



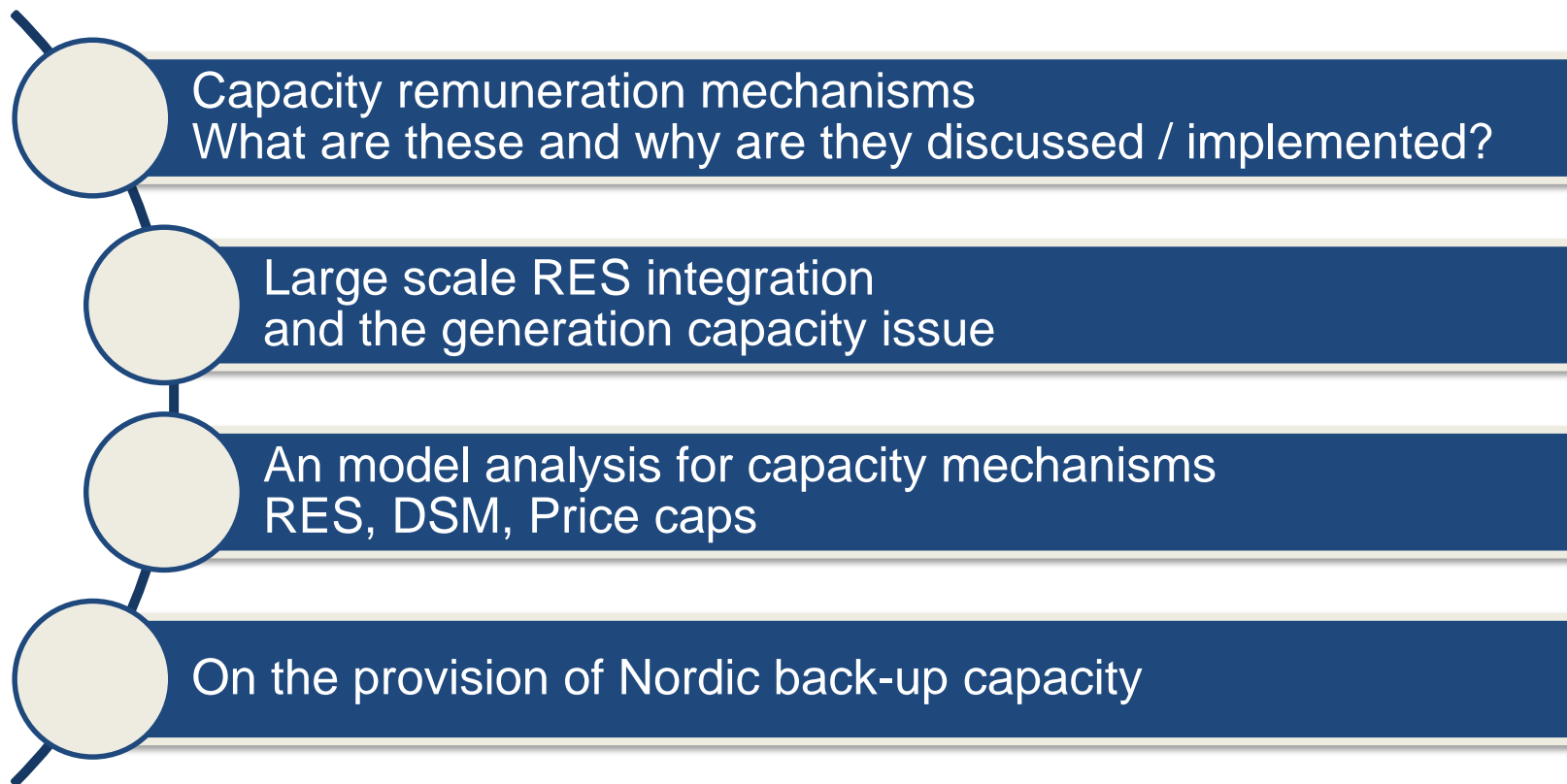
**NTNU – Trondheim**  
Norwegian University of  
Science and Technology

# **HydroPeak - WP3**

Assessing capacity mechanisms  
in the European power system

Stefan Jaehnert, PhD  
HydroPeak User group meeting, Trondheim, 30.10.2014

# Outline

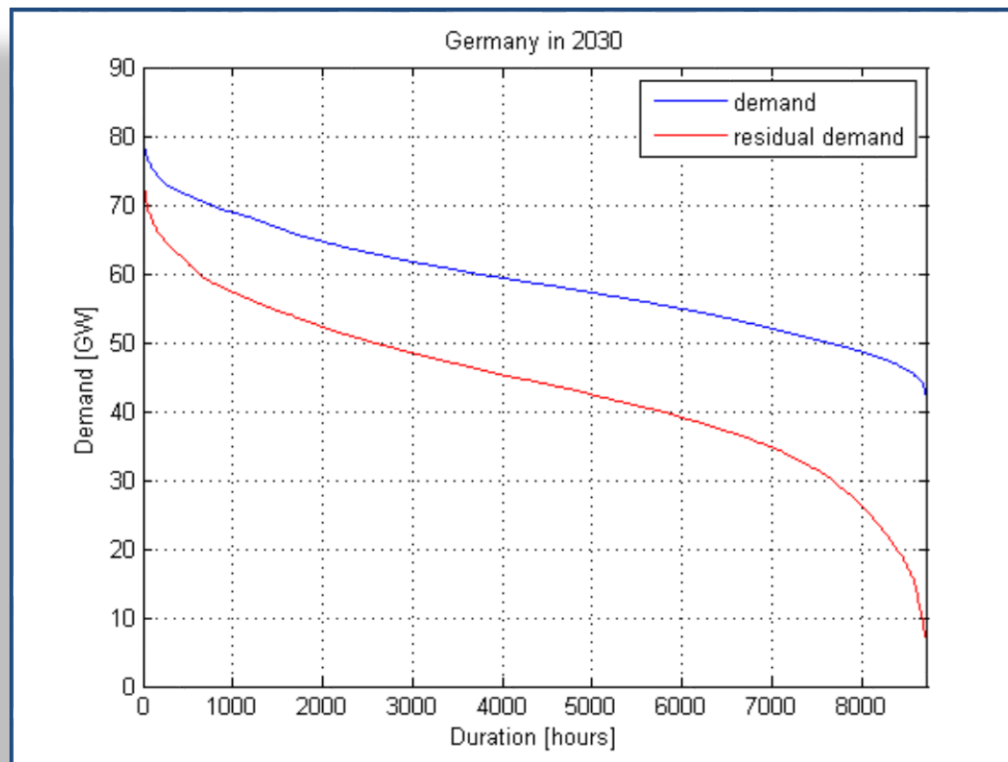


Capacity remuneration mechanisms

# **WHAT AND WHY?**

# Renewable energy sources

## Challenges for conventional power plants



**Residual** demand to be covered by conventional power plants

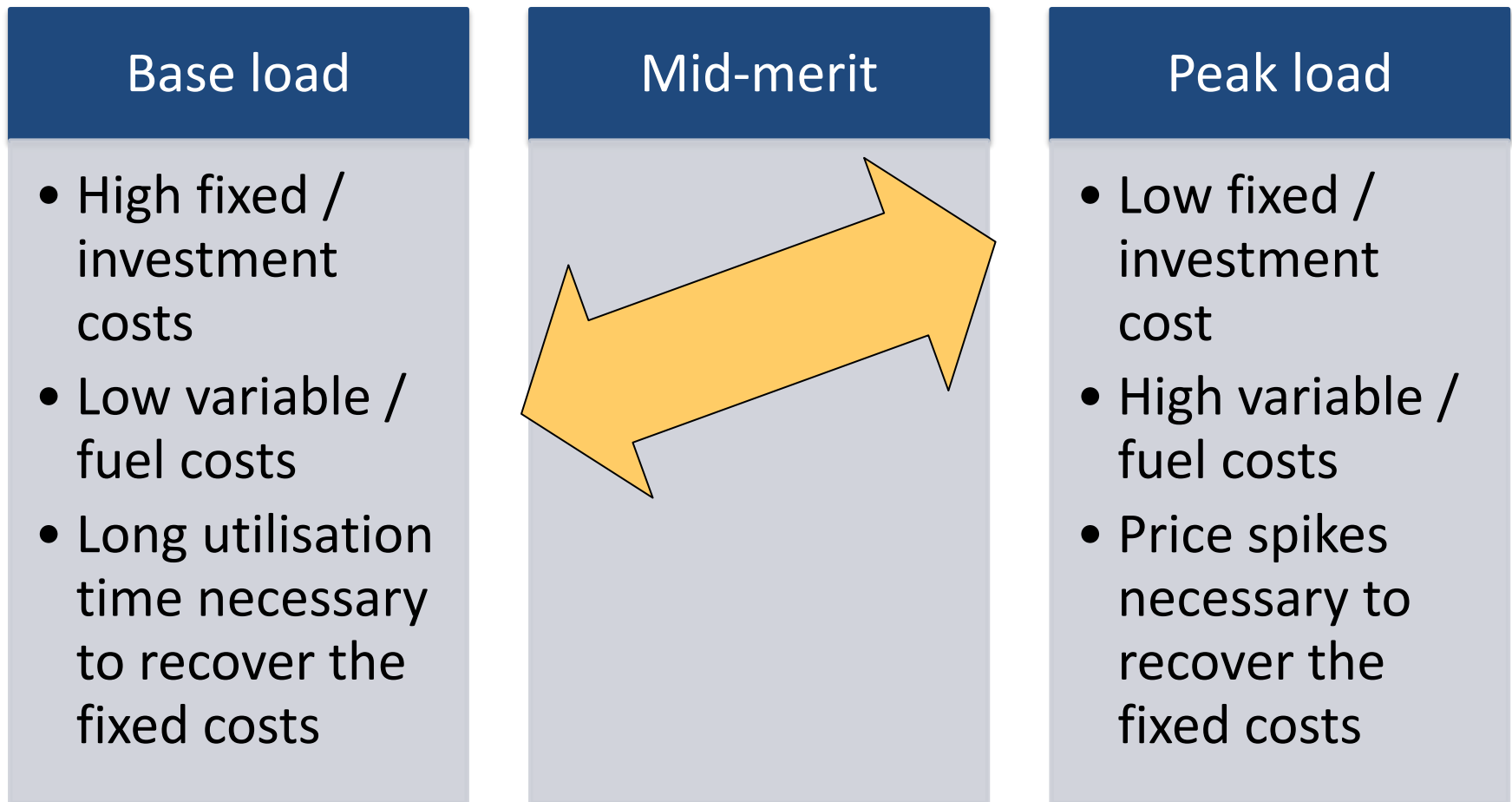
Higher variability of demand

Lower utilisation time of power plants

But nearly equal size of conventional generation capacity required

=> Call for capacity mechanisms to ensure system adequacy

# Profits of (thermal) power plants

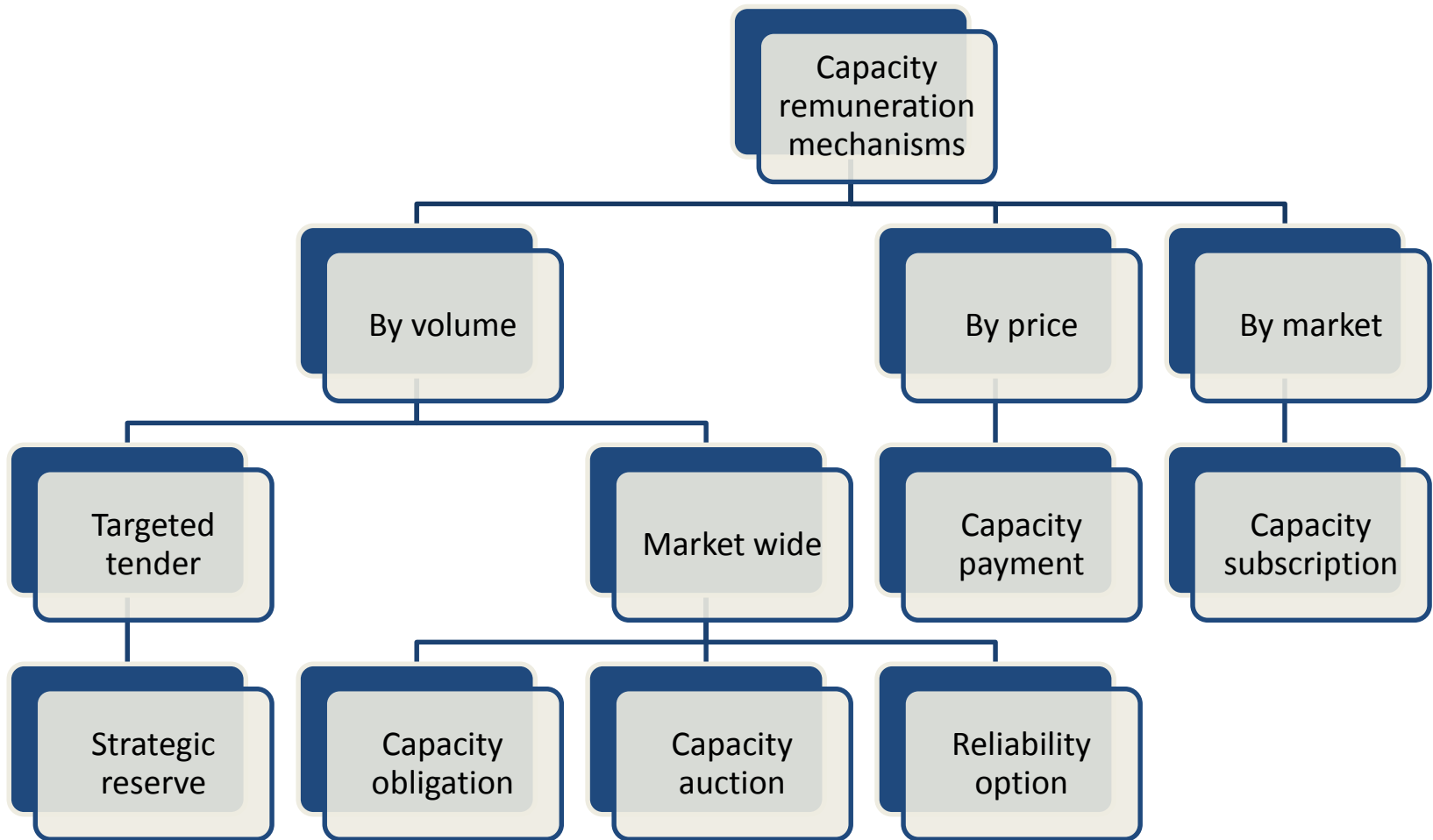


# Capacity Mechanisms

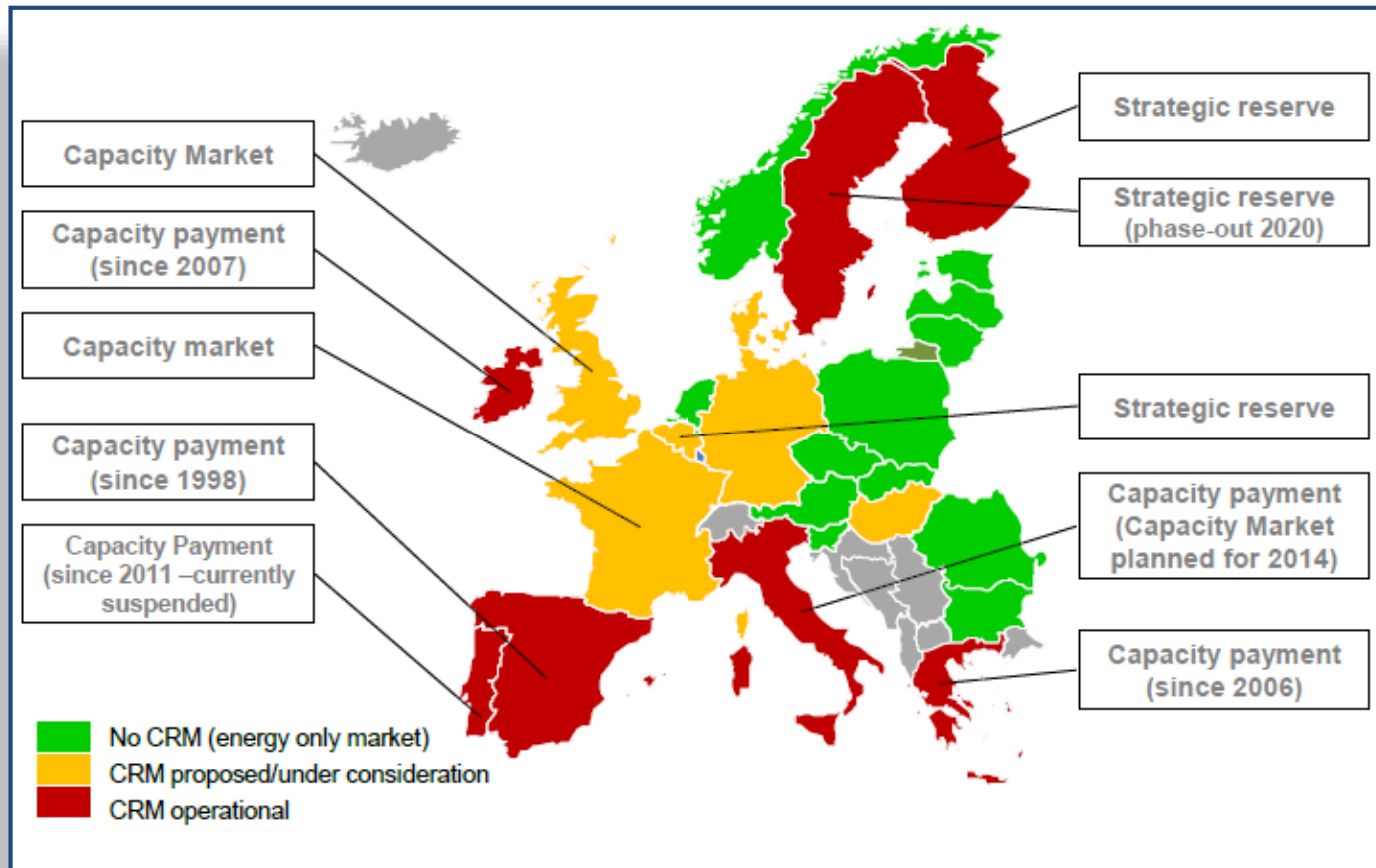
## Capacity (remuneration) mechanisms - CRM

- **Requirements for or Remuneration of installed / available** generation capacity
- Implementation to ensure system adequacy (sufficient generation capacity to cover the peak demand)
- Payments in EUR/MW installed / available generation capacity

# CRM classification



# CRMs in Europe



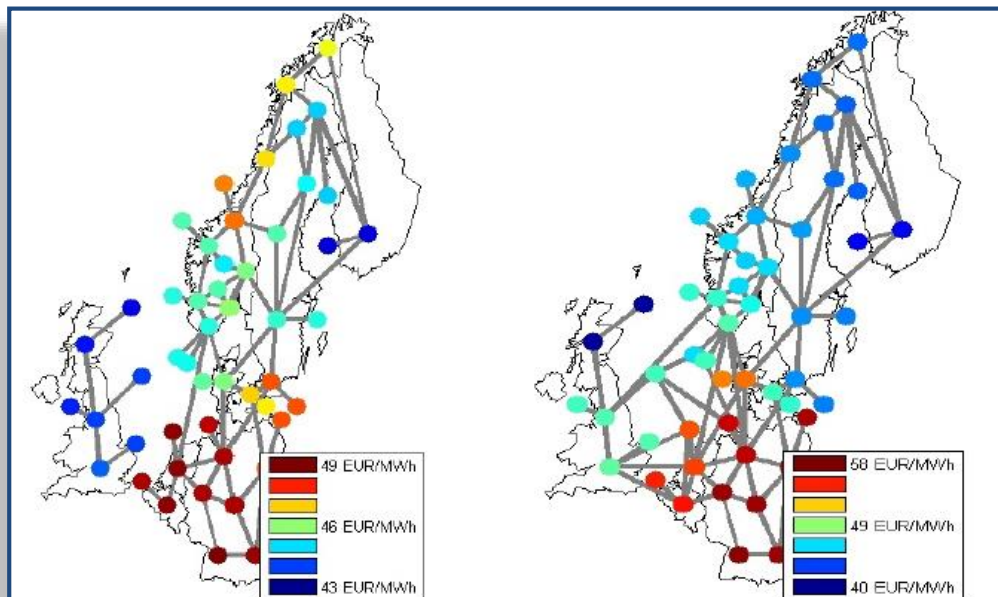
ACER, "Report: CAPACITY REMUNERATION MECHANISMS AND THE INTERNAL MARKET FOR ELECTRICITY", 2013,  
[http://www.acer.europa.eu/Official\\_documents/Acts\\_of\\_the\\_Agency/Publication/CRMs%20and%20the%20IEM%20Report%20130730.pdf](http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/CRMs%20and%20the%20IEM%20Report%20130730.pdf)



Capacity remuneration mechanisms

# **LARGE SCALE RES INTEGRATION**

# Future RES scenarios



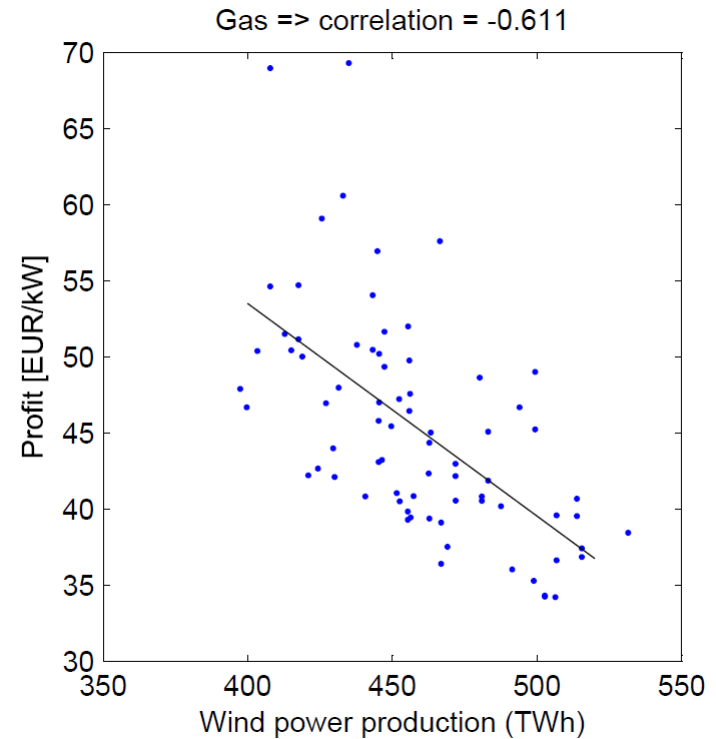
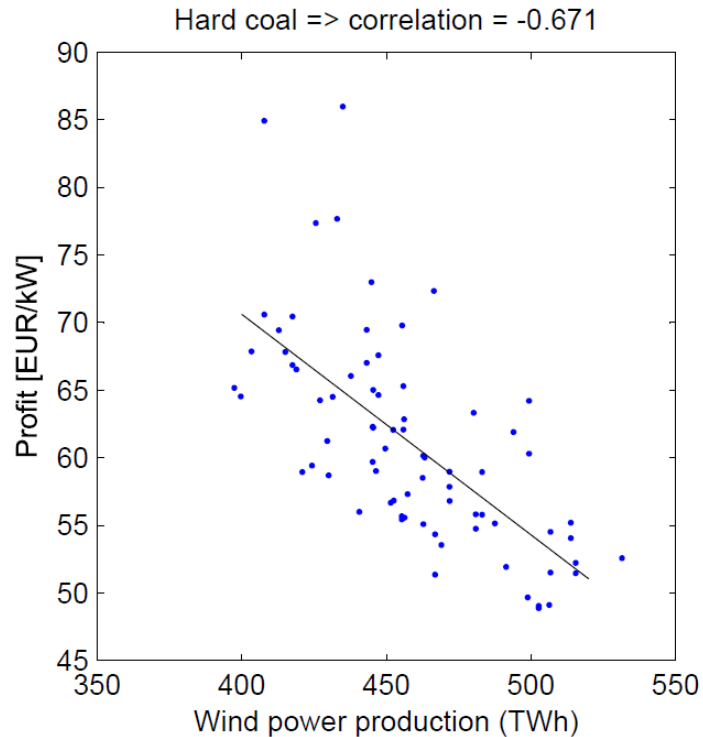
## 2010 / 2030 scenario:

- 192 GW wind + 30 GW solar generation capacity
- 11GW extra hydro in southern Norway
- Doubling of interconnection capacity Nordic  $\Leftrightarrow$  continental Europe
- Increased CO<sub>2</sub> cost

MSc Ingri M. Hyldbakk

Ingri M. Hyldbakk: "Lønnsomhet i produksjon i et system med en stor andel fornybar energi",  
Master thesis, NTNU, February, 2014

# RES impact (2030)



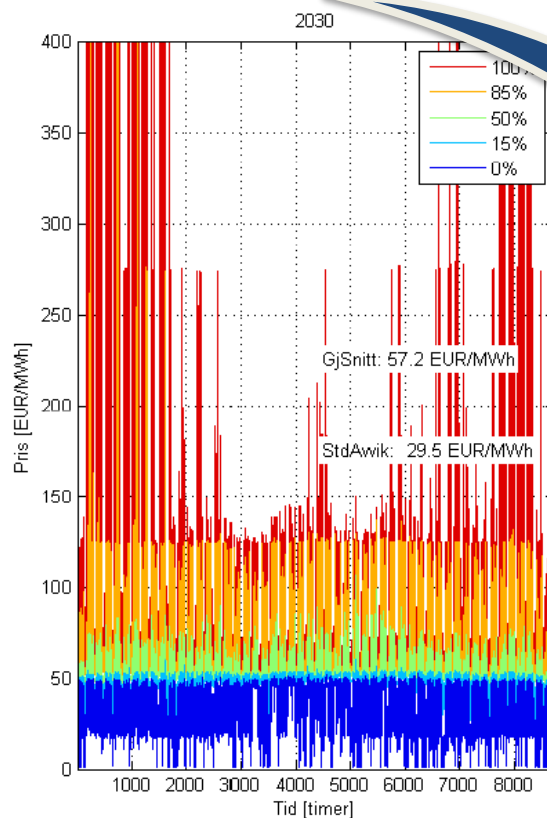
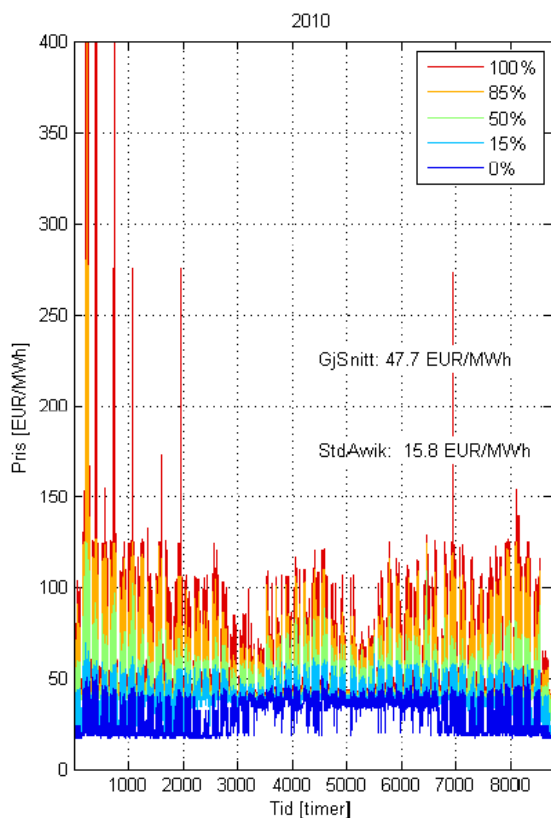
Ratio min / max profit

~0.5

Ingri M. Hyldbakk: "Lønnsomhet i produksjon i et system med en stor andel fornybar energi",  
Master thesis, NTNU, February, 2014

# Profit for thermal producer

## Annual average profit



2010

- Coal 98.6 EUR/kW
- Gas 39.9 EUR/kW

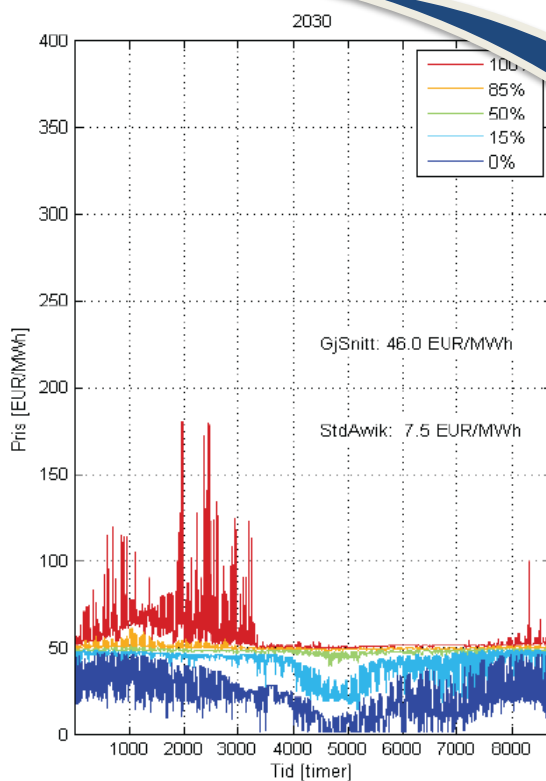
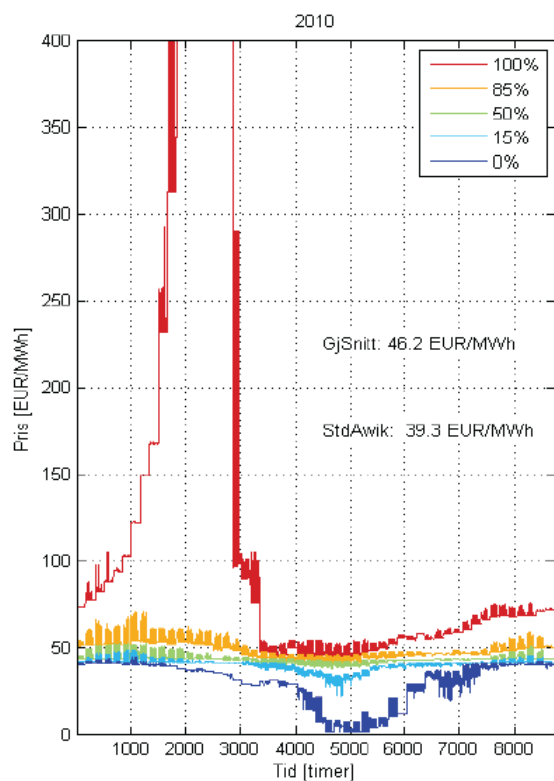
2030

- Coal 51.1 EUR/kW
- Gas 43.3 EUR/kW

Ingri M. Hyldbakk: "Lønnsomhet i produksjon i et system med en stor andel fornybar energi",  
Master thesis, NTNU, February, 2014

# Profit for hydro producer

Annual average profit



2010

• 197.4 EUR/kW

2030

• 132.9 EUR/kW

Ingri M. Hyldbakk: "Lønnsomhet i produksjon i et system med en stor andel fornybar energi",  
Master thesis, NTNU, February, 2014

# Capacity mechanisms

## in Northern Europe

Analysing the impact of CRMs on the long-term power-system development

- Implementation of capacity requirements in a power-market simulator (EMPS)
- Assessment of future (RES) scenarios, i.e. 2030 with and without CRM
- Outcome for various stakeholders, with focus on Norwegian hydro producer

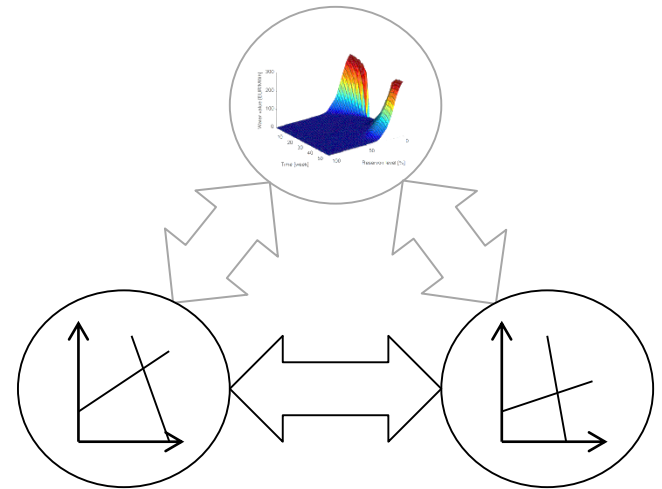
MSc cand. Astrid Karsrud

Capacity remuneration mechanisms

# MODEL ANALYSIS

# A simple two-area model

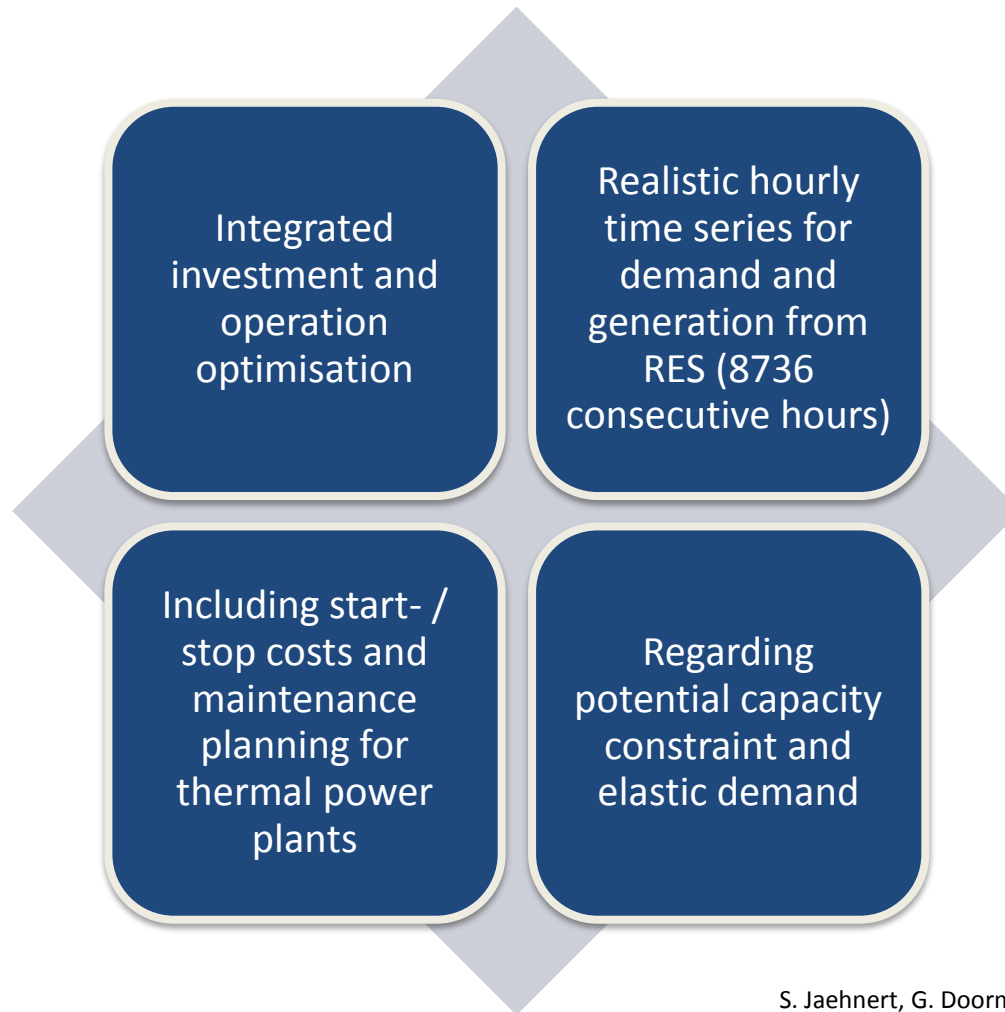
## Specification



S. Jaehnert, G. Doorman, "Analysing the generation adequacy in power markets with RES", 11<sup>th</sup> EEM conf., May, 2014



# Model characteristics



S. Jaehnert, G. Doorman, "Analysing the generation adequacy in power markets with RES", 11<sup>th</sup> EEM conf., May, 2014

# Case studies

## Increasing RES under

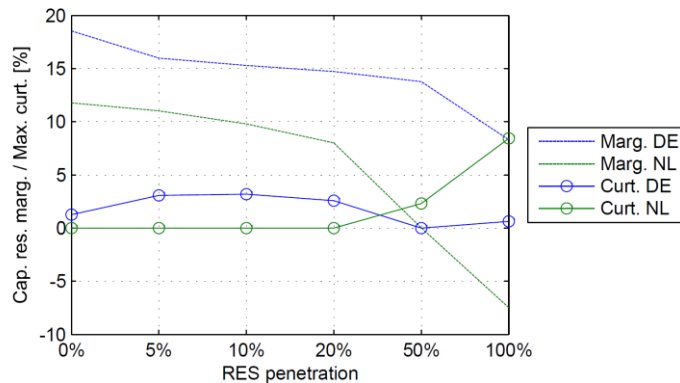
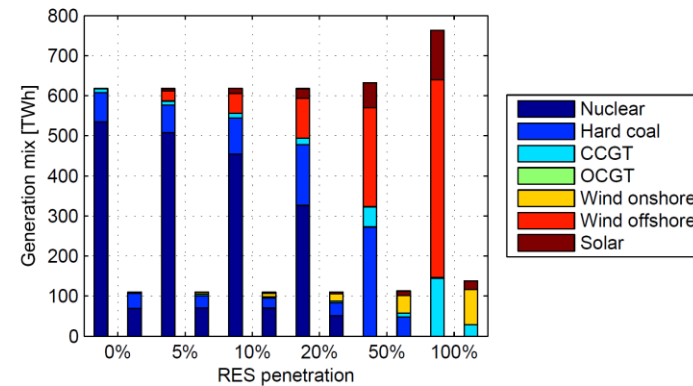
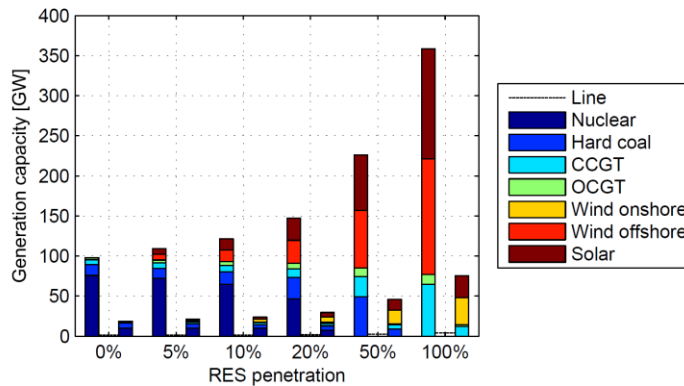
- Energy-only market  
=> How do RES impact the generation capacity?
- With capacity mechanism  
=> What does a CRM change?

## Impact of

- A cap for bidding prices
- Demand reaction  
=> Are there other remedies for the generation capacity issue?

S. Jaehnert, G. Doorman, "Analysing the generation adequacy in power markets with RES", 11<sup>th</sup> EEM conf., May, 2014

# Energy-only market

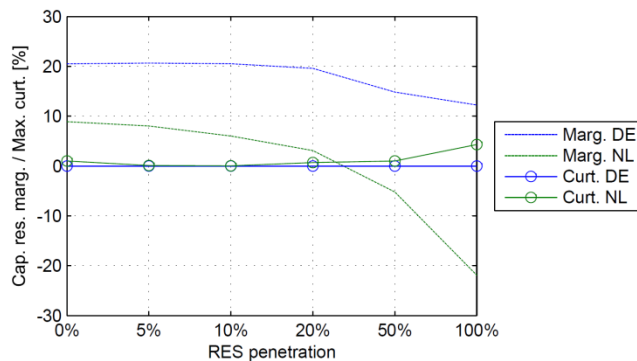
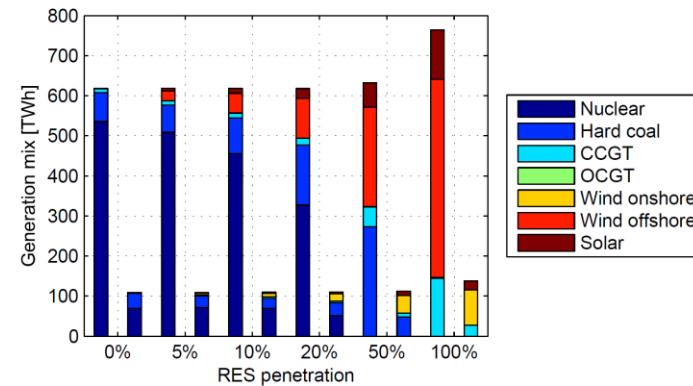
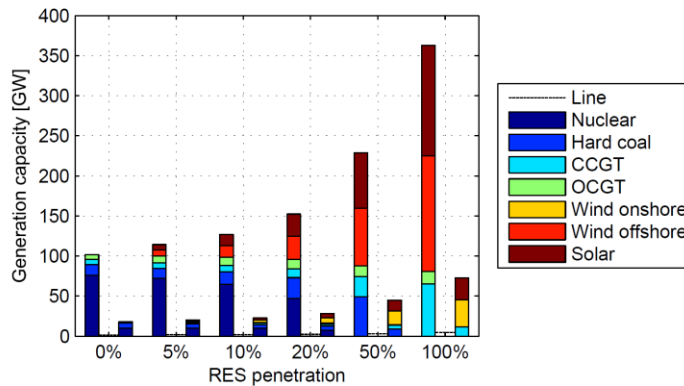


With increasing RES penetration:

- Less base load / more peaking generation capacity
- Decreasing capacity margin
- Shutdown of RES at high penetration levels

S. Jaehnert, G. Doorman, "Analysing the generation adequacy in power markets with RES", 11<sup>th</sup> EEM conf., May, 2014

# With capacity mechanism



## With a CRM in Germany:

- Similar generation capacity development, but:
- Much higher reduction of capacity margin in the Netherlands
- Load curtailment only in the Netherlands

S. Jaehnert, G. Doorman, "Analysing the generation adequacy in power markets with RES", 11<sup>th</sup> EEM conf., May, 2014

# Analysis conclusion

Decreasing capacity margin with increasing RES

- Higher load curtailment and shutdown of production from RES

Implementation of CRM in one country to avoid load curtailment

- Significant effect on the neighbouring country

Adjustment of the bidding price cap and higher demand reaction on prices

- Increasing system adequacy

Capacity remuneration mechanisms

# **ON THE PROVISION OF NORDIC BACK-UP CAPACITY**


# New offshore cables

## from Norway

Nord.Link (NO-DE) / NSN (NO-UK) HVDC cables



Permits granted from OED to build HVDC cables to Germany & UK (13.10.)



Capacity market implemented in UK / under discussion in Germany



Requirement (of the permits) that cables can participate in the national CRMs

# Cable outage analysis

## Research objective

- Outage statistics
- Economics of cable outage for various stakeholders
- What is the impact of cable outages on the capacity-purchasing side => is cable participation possible?

MSc cand. Christian Melaeen



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