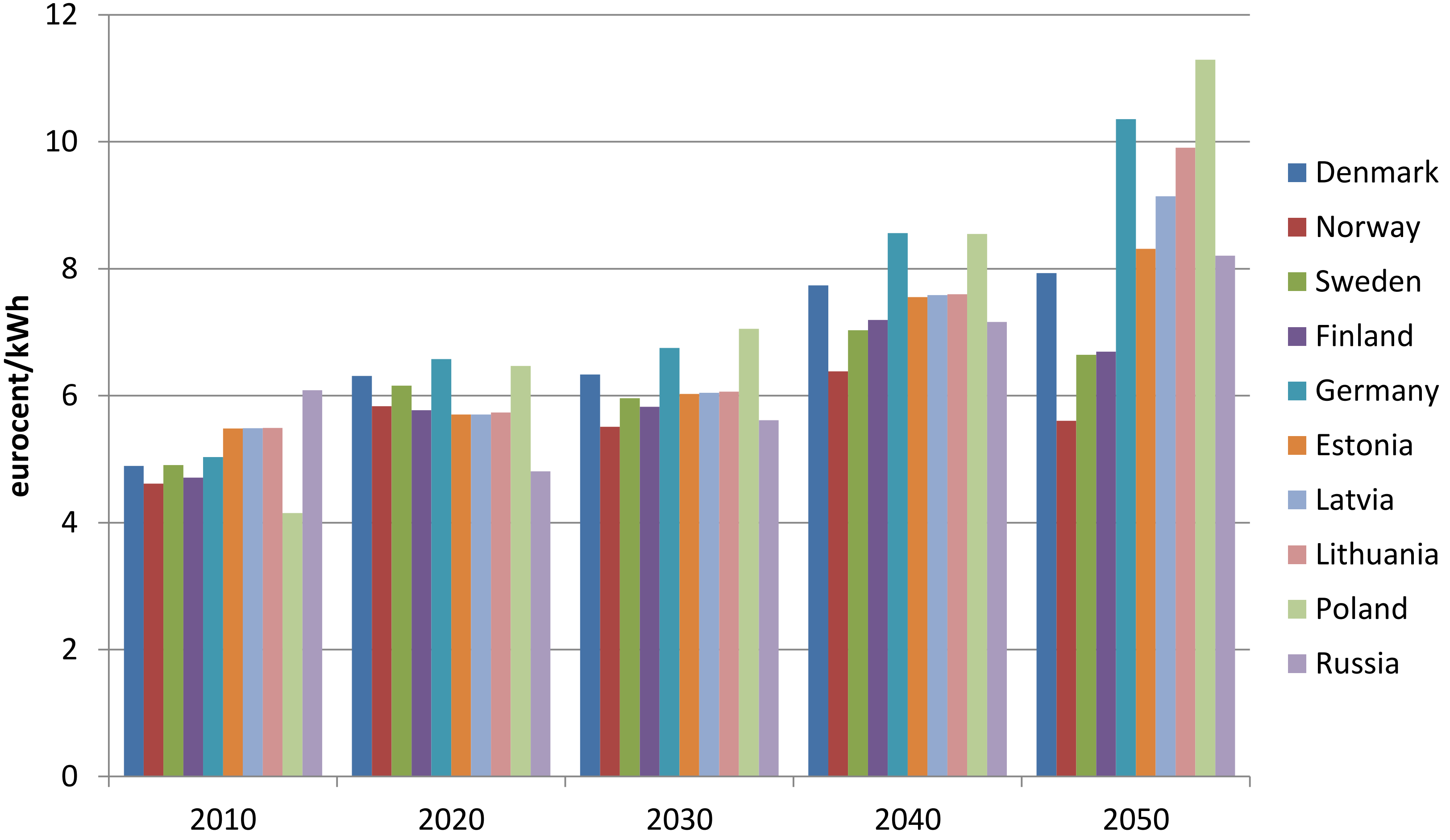
# Low carbon case: Marginal $CO_2$ price

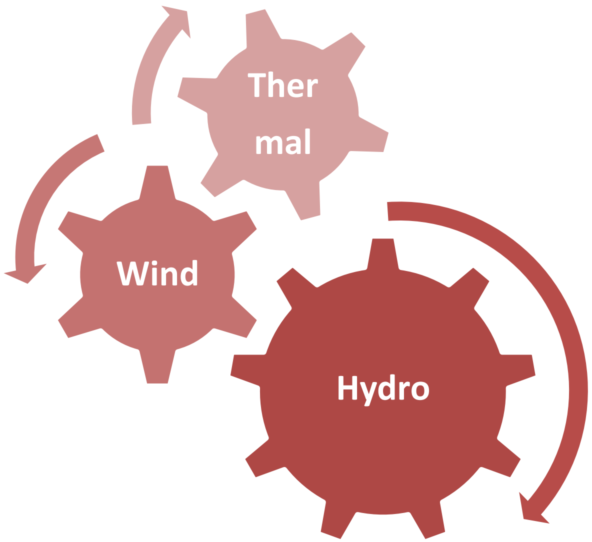


# Low carbon RE case: Electricity market prices



# Main findings

- It is technically possible for the Baltic Sea Region to become carbon neutral by 2050 at moderate economic costs
- Most important technologies are wind power, biomass, nuclear and hydro
- Massive investments in the electricity grid will be required
- Substantial cost reductions through regional cooperation



# DESIGN OF ESTONIAN LONG-TERM ENERGY SCENARIOS

# Possible Estonian long-term energy technological-economic scenarios?

| Other countries | BAU | Low $CO_2$ price 0 €/ton | High $CO_2$ price 100 €/ton |
|---|---|---|---|
| Estonia: Optimal investments and operation (as other countries) | | | |
| Estonia: Maximum oil shale | | | |
| Estonia: 100% renewable in 2050 | | | |

This is only a preliminary suggestion that is meant to spur on discussion

+ combination scenario

# 5. NEXT STEPS

# Dates

| | |
|---|---|
| **4.12.2012** | **Kick-off meeting, Tallinn** |
| 21.12.2012 | Kick-off paper with detailed work plan and input data |
| **7.-8.1.2013** | **Meeting with stakeholders** |
| 16.1.2013 | Accept of input data and BAU scenario and for “single-track scenarios” |
| 1.4.2013 | Interim report with results for BAU scenario and for “single-track scenarios” |
| **8.4.2013** | **Meeting with stakeholders**<br>**Definition of combination scenario** |
| 7.5.2013 | Draft final report |
| **14.5.2013** | **Meeting with stakeholders** |
| 31.5.2013 | Final report, transfer of models |