Climate Change and the Future Nordic Energy System

with focus on the electricity system

Dag Henning
Optensys
Linköping, Sweden

Mikael Togeby
Ea Energianalyse A/S
Copenhagen, Denmark

European Conference on Impacts of Climate Change on Renewable Energy Sources Reykjavik, Iceland, 7 June 2006

Dag Henning
Optensys Energianalyse
Örngatan 8C
SE-582 37 Linköping
Sweden
phone +46 13 10 05 16
E-mail dag.henning@telia.com
www.optensys.se

Mikael Togeby
Ea Energianalyse A/S
Frederiksholm Kanal 1
DK-1220 København K
Denmark
phone +45 60 39 17 07
E-mail mt@eaea.dk
www.eaea.dk

20 minutes
Direct and in-direct impact of climate change on the energy system

Changes in average climate properties (average values for temperature, wind and precipitation) influence e.g. the demand for electricity and the electricity production from hydro and wind power.

Changes in extreme climate events, like storms and floods (due to heavy rain) (and long periods with unusually high or low temperatures.)
Security of supply is threatened, e.g. dam security (and backup for wind power and reliability of overhead lines)
A vulnerable energy system, disruption of power supply, uncertain frequency and seriousness of extreme weather

Economic activities may be (directly) influenced: agricultural production (and energy-intensive industry due to altered energy policy)

Responses to consequences of climate change: Ambitious energy policy may limit CO2 emissions and support renewable energy sources and energy efficiency.
Harmful impact expand the use of policy instruments: Taxes and emission allowances can raise the cost for fossil fuels and green certificates and feed-in tariffs can promote renewable electricity.
Energy system development

- Outline of possible long-term developments for the Nordic energy system due to economic, technical and political changes
- Stationary energy system focus on the electricity system
- 2050
- Three scenarios
- A medium-path scenario: a continuation of current trends modest economic growth balanced energy policy

General development of the energy system

Not transportation

2050 - Most parts of the energy system are changed.

I will primarily present the medium path

Balanced energy policy, whatever that is

We consider the medium path most probable
Very uncertain and can be discussed
Even if you do not agree, these issues need to be considered
There is continuous interplay among various components in the stationary energy system, from energy sources, via conversion and distribution units to demand, which may be influenced in several ways.
Global energy demand and supply

- Global energy demand increases due to industrialization and enhanced standard of living in many countries.
- Increased energy demand and limited cheap energy supplies make energy carriers more expensive.
- Fossil-fuel use decreases.
- Better conditions for biomass production helps enhancing biofuel supply.

China and India - rapid growth

...energy carriers more expensive.
Therefore, and due to energy policy, fossil-fuel use decreases.

Climate change may bring about better conditions for biomass production
Condensing power plants produce electricity but the heat is wasted.

Renewable energy increases
primarily biofuel, wind power, solar energy
for which technologies already are more or less commercial

New technologies emerge:
better solar cells,

A technology that might be a means to reduce CO2 emissions is carbon dioxide capture and storage

Hydrogen is often mentioned as a part of the future energy system
Hydrogen is an energy carrier, not an energy source
Other sources have to be used to produce hydrogen
Market, distribution

- Nordic power grids more linked to continental Europe.
- A common European electricity market
- Long distance power transmission between countries increases.
- Power electronics, Flexible AC transmission systems (FACTS), superconducting cables
- Electricity flow controlled systematically: allows a high share of wind power.

CHP

- Efficient combined heat and power (CHP) production
- District heating: common in all Nordic countries?

Nordic electricity market is a part of
a common European electricity market

Electricity flow may be controlled systematically, allowing a high share of intermittent power production, e.g. wind power.
Energy demand

• Nordic electricity consumption per capita now much higher than EU average.
• Increasing temperatures reduce space-heating demand and its seasonal variations.
• Cooling demand in summer increases, but less.
Energy conservation
Energy-carrier switching

- Energy is used more efficiently.
- Heat can be recovered for repeated use in industry and for heating.
- Electricity used for heat production can be replaced by fuels, district heating or solar energy.
- Heat-driven cooling
- Industrial electricity consumption decreases to continental level.

Heat can be recovered for repeated use at different temperature in industry and finally for low-temperature space heating.

Electricity used for heat production can often be replaced by fuels, district heating or solar energy, which have sufficient quality for heating.

There are substitution possibilities for electric cooling

Heat-driven cooling
Absorption cooling driven by heat
Presupposes heat produced at low cost due to low efficiency
e.g. from waste incineration or industrial waste heat
Used in Sweden

Industrial electricity consumption becomes more similar to continental Europe, where less electricity normally is used for manufacturing one unit of goods.
Distributed generation, demand response

- Small-scale electricity (and heat) production, e.g. fuel cells
- Demand response
  Communication technology helps consumers change their demand.
  Delay demand to reduce peak generation
  Automatic demand control to avoid expensive periods
- Activate small-scale generation at high prices
- Dynamic nodal pricing
  Places have different prices due to local demand and supply.

Demand response
Also called load management
Communication technologies can enable consumers as players in the electricity system and influence the demand for energy supply
Demand may be delayed for some hours and in that way reduce the need for peak production.
Electronic equipment can automate the control of electric demand in order to avoid expensive periods and transmission congestion

Dynamic nodal pricing, an even more advanced concept
Places have different prices due to local demand and supply
which can be used to control distributed generation with demand-response equipment
Increased energy demand and limited energy supplies increase fuel prices.

The increasing connection to continental power systems will raise Nordic electricity prices to levels that are similar to continental Europe, which dampens electricity consumption.

Nordic electricity use normally increase operation and carbon dioxide emissions from the committed power plants with highest operation cost, now coal (in the future natural-gas) fired condensing plants.

Switching from electricity for space heating reduces seasonal variations of electricity consumption.

Switching from electricity to district heating for heat supply increases the heat sink for CHP production.

If I turn on the light in Sweden, more water is not used because almost all water is used anyway but more coal is fired in Germany.
Impact of demand-side measures

- Efficiency improvements reduce primary energy supply but not the benefit.
- Switching from electricity for heating reduces seasonal variations of electricity consumption.
- Switching from electricity to district heating increases the heat sink for CHP production.

Efficiency improvements reduce primary energy supply but not the benefit of energy use.

Switching from electricity for heating reduces seasonal variations of electricity consumption.

In addition to the reduction of seasonal variations due to climate change.

Switching from electricity to district heating influences the electricity situation twofold by reducing electricity demand and enabling increased power production in CHP plants.
Possible wind power capacity is an economic trade-off
Hydropower dams can balance fluctuating wind power
Adaptation of electricity consumption through demand response can help absorbing wind variations.
On New years day 2006, Russia turned off gas supply to Ukraine and central Europe.

To secure energy supply, a general advice is to use many different energy sources and technologies with preference for local resources, which often are renewable.
Alternative scenarios

- An extreme free market scenario
  - High economic growth
  - Little environmental regulation
  - High energy demand
  - Large power plants: fossil fuel condensing power, new large hydroelectric and nuclear plants

- An environmental scenario
  - Low energy demand: high energy efficiency, less heavy industry
  - Firm policy instruments: renewable energy, reduced CO₂ emissions.
  - Distributed generation
  - Low-energy buildings, internal DC micro grids
  - Domestic energy resources, security of supply

  - Robustness
    - share of hydropower
  - free market: low
  - environmental: high

Free market can certainly be combined with environmental concern but we wanted to lump various features together to describe two (but not more) extreme scenarios.

Internal DC micro grids, to get rid of all small electric radiators for our electronic equipment, which are called chargers (and include transformers).

Share of hydropower:

- low in the free market scenario (with high energy demand)
- high in the environmental scenario (with low energy demand)

Probably, none of these three scenarios will be realised but perhaps some kind of mixture.
The direct impacts of climate change will only have marginal consequences for the energy system. This holds for all of the three scenarios and because the two latter reflect extreme futures, it is likely to be a plausible conclusion.

But probably, events occur that we cannot even imagine today.