

The future Norwegian Energy System in a European context

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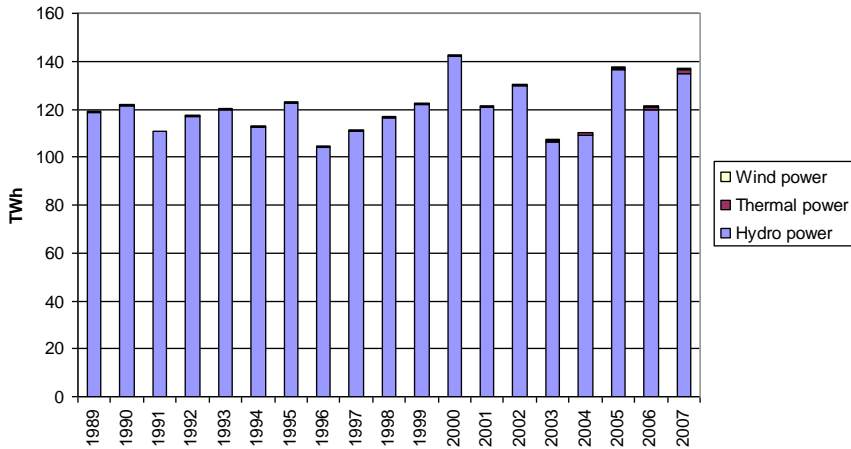


Content

- Some facts about the Norwegian energy system
- The Norwegian TIMES model
- The North European TIMES model
- Ongoing work: Wind data
- Concluding remarks



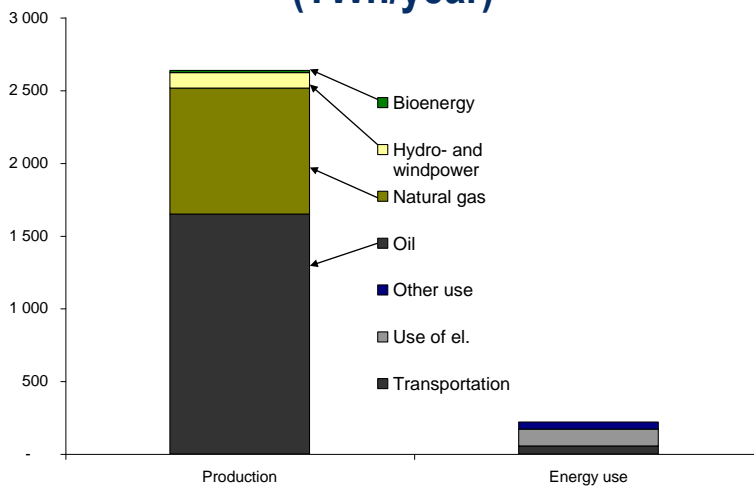
Electricity production in Norway



27.07.2011



Energy production vs final energy use (TWh/year)



27.07.2011

(Source: SSB)



Electricity consumption in Norway

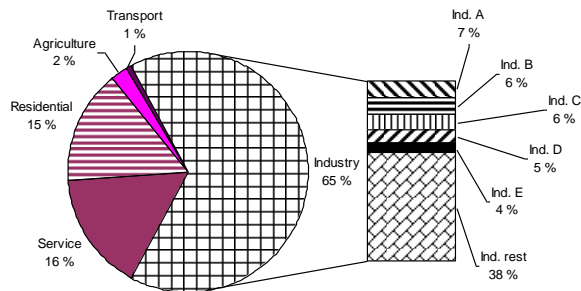


Figure : Norwegian electricity consumption by end-use in 2006

Industry: Pulp & paper, aluminium, other metal industries, chemical industry, refineries & other industries

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Norwegian TIMES model (2005 -2050)

- Previous developed to 2020, currently extended to 2050
- Norway is divided into seven regions
- High time resolution (260 per year)
 - Better presentation of intermittent power, storage and trade
 - Each week is divided into

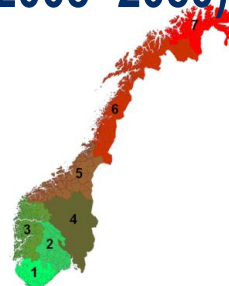
Day 1	07 – 11
Day 2	11 – 17
Day 3	17 – 23
Night	23 – 07
Weekend	23 Friday to 23 Sunday
- Can be linked with EMPS; power system model
 - From EMPS: Electricity prices
 - To EMPS: Electricity demand



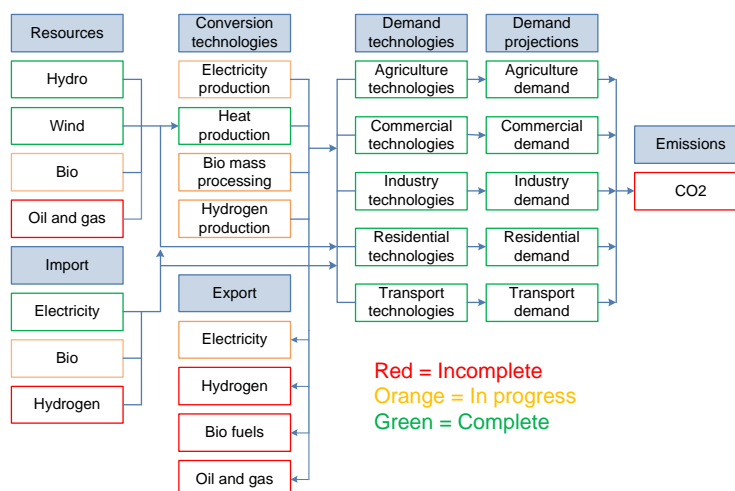
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Norwegian TIMES model (2005 -2050)

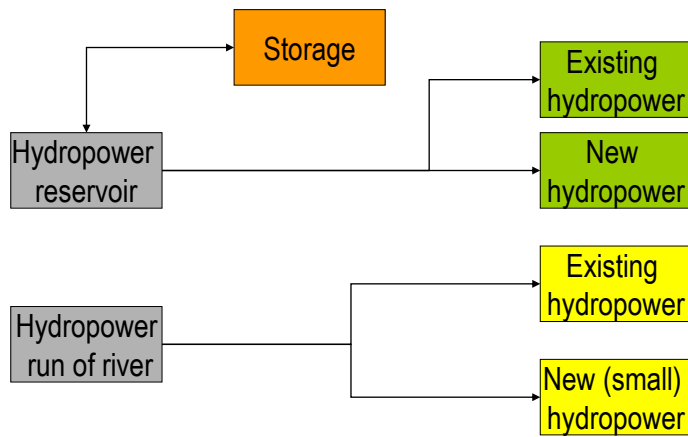
- Demand categories in each region
 - Agriculture (3)
 - Commercial (21)
 - Industry (33 -36)
 - Residential (10)
 - Transport (8)
- Exchange of electricity between regions
- To do:
 - Endogenous exchange of CO₂, fossil fuels, bio fuels, bio mass and hydrogen between regions
 - Improved infrastructure modelling
 - ++++++
- The model is large and we try to reduce the complexity



Norwegian TIMES model (2005 -2050)



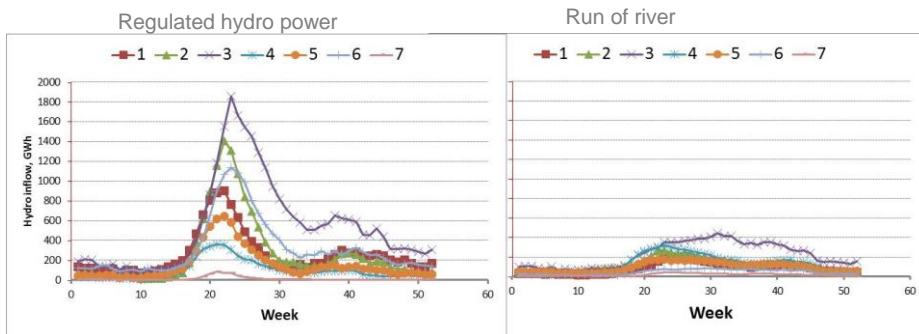
Modelling hydropower



19.06.2009



Modelling hydropower



19.06.2009

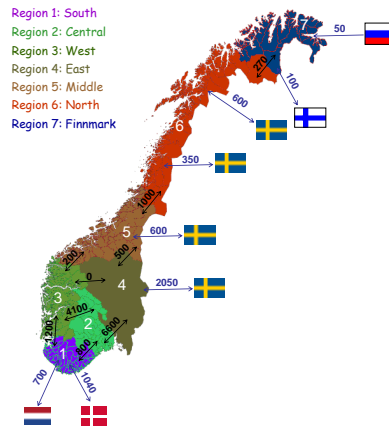


North European TIMES model (2005 - 2050)

Oil and gas infrastructure



Electricity infrastructure

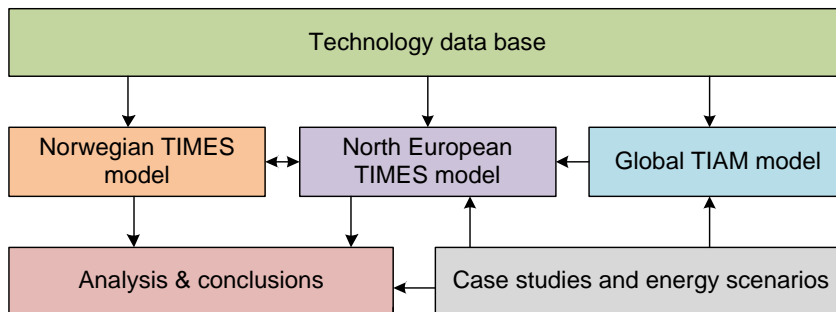


North European TIMES model (2005 - 2050)

- On going project (2011 – 2014)
- High time resolution North European model
 - Covering Nordic and North European countries
 - With basis on the Norwegian regional TIMES model
- Link Norwegian and North European analysis with global analysis → TIAM
- Improved modelling of intermittent energy sources
 - Wind
 - Unregulated hydro



North European TIMES model (2005 - 2050)



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North European model (2005 -2050)

Examples of research questions:

- How will the different global energy scenarios affect Norway and the North European region?
- What will be the role of Norwegian hydropower as a regulator of European wind power?
- What is the potential for pumped hydro?
- What are the consequences of a considerably increased share of intermittent renewable power production, like wind, in the system and how it can be integrated
- How is the future interaction between transport and the power sector?

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North European TIMES model (2005 - 2050)

Improved modelling of intermittent power

- Traditionally a peaking reserve constraint is used
 - Total capacity of all processes producing a commodity must exceed the demand
 - Wind speeds above average is not considered
 - Suitable to model energy storage?
- A small Gams model will be developed to compare
 - Peaking reserve constraint for wind turbines
 - Stochastic modelling of wind speeds / availability
- If results differ:
 - Implement an improved method to TIMES



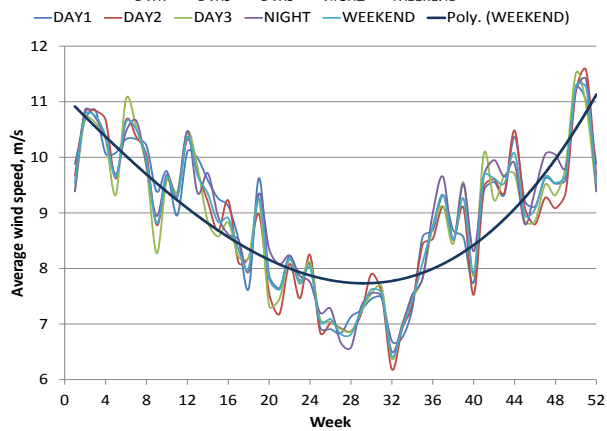
Ongoing work: Wind data

- Improved wind turbine data for the 7 Norwegian regions
 - Availability
 - Wind profiles
 - Peaking reserve constraint
 - Wind turbine cost classes
 - Weibull distribution
- Using hourly wind speed data for the past 11 years for representative measuring stations
- Assumptions
 - Cut-in speed: 3.6 m/s
 - Cut-out speed: 26 m/s
 - Wind turbine height: 100 m above sea level



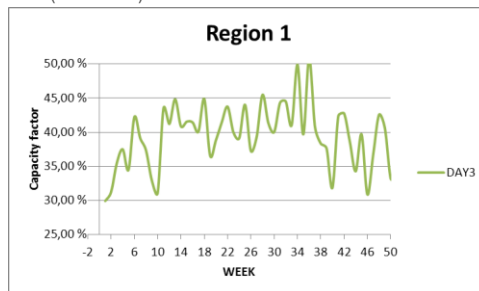
Ongoing work: Wind data

Region 6: Average wind speed, Fakken, 2000 - 2011



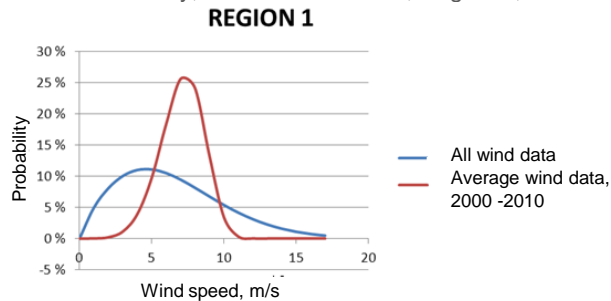
Ongoing work: Wind data

- Peaking reserve constraint calculated
 - Average & per time period
- Example region 1:
 - Average peaking reserve constraint: 32.5 %
 - DAY 3 (afternoon):



Ongoing work: Wind data

- Wind variability, Weibull distribution, Region 1, 2000-2010:



- The average wind speed is higher than the wind speed that has the largest probability to occur



Concluding remarks

- A long term Norwegian TIMES model and a North European TIMES model is under development
 - High time resolution
 - Focus: The future interaction between Norway and its neighbour countries
- Improved modelling of intermittent energy resources
 - Is the peaking reserve capacity method sufficient?
- Wind data
 - Average wind speed data, variability in wind speed data
 - Peaking reserve constraint
- We are interested in cooperating with teams having the same challenges!





Thank you for your attention!

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