The Impact of Climate Change on the Renewable Energy Production in Norway

2013 International Energy Workshop

Arne Lind, Eva Rosenberg, Pernille Seljom & Kari Espegren

Institute for Energy Technology

Flooding: Random occurrences or …

Outline

- Introduction
  - Purpose of study
- Methodology
  - Climate data
  - Renewable resources
  - Modelling framework: TIMES-Norway
- The impact of climate change on the energy system parameters
  - Change in hydro inflow
- Analyses and results
  - Assumptions and scenarios
  - Electricity production and export
  - Renewable fraction
  - Transport sector
- Concluding remarks

Purpose of study

Goal:	Identify how changes in renewable energy resources and end use demand, due to climate change, influence the entire Norwegian energy system
Sub objectives:	1) Study the effects on a regional level, and 2) Special focus on renewable energy production
Input:	10 Norwegian climate data experiments – Derived from various global climate models and emissions scenarios
Tools:	Climate models, end use demand models & TIMES-Norway
Results:	The effects of climate change at the national and regional level of the Norwegian energy system

The Norwegian energy system

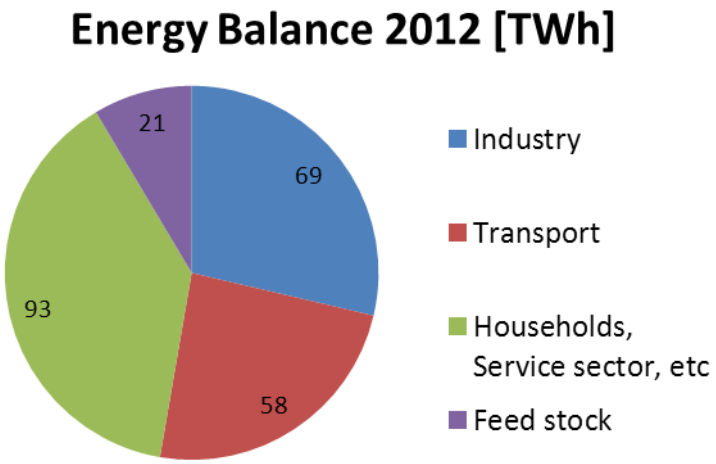
Electricity production is mainly based on hydropower (~99%)

Some potential for new run-of-river hydropower

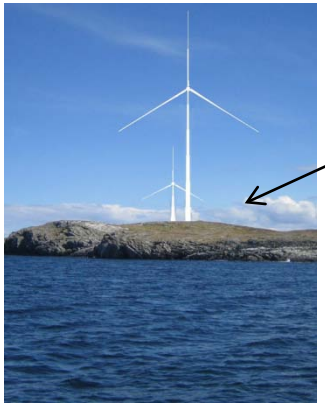
Huge potential for both onshore and offshore wind facilities

Cold climate -> High demand for space heating

Electricity has been relatively inexpensive

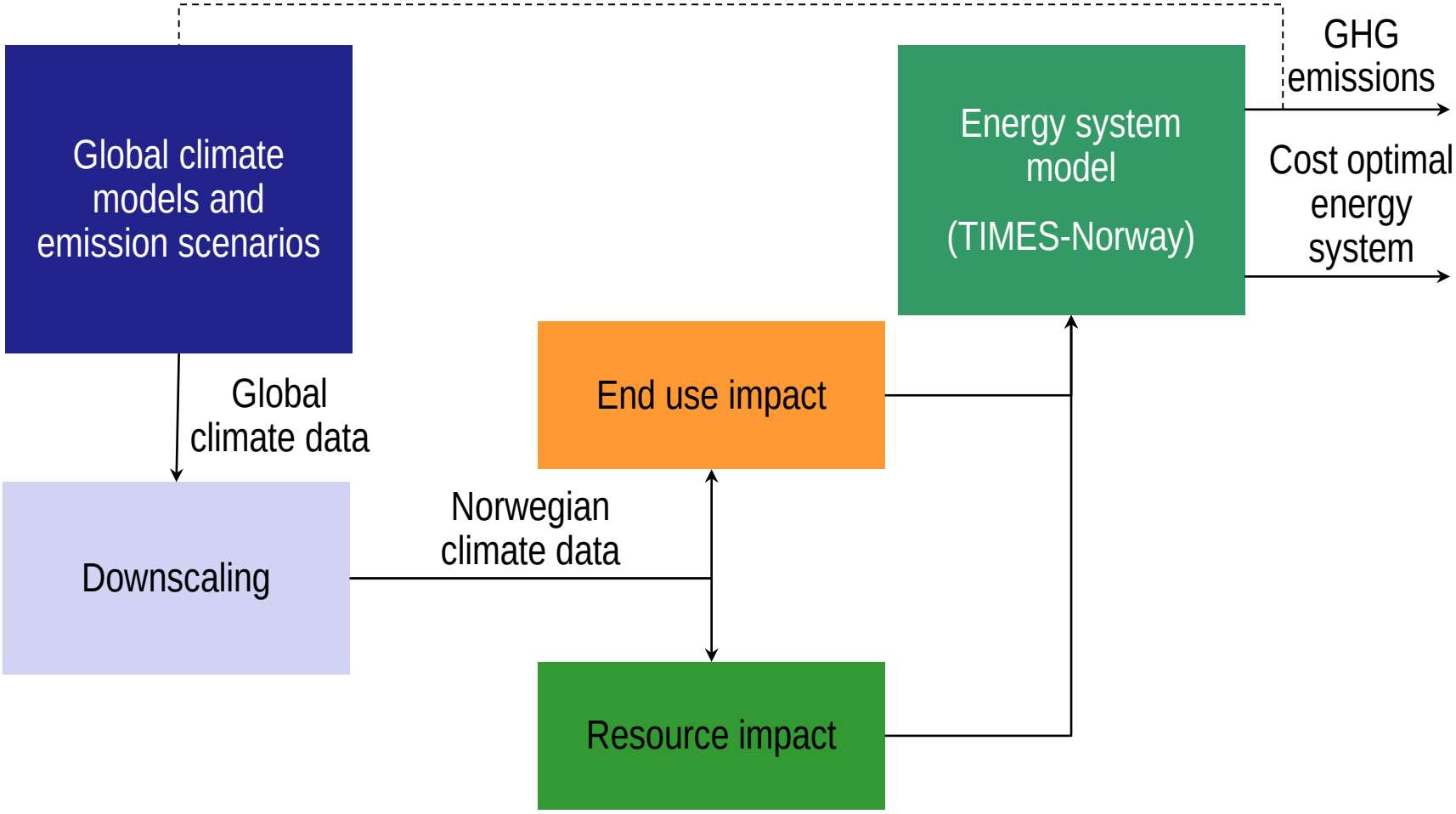


Future?



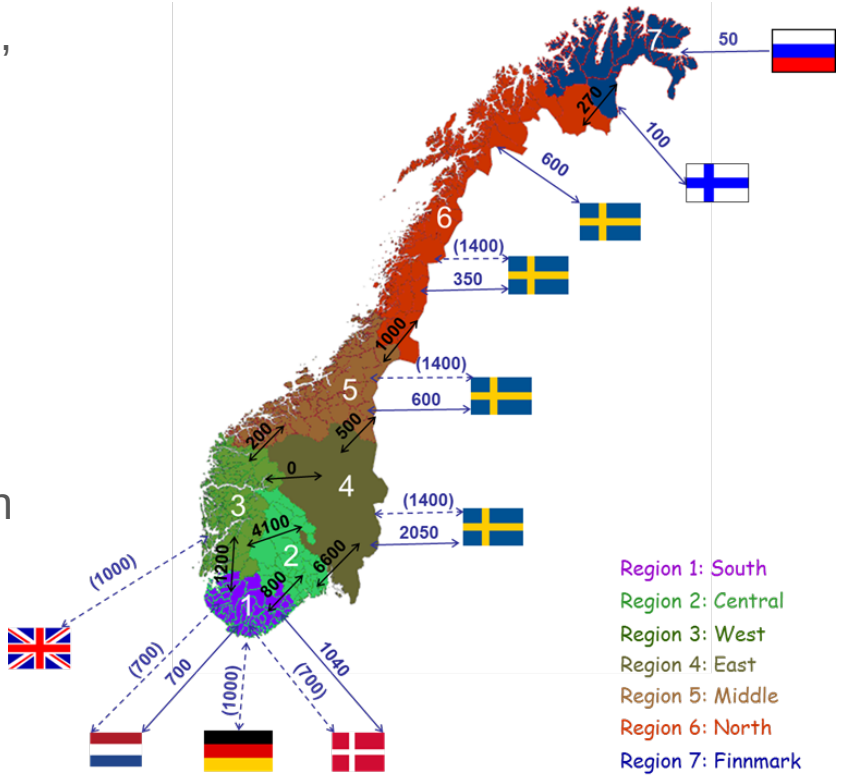
Methodology

Methodology overview



Modelling framework: TIMES-Norway

- TIMES-Norway is a national, bottom-up, techno-economic optimisation model
  - The model has a high time resolution and a model horizon from 2006 to 2050
- TIMES-Norway covers seven Norwegian regions
  - Exchange of electricity between regions
  - Exchange of electricity between neighbouring countries
- The model assumes perfect competition and perfect foresight and is demand driven
- Energy demand is exogenous input to the model
  - 75-78 end use groups per region



The impact of climate change on the energy system parameters

The impact of climate change on the energy system parameters

- The future increase in Norwegian hydro power potential varies from 3.7% (Exp. 4) to 13.5% (Exp. 9*)
  - The impact is larger for the scenarios that are adjusted with a hydrology model (*)
  - On average, the mean precipitation in Norway is expected to increase for most regions and seasons
    - ✓ Large variability between scenarios
- No clear relation between precipitation level and CO_2 concentration
- Climate change will also result in a larger share of flooding
- Changes in average and maximum wind speed are rather small
- The temperature change at different locations were analysed to vary from a monthly increase of 0.5 to 4°C
- The solar radiation levels both increased and decreased depending on location and time of year

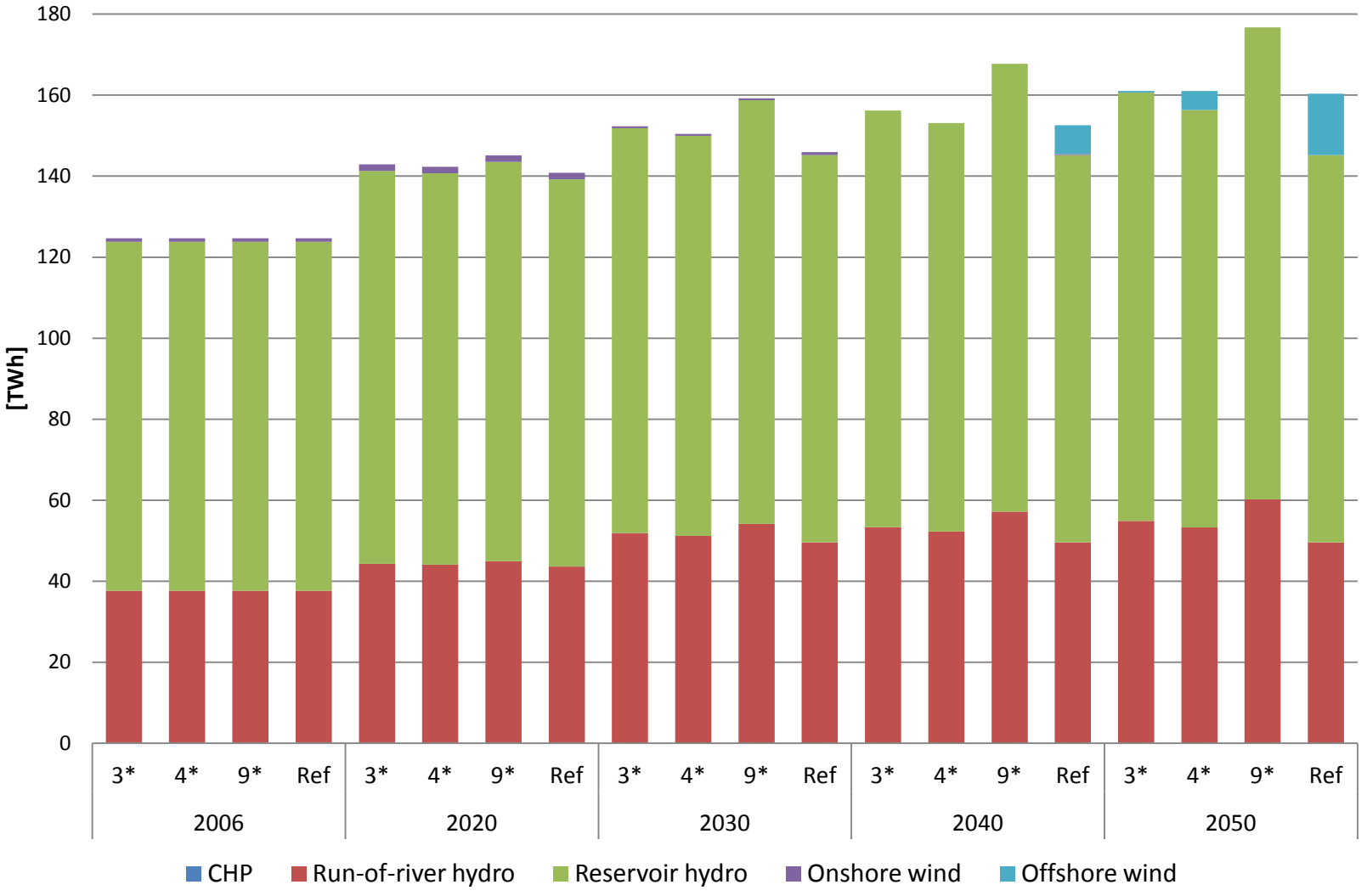
2008-06-11

Analyses and results

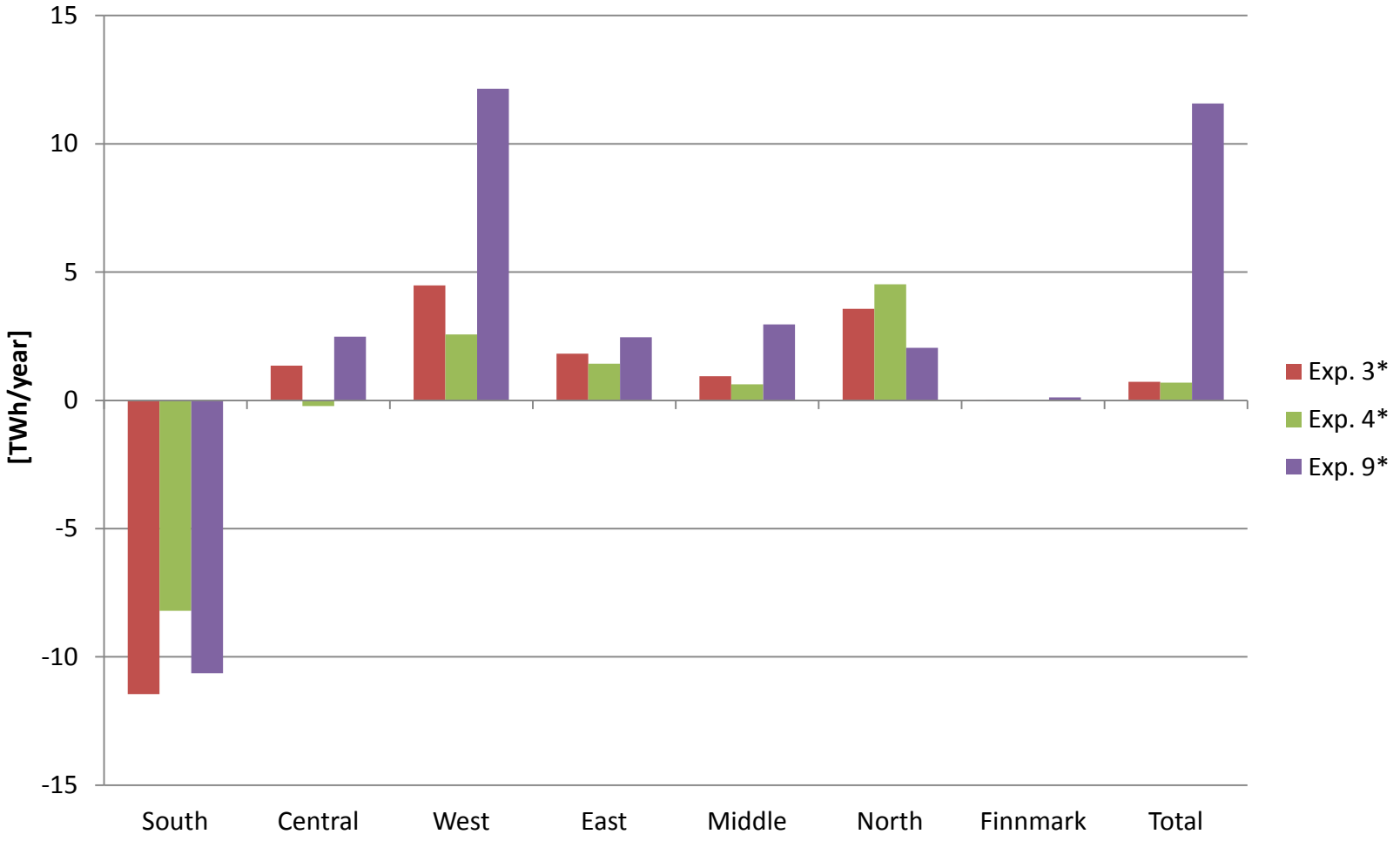
Assumptions and scenarios

- Base scenario
  - Includes active national measures of today
    - ✓ E.g. green certificate market and present policy measures of Enova (e.g. investment grants)
    - ✓ CO_2 market price is included as a CO_2 tax in the analyses
  - The energy taxes are kept constant at the 2010 level
  - Development in energy prices are equal to the *Current Policy Scenario* (ETP 2012)
    - ✓ The prices of electricity exports/imports are given exogenously (N-ETP 2012)
- Climate change scenarios
  - The TIMES-Norway model is used to analyse how climate change will affect the composition of the Norwegian energy system
- End use demand sensitivities
  - The effect of variations in demand is studied through analyses with different demand sensitivities
    - ✓ High population, low industry demand, electrification offshore and industry clusters

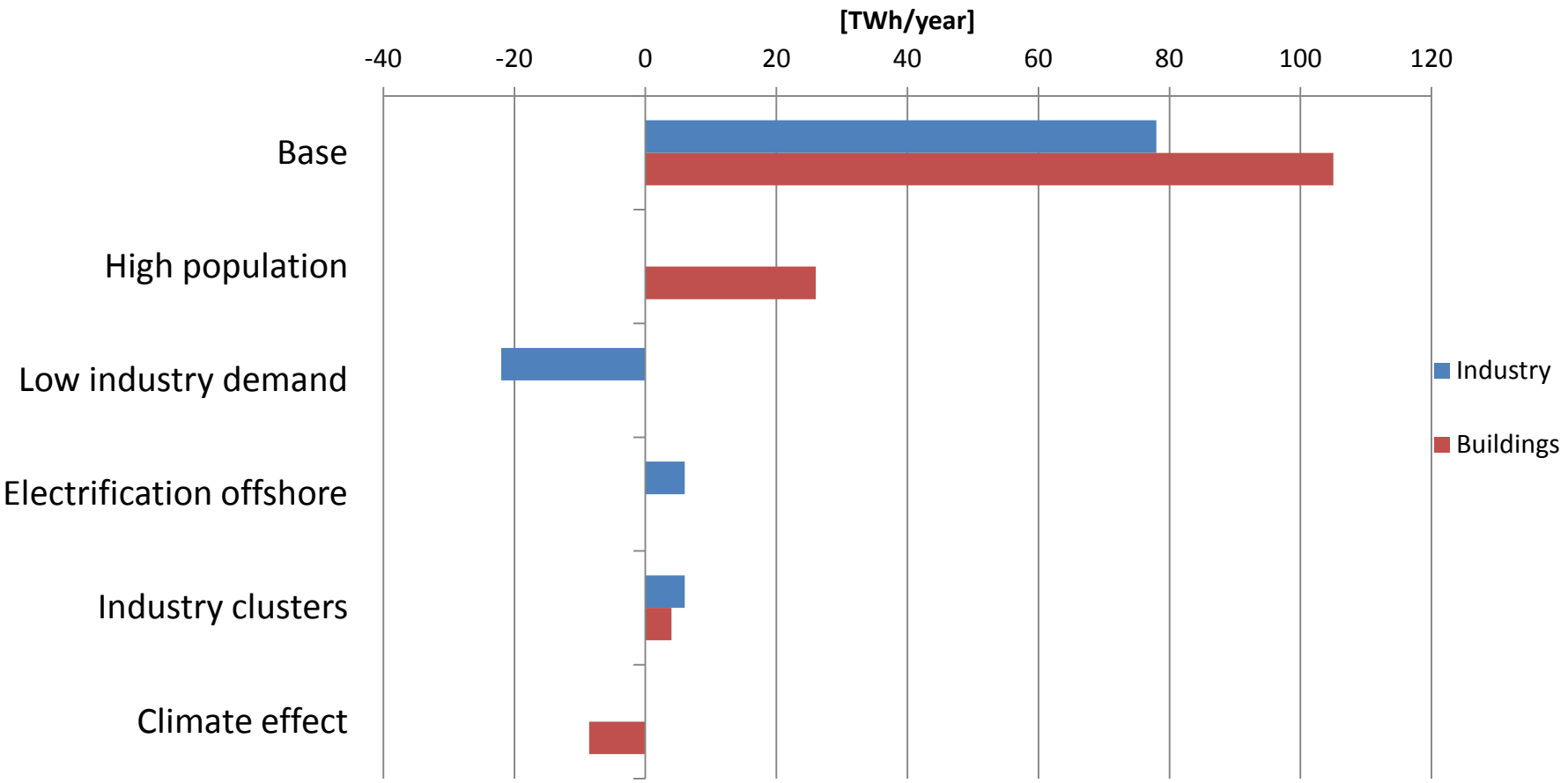
Electricity production



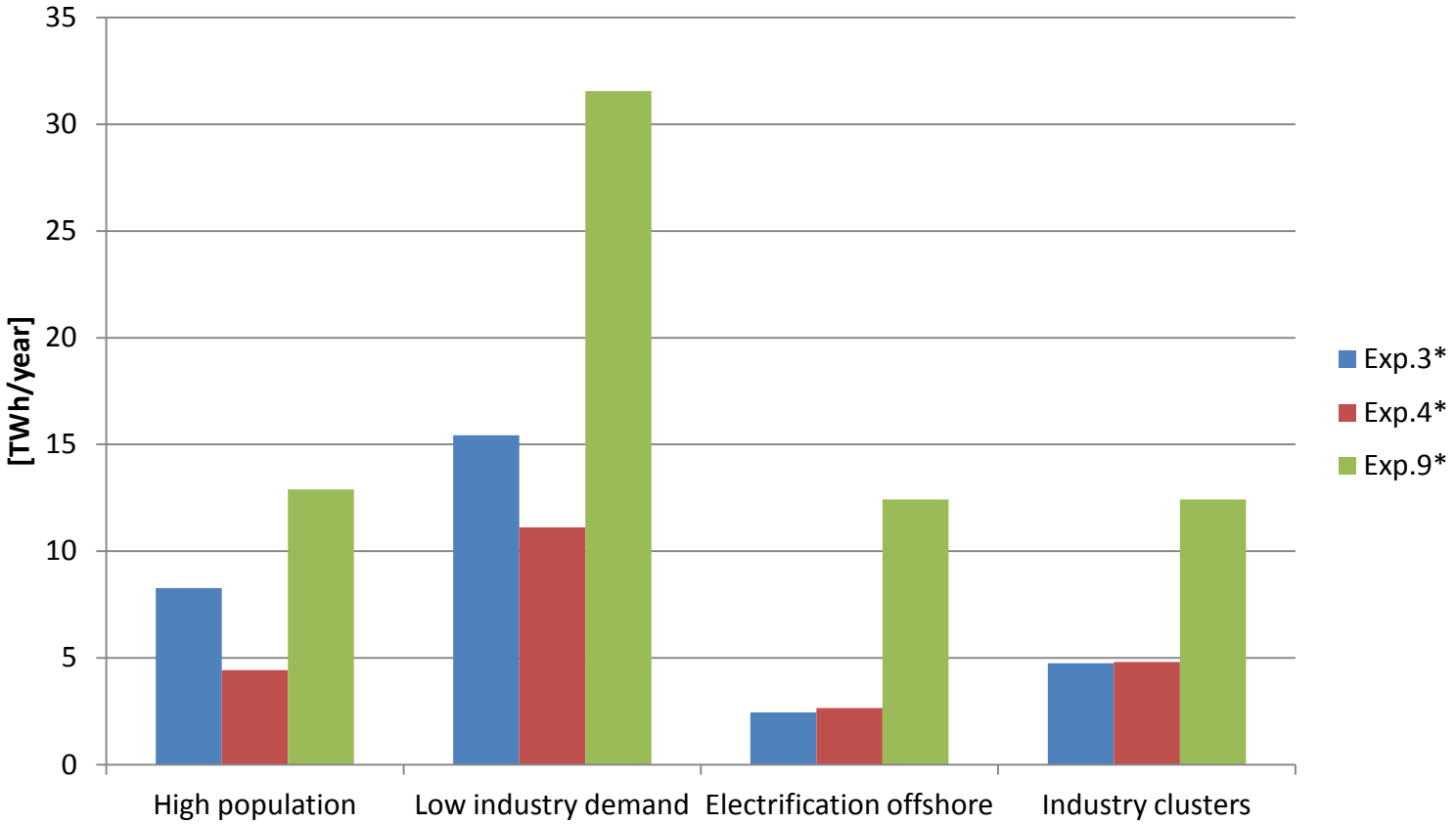
Electricity production per region (2050)



Energy demand 2050

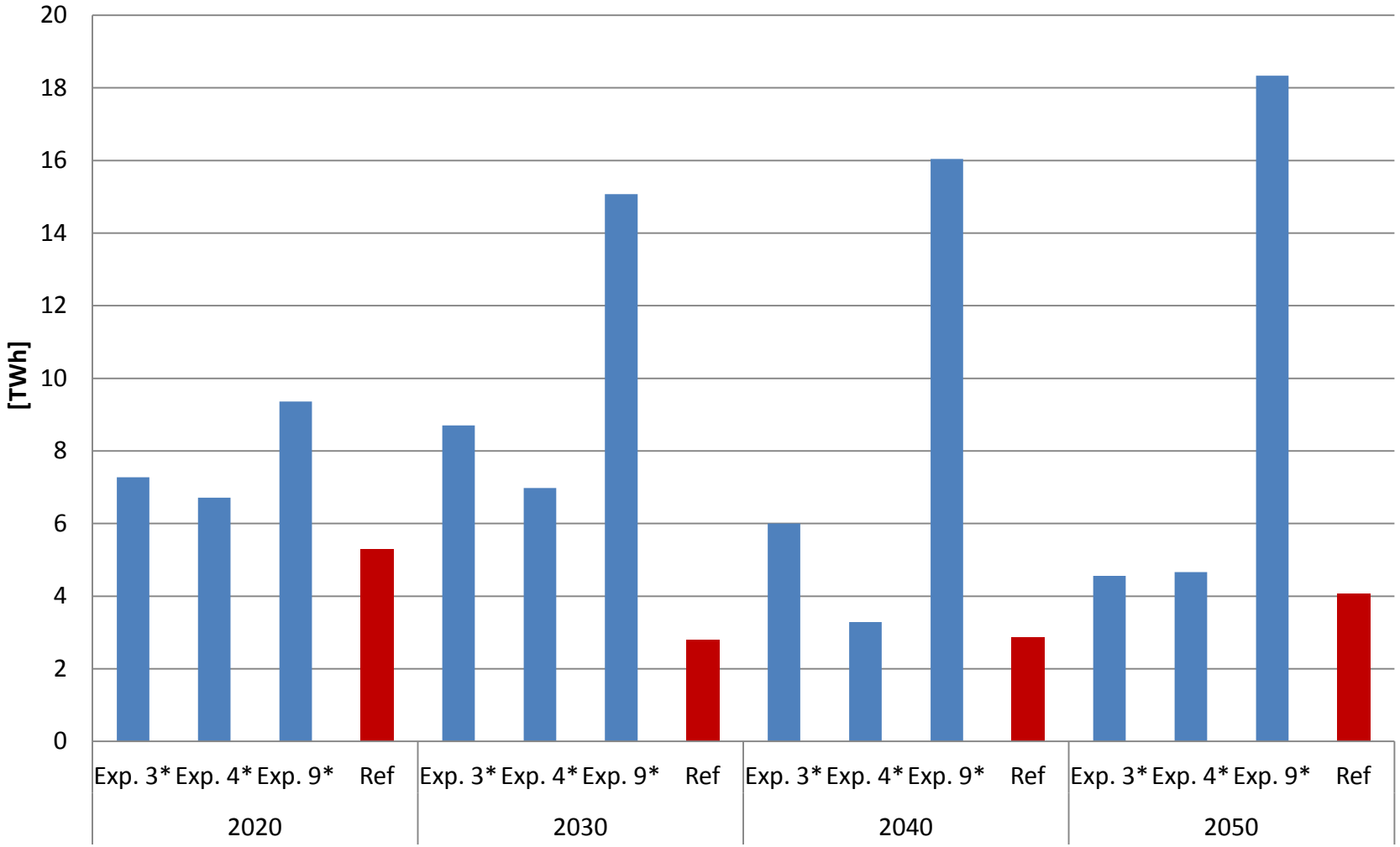


Change in electricity production 2050

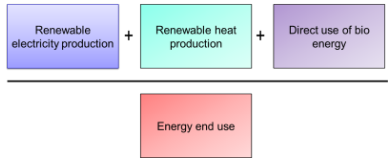


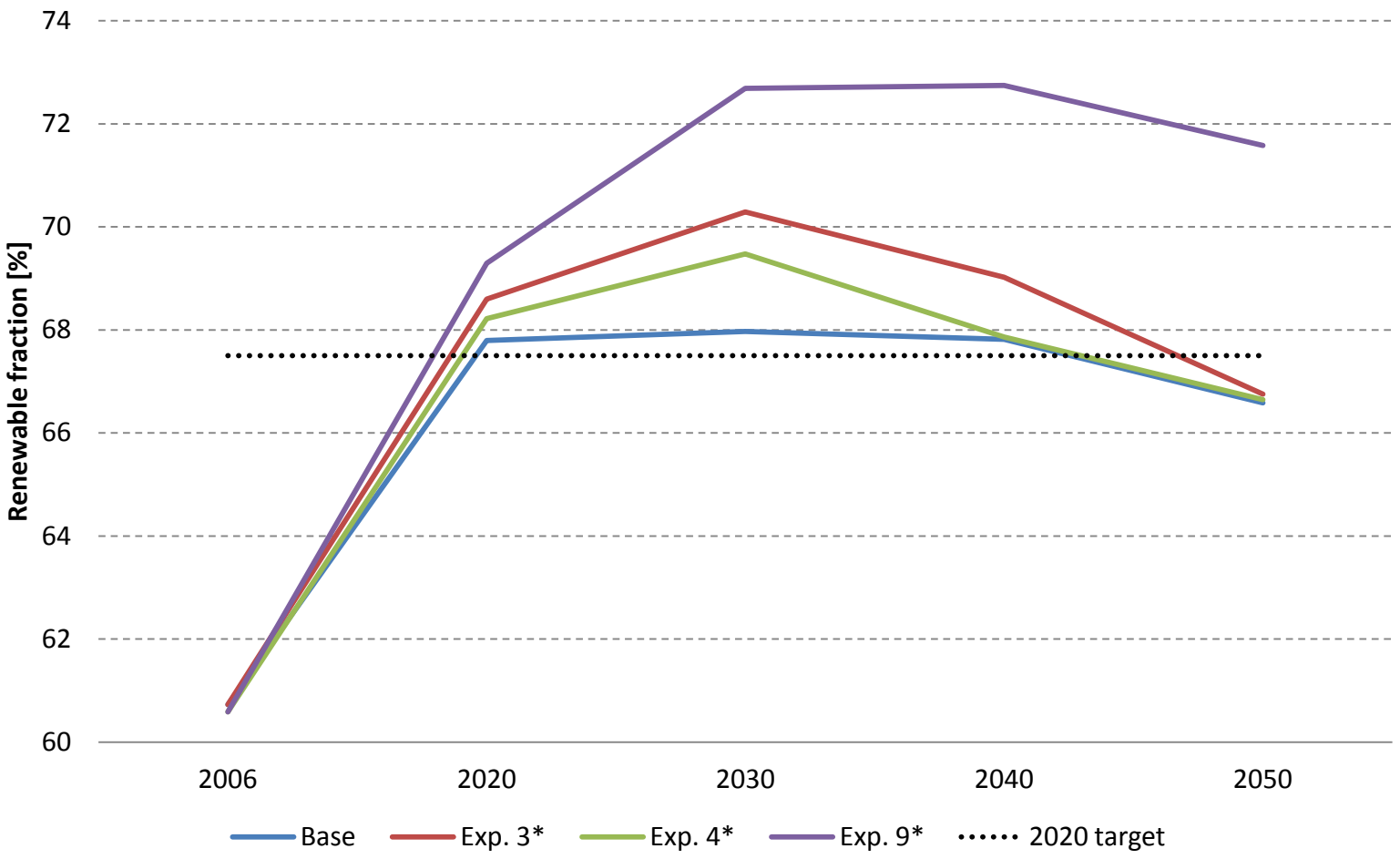
Ref values:	171 TWh	145 TWh	164 TWh	164 TWh

Net electricity export

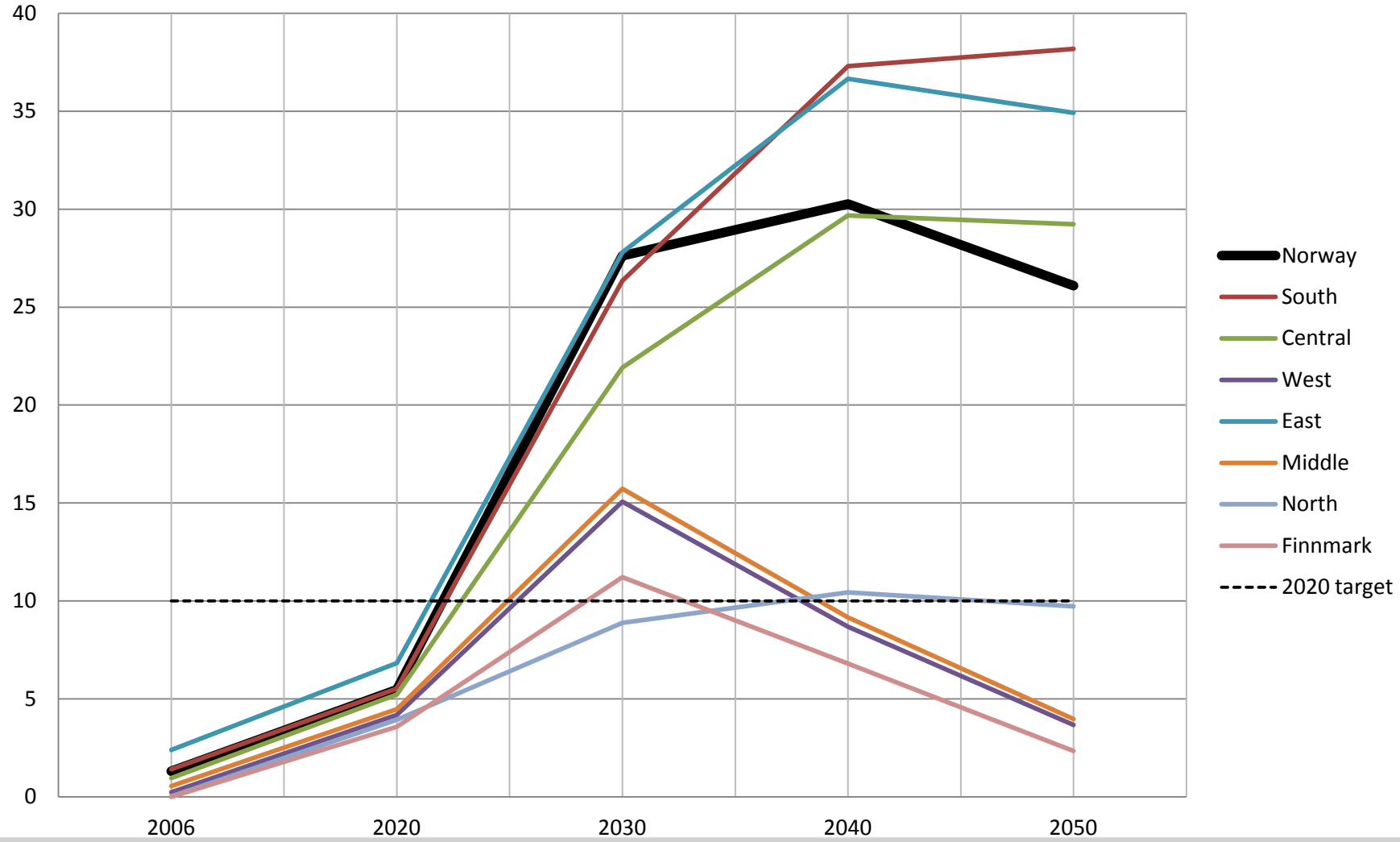


Renewable fraction





Renewable transport fraction



Concluding remarks

Conclusion

Power production

- GCM promotes new projects before 2020
- Climate change effects increase the power production from existing hydro power plants
- Climate change affects investments in offshore wind power
- Increased power production for all end use demand sensitivities (- low industry demand)

Net electricity export

- Varies from 0 to 34 TWh in 2050
- Increased net export for all climate scenarios
- Decreased net export for all end use demand sensitivities (- low industry demand)
- Results from N-ETP showed a net Nordic export of 40 to 100 TWh in 2050

Renewable fraction

- Reaches a maximum value around 2030
- Limited investments in renewable technologies after 2030 but the energy use continues to grow
- Need for additional measures after 2030 to maintain a high renewable share

Overall conclusion

- Consistent trend for all climate scenarios
- Lower heating and increased cooling demand
- Higher hydropower potential
- Limited impact on the wind power potential

Thank You!

Arne Lind, PhD
Research scientist

Institute for Energy Technology
2027 Kjeller, Norway

e-mail: arne.lind@ife.no