

The impact of the EU Renewable Energy Directive on a hydro power based energy system

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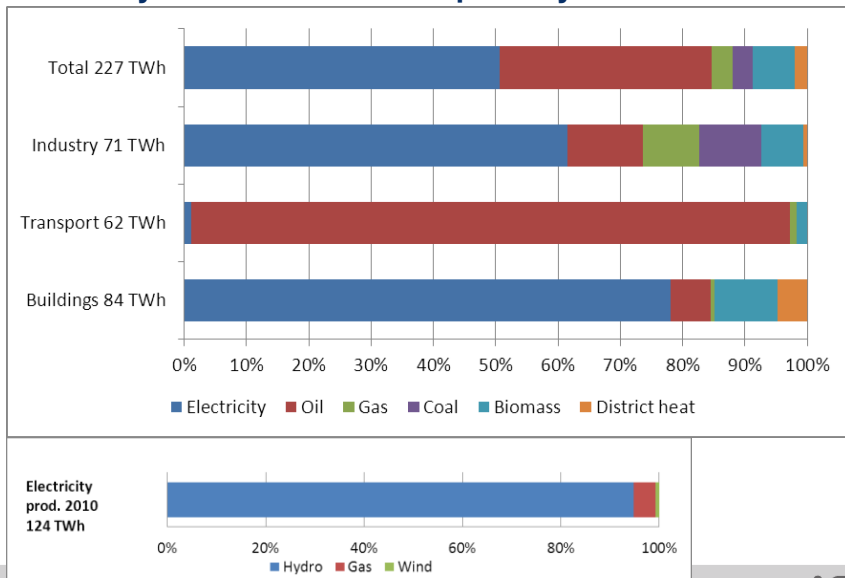
Outline

- Energy use and electricity production in Norway
- RES-directive and green certificates
- TIMES-Norway
- Results of RES-analyses with TIMES-Norway

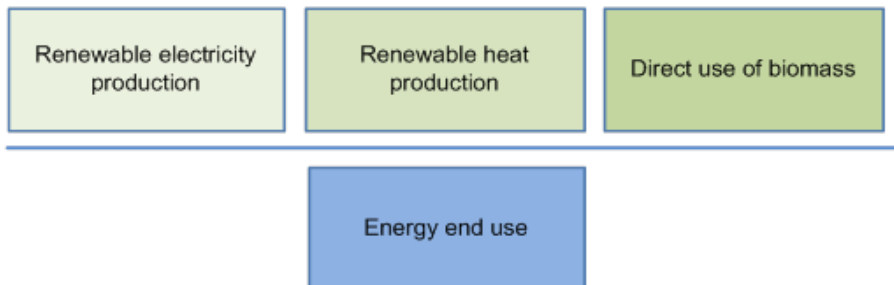
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Norway 2010 - Final consumption by sector and fuel



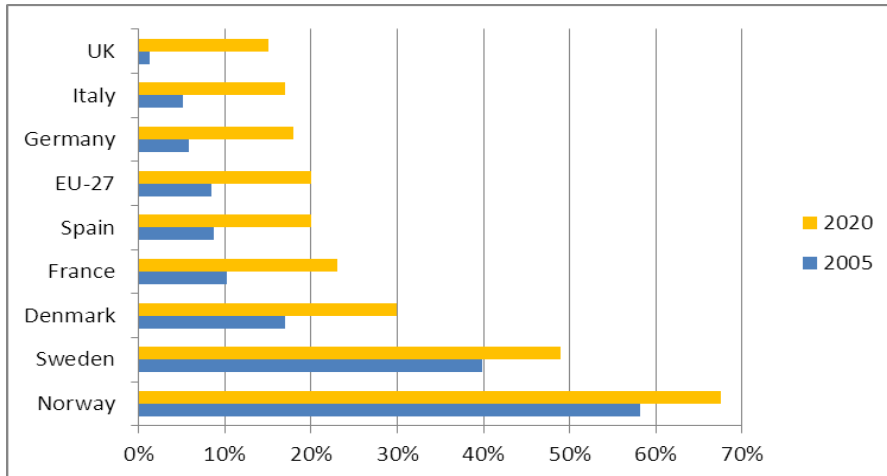
Modelling of the RES directive



Transportation target of 10 % biofuels



RES target in some selected countries



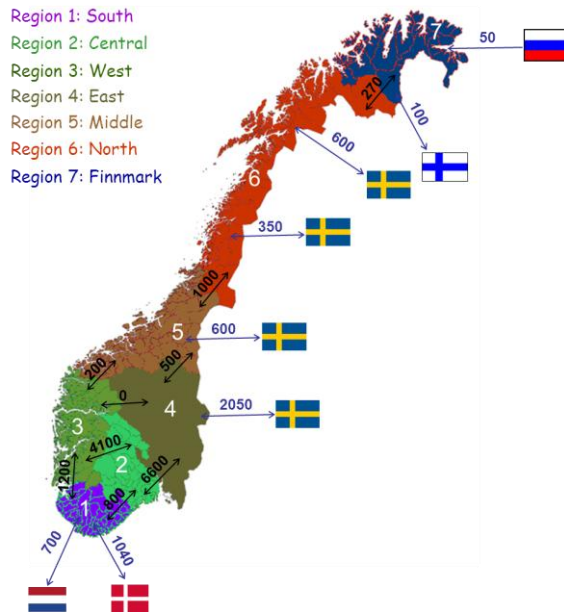
Green certificates

- Common market Sweden-Norway (1 Jan 2012)
- Annually 26.4 TWh new renewable electricity by 2020
- Each country counts 13.2 TWh in the RES-target
- Power producers receive electricity certificates from authorities
- Electricity customers covers the cost (added to the electricity bill)
- The certificate price is determined by supply and demand



TIMES-Norway

- 2006-2050
- 7 Norwegian regions
 - Exchange of electricity between
 - regions
 - neighbouring countries
- Can be linked with a power market model (EMPS)
 - From EMPS: Electricity prices
 - To EMPS: Electricity demand
- The regions were defined in order to be used with the Multi-area Power-market Simulator



Time resolution in TIMES-Norway

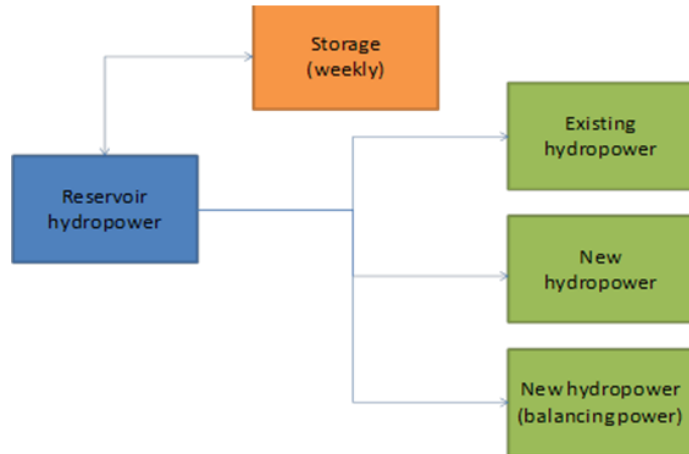
- A high time resolution was needed in order to have a very detailed description of the Norwegian hydropower system
 - Also needed in order to be used in connection with the Multi-area Power-market Simulator
 - Therefore, each week is divided into five time slices, giving 260 times slices annually:

Time slice name	Hours	Hours per week
DAY 1	07.00 - 11.00	20 (4 hours x 5 days)
DAY 2	11.00 - 17.00	30 (6 hours x 5 days)
DAY 3	17.00 - 23.00	30 (6 hours x 5 days)
NIGHT	Monday: 00.00 - 07.00 23.00 - 07.00 for all other weekdays	39 (7 hours + 8 hours x 4 days)
WEEKEND	Friday 23.00 - Sunday 24.00	49 (1 hour + 24 hours x 2 days)



Hydro power - Reservoir is modelled by weekly inflow series:

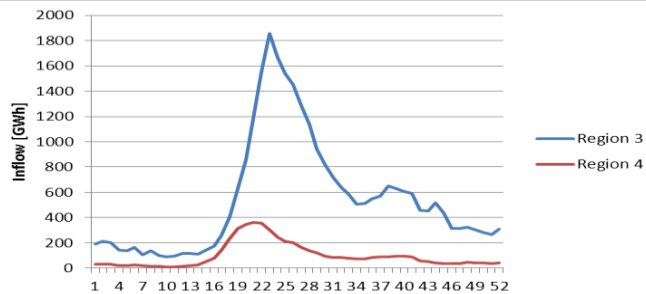
- The water can either be stored to the next period or be used directly to generate electricity within the period
- Electricity generation is divided between existing plants, new large scale plants and plants for increased capacity (balancing power)



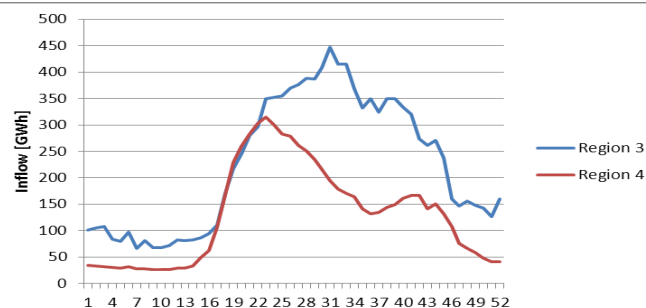
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Reservoir



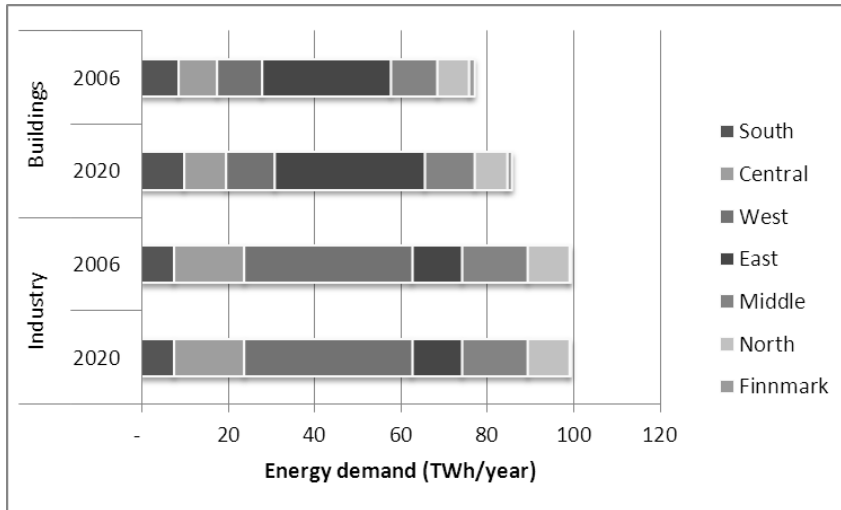
Run-of-river



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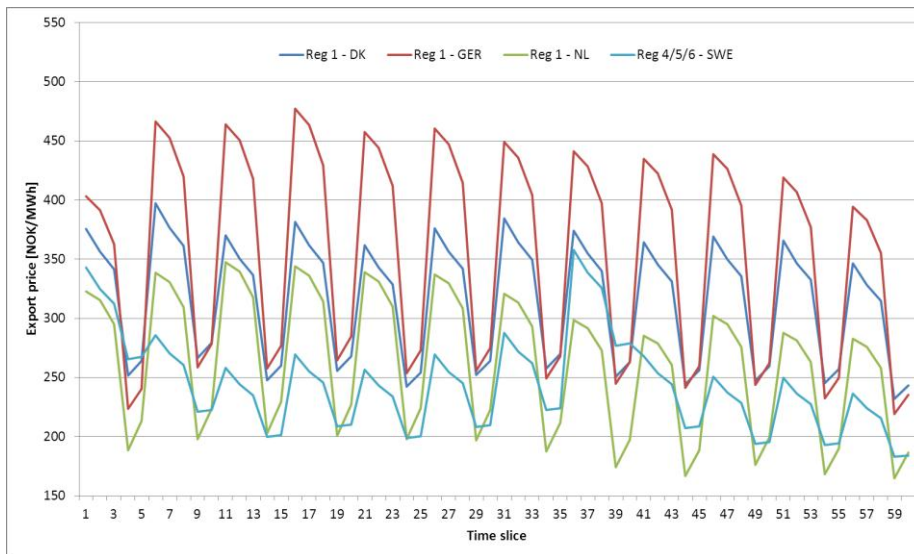
Energy demand forecast



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Electricity export prices in 2020



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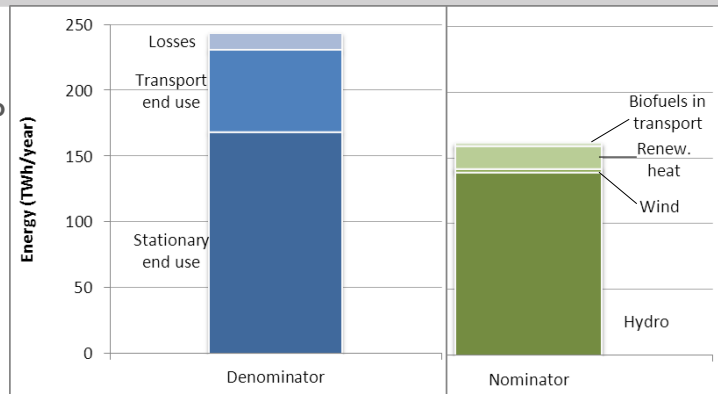


Analysed scenarios

Scenario	Description	Main scenario	Variant scenario(s)
Base	No RES constraint	Yes	High Hyd
RES + CER	Active RES constraint + Transport restriction + Green certificate market	Yes	High Bio & Low Exp/Imp
CER	Green certificate market	Yes	High CER
High Hyd	Higher hydro power investment costs	No	
High CER	Green certificate market with higher certificate prices	No	
High Bio	Higher cost of biodiesel and bioethanol + Active RES constraint + Transport restriction + Green certificate market	No	
Low Exp/Imp	25% lower export and import prices to neighbouring countries	No	

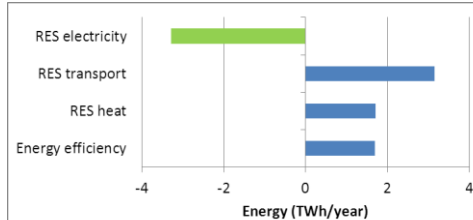


Base case
 + 15.5 TWh hydro
 + 1.4 TWh wind
 + 2.1 TWh renewable heat

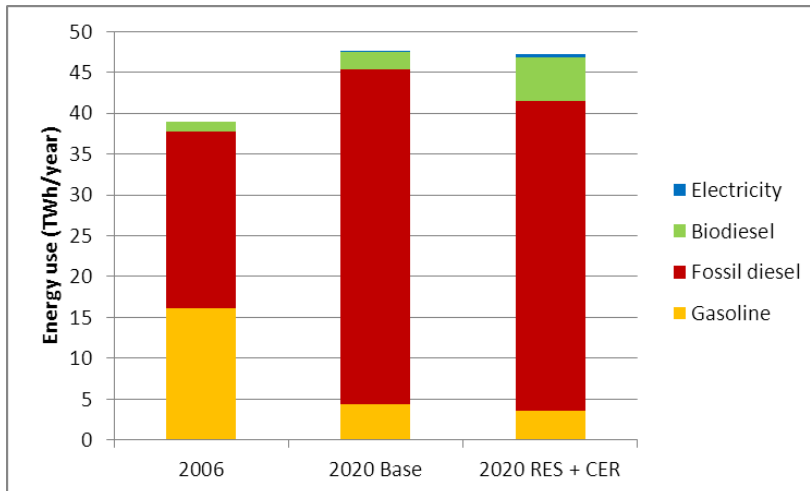


RES-directive and green certificates

- Higher certificate prices gives more wind power
- Lower electricity export prices gives less el. prod. and less export



Fuel use in road transportation



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Conclusions

- Both the overall RES target and the transport constraint for 2020 can be achieved with a diversity of options including:
 - hydro power
 - wind power
 - high-voltage power lines for export
 - various heat pump technologies
 - energy efficiency measures (incl. more efficient cars)
 - more use of bio diesel in the transportation sector
 - More use of biomass for heating
- The green certificate market contributes to increased investments in:
 - wind power
 - renewable heat

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Thank you!

