Position paper:
Norway’s role as a flexibility provider in a renewable Europe

CenSES
Centre for Sustainable Energy Studies
Authors

Kjetil Trovik Midthun  
Senior Research Scientist, SINTEF

Asgeir Tomasgard  
Professor, NTNU  
Senior Research Scientist, SINTEF  
Director, CenSES

Bjørn Harald Bakken  
Research Manager, SINTEF Energy AS

Atle Harby  
Senior Research Scientist, SINTEF Energy AS  
Director, Cedren

Audun Ruud  
Research Scientist, SINTEF Energy AS

Ingeborg Graabak  
Research Scientist, SINTEF Energy AS

Ánund Kilingtveit  
Professor, NTNU  
Vice Director, Cedren

Marte Fodstad  
Research Scientist, SINTEF

Christian Skar  
PhD candidate, NTNU

Gerard L. Doorman  
Professor, NTNU

CenSES
Centre for Sustainable Energy Studies
Status

• Cooperation between FMEs CenSES and CEDREN

• Technoport Talk in Trondheim in June 2013
  • Debate: Ola Borten Moe, Connie Hedegaard, Asgeir Tomasgard
  • Summary of the Position Paper prepared for Technoport Forum

• Draft version finished July 2013
• Final version will be finished soon

• Based on results from projects such as LinkS, BM-MPM, EU FP7 TWENTIES, Ramona, and others
Outline

Background and motivation
Research questions / Limitation of scope
Example of results
Conclusions
Background / motivation

- Increased power generation from renewable sources in Europe towards 2050
  - Reported in numerous scenario studies
  - The non-dispatchable nature of many renewable sources leads to an increase in the need for balancing services
    - Multiple time scales
    - Periods with considerable deficit energy, and periods with considerable surplus energy
- What is Norway's potential for providing Europe with flexible services and balancing energy?
Contents

The Norwegian power and natural gas system – status and expected developments
Need for flexibility and balancing services due to increased renewable energy production
Operational benefits and challenges for integrated power system balancing in Northern Europe
Energy scenarios for Europe towards 2050
Environmental issues
Flexible energy services from Norway
Wind power in Europe (EWEA)
Wind Power North-Sea Region - Jan – March 2001
Hydro and gas for balancing power

Timesteps
Days and weeks (relate to wind power)
Day-night regulation (~12 hours)
Spot marked (1 hour)
Balancing marked (msec - 15 min)
Capital costs per cycle:

- Log scale

[Bar graph showing capital costs per cycle for different energy storage technologies, with PS2H having the highest cost and PSH having the lowest cost.]
Blåsjø
7.8TWh RESERVOIR
CEDREN Case study 2030
The technical potential

20 000 MW in southern Norway possible
Flexibility – natural gas

Natural gas is easily storable

- Reservoirs
  - Seasonal variations, weekly variations
- Linepack
  - Day to hours balancing
- Conventional storages
- LNG storages / the value chain for LNG
Yearly deliveries from Norway

**Billion sm³ gas**

**Energy content (TWh)**

![Graph showing yearly deliveries from Norway in billion sm³ gas and energy content (TWh).]
Daily capacity

Pipeline capacity (Msm³)

Capacity in GWh

CenSES
Centre for Sustainable Energy Studies
Research questions

- How will different policy scenarios influence Europe’s need for flexibility services?
- What are the Norwegian capabilities to be part of the solution by providing flexibility to the European energy market, both from the natural gas system and from the hydropower system?
- Which uncertainty faces potential investors in energy infrastructure and generation capacity providing flexibility to Europe?
- How may this uncertainty be reduced and by whom?
Limitation of scope

• Analyze the added value from the flexibility of the Norwegian energy resources as a service, not the export of energy in itself
  • net energy export may be zero
• We do not consider prioritization between power production and energy savings/efficiency or energy export versus alternative use of energy (for instance, electrification)
• We only study the power market
Energy scenarios

- **Global 20-20-20**
  - The rest of the world adopts the three policy targets in the European 20-20-20 program but at different points in time. Renewable portfolio standards, energy efficiency improvements and share of bio fuel in the transportation sector are set for different regions across the world

- **450 ppm stabilization**
  - A policy scenario where the atmospheric concentration of greenhouse gases is limited to 450 ppm CO$_2$-eq by the end of the century. Emission reduction is achieved by implementing a carbon price

- **650 ppm stabilization scenario**
  - A policy scenario where the atmospheric concentration of greenhouse gases is limited to 650 ppm CO$_2$-eq by the end of the century. Emission reduction is achieved by implementing a carbon price (but at a slower rate than in the 450 scenario)
Analysis method

Global IAM

The EMPIRE power system model

break down

Demand, fuel prices, CO₂ prices

SINTEF

NTNU – Trondheim Norwegian University of Science and Technology
Results from GCAM

Energy demand in Europe

CO2 price
EMPIRE

- Power system design and operation
  - Models each European country’s generation capacity and import/export channels, not physical lines
  - Time horizon until 2050 – investments in 5 year steps
  - Model operational time periods: demand, supply (stochastic wind and solar PV) and optimal dispatch.

- Taking fuel prices, expected load and costs as input
- Provides a cost minimization capacity expansion plan for Europe, detailed for each country
Energy mix in Europe

CenSES
Centre for Sustainable Energy Studies
New infrastructure

650 ppm

450 ppm

Global 202020

--- No invest
--- 0.5 GW
--- 1 GW
--- 2 GW
--- 3 GW
--- 4 GW
--- 5 GW
--- 10 GW

Centre
Result example: Power exchange

450 ppm

650 ppm

202020

GWh/h

Season 1
Season 2
Season 3
Season 4

GWh/h

Season 1
Season 2
Season 3
Season 4

GWh/h

Season 1
Season 2
Season 3
Season 4

CenSES
Centre for Sustainable Energy Studies
Result example: Electricity from NG

450 ppm

650 ppm

202020
Conclusions

Uncertain future – many scenarios
Rapid changes may come (…Fukushima)

Natural gas is easily storable and may provide substantial flexibility
Hydro reservoirs = always an excellent energy storage

We probably need governmental agreements and new markets
Large opportunity for Norway to investigate

We are currently performing quality checks of the results in the paper and plan to publish it soon