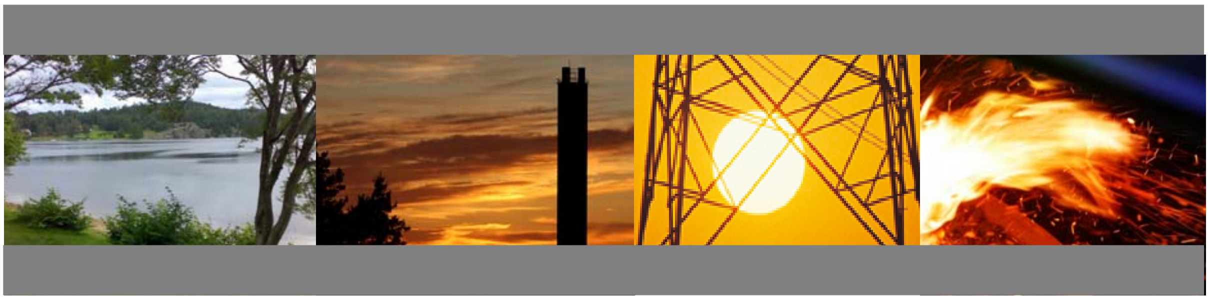
Intermediate report



Synthesis report

Preliminary conclusions from the continued research work in the second phase of the project

March, 2009

Nordic Energy Perspectives

Preface

Nordic Energy Perspectives (NEP) is an interdisciplinary Nordic energy research project with the overall goal of demonstrating means for stronger and sustainable growth and development in the Nordic countries.

NEP analyses the national and international political goals, directives, and policy instruments within the energy area, as well as their influence on the Nordic energy markets and energy systems and the infrastructures and institutional structures. NEP aims at clarifying to decision-makers the consequences of political and strategic decisions for politicians, energy actors and the public. The project is to promote a constructive dialogue among researchers, politicians, authorities and actors on the energy markets.

For further information about the project, please visit: *www.nordicenergyperspectives.org*.

This series of reports are the second reporting from the second phase of the project. The following intermediate and final reports are now presented:

<u>Synthesis report, March 2009:</u>

- Second NEP2 synthesis report *(Responsible: Peter Fritz, Håkan Sköldberg, Bo Rydén)*

<u>Final reports, March 2009:</u>

- Widened view of energy efficiency and the resource management *(Responsible: Bo Rydén)*
- Technology options for a low CO_2 energy system *(Responsible: Tiina Koljonen)*
- Wood markets and the situation of the forest industry in the Nordic countries *(Responsible: Per Erik Springfeldt)*

<u>Intermediate reports, March 2009:</u>

- Reference and policy scenarios *(Responsible: The NEP model group)*
- Global scenarios *(Responsible: Janne Niemi)*
- Biomass market and potentials *(Responsible: Tiina Koljonen)*
- Nordic perspectives on the EU goals relating to CO_2, renewable energy and energy efficiency *(Responsible: Thomas Unger, Bo Rydén)*
- Prominent strategies for environmental sustainability in the stationary energy sector *(Responsible: Anders Sandoff)*
- The future of the Nordic district heating *(Responsible: Monica Havskjold, Håkan Sköldberg)*
- Trade within the RES directive and related power interconnection issues *(Responsible: Berit Tennbakk)*
- Natural gas in the Nordic countries *(Responsible: Peter Fritz)*

Our intention in NEP is to present all reports in English. Due to lack of time, some of the texts in some of the reports are at this stage still in Scandinavian languages. We apologize for this. These texts will as soon as possible be translated into English. The translated texts/reports will be available on the project's web site, *www.nordicenergyperspectives.org*, soon after the Oslo conference.

Oslo, March 2009

The NEP Research Group

Content

1. Millions of electric cars in the Nordic countries

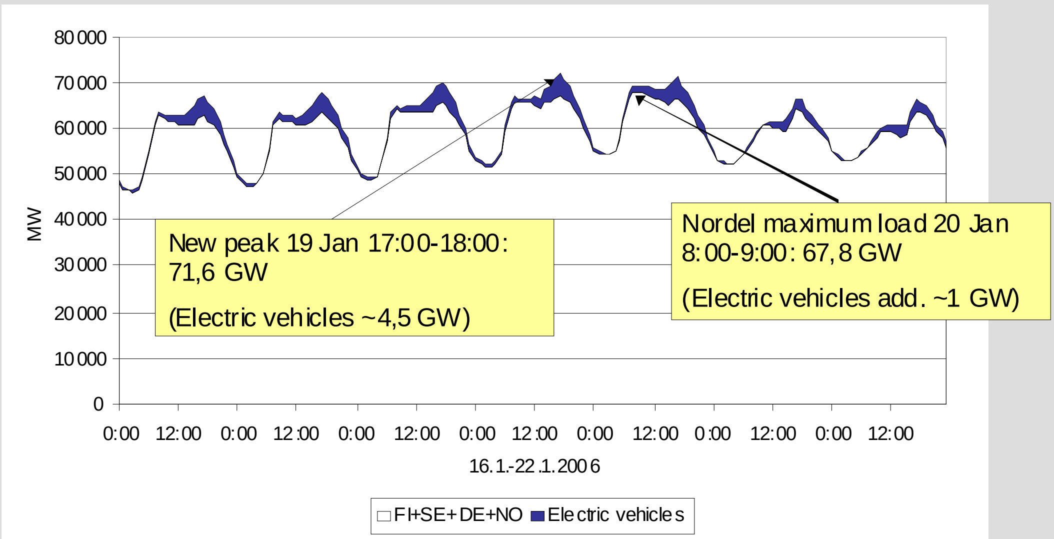
- impacts on the Nordic electricity system

NEP studies indicate new load peaks in the Nordic system after an introduction of 5 million electric cars (EV) on the roads. The study assesses the impact of 1 million battery powered electric vehicles (BEV) and 4 million plug-in hybrids (PHEV) distributed among Finland, Sweden, Norway and Denmark. The global production of EVs is estimated by car component manufacturer Bosch to be around 3.5 millions in 2015, so it is not very likely that there will be altogether 5 million electric cars in the Nordic countries by 2020. But if there were - it is a good bet that there will be at some time - what effects would they have on the Nordic electricity system?

Peak load can grow by 6%

The NEP results indicate that the Nordic system peak load (compared to 2006 data) would grow by 6 % reaching 71 600 MW. However, in this case the EVs are using electricity mainly at high load times.

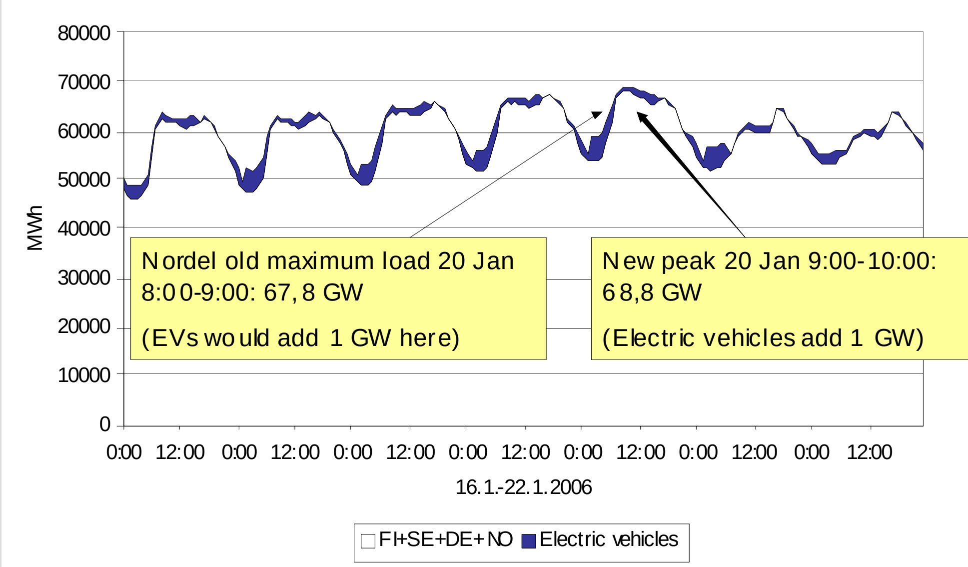
The daily driving and charging of EVs was stochastically modeled using Finnish survey results about typical distances driven each day, timing of the travel, average trip lengths, trips per day, etc. as basis. It was assumed that all cars were charged through household electricity outlets (max 2500 W) and that 20% of the EVs had the possibility to charge at work, while 2% didn't ever charge at home. PHEVs differ from BEVs in the respect that they have smaller batteries, enough for 20-100 km, after which the car's fuel-based motor is used. Smaller batteries indicate shorter charging times. The charging of the cars was assumed to be without any controlling intelligence (smart charging), i.e. charging started as soon as the cars were plugged in.



The charging effect of 5 million EVs on the Nordic peak load, if the charging of the vehicles is not controlled. The Nordel peak load week from 2006 is used as basis. The time of the peak load with EVs moves from Friday morning to Thursday evening, and increases by 3 800 MW (6 %).

Smart charging

The charging of the EVs should be affected by policy recommendations issued in all likelihood in the future. If not, then the burden added to the peak load from unregulated charging would be too heavy as shown in the previous example Just a few simple rules or recommendations concerning smart charging would achieve a much nicer picture. For example, if 90% of all charging otherwise taking place between 16:00 and 23:00 local time is moved to the night hours (0:00 - 07:00), then the peak load increases only by 1 000 MW. The gap between daytime and night time consumption diminishes clearly.



Smart charging. *The peak load moves to the next hour compared to the case of no EVs, and increases by a measly 1 000 MW. The load also looks much nicer.*

The smartness could and probably would be tied to price signals, for example the Nordic spot market price and/or balance regulation prices. And of course express charging places, where a battery will be charged in minutes at high power, will in all probability be available. However, they are considered to be of no actual importance in this study. Most charging is likely to take place at home even when fast charging is available.

Total electricity demand up 15 TWh in the Nordic area

Consumption rates of 0.17-0.25 kWh/km including charging losses were used for EVs in the above examples of the EVs' impacts. The 5 million EVs would have a noticeable, but a rather small effect on the Nordic electricity system. The increase in electricity consumption would be approximately 14 TWh. That is only 3% of the total electricity demand in the Nordic area, even though roughly half of all cars would be EVs. Network losses would add another TWh, bringing the total growth in electricity demand to roughly 15 TWh.

2. Prominent strategies for environmental sustainability

- in corporations in the energy sector

There is an obvious need for the stationary energy sector to intensify its efforts to contribute to sustainable development, both at a strategy level and in order to integrate sustainable practices into its operations. To gain insight in how environmental sustainability is put into practice within corporations, close-up investigation is essential. For this reason, case studies of companies with a prominent strategy for environmental sustainability were chosen as a research methodology. The selection of case companies was based on an emerging framework of measures for environmental sustainability that was established from an initial study of Swedish and European energy companies.

Focus areas for sustainable development

The findings from the case study interviews are reported by highlighting five focus areas for sustainable development. The first focus area, **Corporate Governance**, focuses on the interplay between owners and the management in relation to corporate environmental issues. The focus area **Co-operation** highlights the possibilities and dimensions offered to sustainable development by joining forces. **Communication** is a further area of interest, exploring the role and benefits of communicating to enhance environmental sustainability. In the forth area, **Innovation**, it is explored how energy companies enhance the sustainability of their products and processes. Lastly, under the heading **Integration** the processes and structures effectively enhancing environmental sustainability are studied.

Empirical findings

CORPORATE GOVERNANCE

Active ownership and a close collaboration between the board of directors and managers seem to be a common denominator for companies that take an active interest in environmentally sustainable development. This shows for instance in a good understanding by both board members and the management of the company's environmental impact and the possibilities to mitigate this impact. There is also clearly a consensus at the board and management level that environmental sustainability is important for business success.

CO-OPERATION

Co-operation was identified as a strong feature of the energy companies studied. One way co-operation is looked at is to see it as a means for business expansion. The benefits of strategic co-operation are an extension of available competences and production resources, leading to better economies of scale and financing possibilities. If synergies can be achieved, the businesses can operate more efficiently, resulting in benefits for the environment. Co-operation is also beneficial for the exchange of ideas, for instance within networks such as business associations or professional networks. Moreover, co-operation with universities can lead to innovations.

COMMUNICATION

Communication both within the company and with its stakeholders is a central aspect of sustainability work. From an internal perspective, communication is vital to create employee commitment to environmental issues which facilitates implementing common goals. Moreover, communication creates transparency about the company's sustainability-related goals and the means by which these are to be achieved. This helps to create trust and acceptance for corporate strategies and products with the company stakeholders. Furthermore, by communicating its sustainability achievements to a broader public via the homepage and media, the company can, by showing good examples, have an impact on sustainable development.

INNOVATION

Innovation at a strategic and at an operational level is important to secure the company's ability to stay competitive. It is also a necessity in order to improve the environmental sustainability of a company's products and processes. To direct the innovation process, a timely identification of opportunities and threats from the environment is vital (preferably beyond Swedish borders). Internal innovation has been observed both at a centralized level and within business units. At a centralized level, a wide view on innovation is applied and issues of strategic nature such as the product portfolio and potential co-operations are areas of interest. Observed areas of innovations are for example energy services, carbon neutral district heat, a new business model for wind farm project etc. At the business unit level, innovation activities are more focused on operations, for example on finding better technical solutions or testing different energy crops. A third source of innovation is external stakeholders. Owners, customers and co-operations can generate new ideas that the company can develop and integrate into its business. Connected to the interest to innovate is the necessity to take risks.

Willingness to take a certain amount of risk can thus be considered a property of the energy companies studied. It seems important to understand that innovative solutions are needed on many levels to cope with the challenge to make the energy system more sustainable.

INTEGRATION

The fifth area that appears to be central for companies that take an active interest in sustainability is that they distinguish themselves by a strong capability to integrate respect for the environment and sustainability thinking into the different business areas and processes. Central to the capability to integrate sustainability swiftly is a well-established and competent environmental organization. A timely adoption of the ISO 14001 norms for environmental management appears to be a decisive factor for achieving a high environmental standard.

Framework of measures for environmental sustainability

The framework builds on a four-field matrix divided into measures with an internal or external focus. A distinction is also made between technical measures and "bonding" measures that require greater social involvement.

1. Emission Reductions: The focus lies on minimizing emissions generated internally as a result of different corporate activities. Also internal efficiency measures fall under this category.

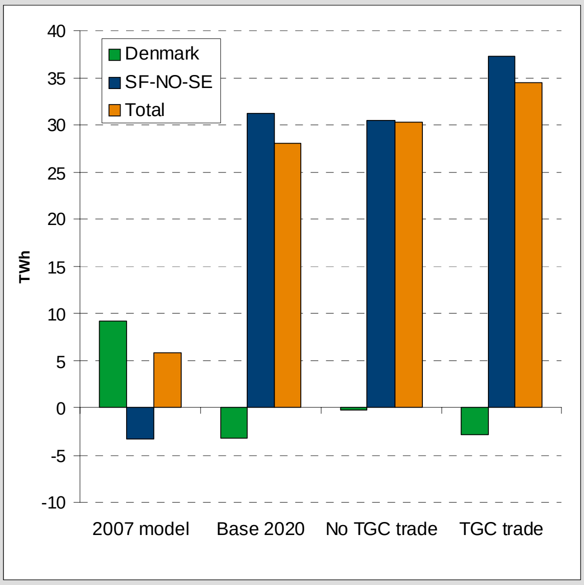
2. Product Stewardship: The company searches for new opportunities to produce its current products more sustainably or effectively, extend the use of its products or offer new products that are beneficial to sustainable development.

3. Clean Technology: Shows the range of renewable and bridging technologies that companies can adopt to reduce its environmental impact or improve efficiency. Internal green R & D also falls under this stage.

4. Sustainable Development: In this most advanced stage, the focus is again external and most measures require high social involvement. A wide perspective is taken on possible measures that lie within the reach of energy companies to promote sustainable development.

3. RES deployment profoundly changes the market balance of the Nordics

Implementation of the RES directive shifts power market balances and trade patterns in Europe significantly. The Nordic area has large and relatively cheap RES potentials, combined with (probably) lenient targets because of a high initial share of RES-E generation. The proposed burden sharing does not take current or future supply/demand balances into account, and the Nordics may become large exporters of both electricity and green certificates if trade in certificates (TGC) develop. The effect is reduced Nordic power prices and reduced thermal generation. The huge expansion of RES-E generation may be accompanied by higher grid costs.

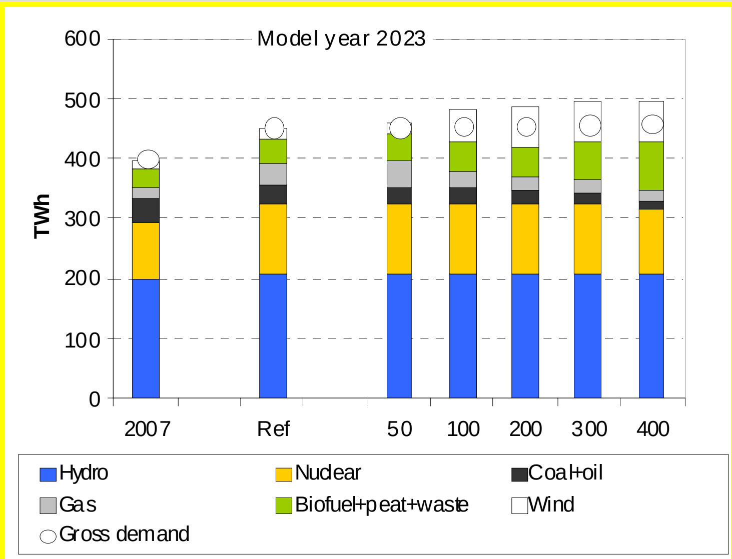


Net electricity exports from the Nordic countries. Total Nordic exports to Germany, Netherlands and Poland is 34 TWh in the scenario with an EU-wide market for green certificates (TGC).

Results from the NEP models clearly demonstrate that ambitious renewables targets profoundly affect market balances in the Nordics. As can be seen in the figure on the right, the market balances in the Nordics are almost reversed compared to 2007 (modelled). Denmark becomes a net electricity importer, while Norway and Sweden become large exporters in 2020. Finland is also a net exporter to the Nordics (imports from Russia and Estonia are not included in the figure).

The pattern is similar inn all three RES 2020 scenrios:
Base: RES generation is developed according to national policies and there is no certificate trade
No TGC Trade: The EU RES target is fulfilled without certicifate trade
TGC Trade: The EU RES target is fulfilled with certificate trade

Finland, Norway and Sweden exporters of Green Certificates



Total power and RES-E generation in the Nordics increase when the TGC price (here 50-400 SEK/MWh) level increases.

Finland, Norway and Sweden are exporters of certificates in the TGC trade scenario, and TGC trade increases the RES-E generation and the electricity exports from Norway and Sweden. Increased electricity supply also reduces prices, and hence demand increases in the Nordics. This implies that net electricity exports do not increase by the same volume as the certificate export.

The MARKAL Nordic model show similar results. The panel to the left shows that total generation and RES-E generation in the Nordics increase when the TGC price level increases. For certificate prices above 300 SEK, most of the cheap potential for RES-E generation in the Nordics is exploited. Model results from the European model (above) yield a European TGC price well above the 300 SEK level.

Increased investments in RES-E generation crowd out thermal generation

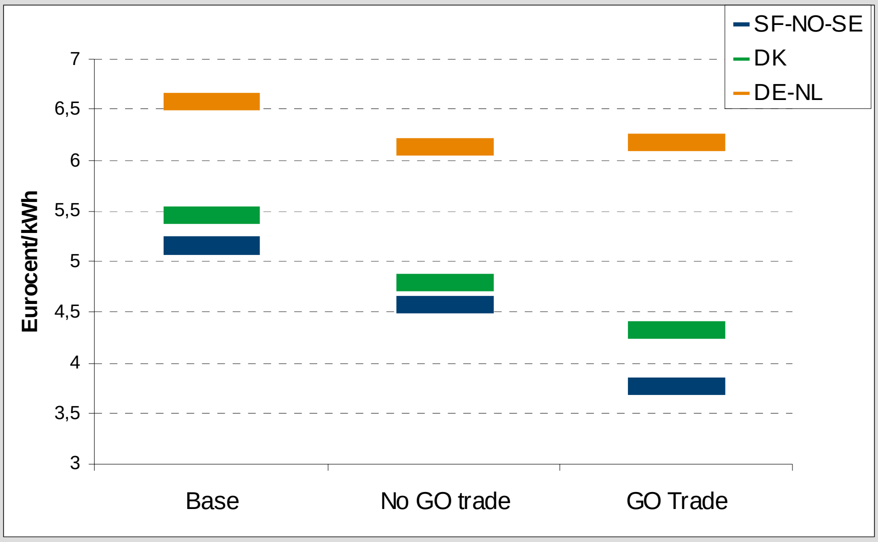
As the share of RES-E generation increases, the generation levels in conventional thermal power plants are reduced. First the generation in existing coal and gas plants is affected, and subsequently, investments in new conventional capacity are postponed. The model results indicate that no new investments in conventional capacity are profitable before 2020 in the TGC trade scenario.

Electricity prices in the Nordics stay below Continental prices

There is a clear division in average price levels in the relevant market areas. TheDanish prices lie between the prices in Norway, Sweden and Finland and the prices on the continent, i.e. Germany and the Netherlands. Allowing trade in RES-E certificates amplify the differences. It should be noted that the reason why price levels are generally lower in the full RES-E scenarios is that EUA prices are lower: 30 €/ton compared to 21.5 €/ton.

New interconnectors more profitable with RES-E certificate trade?

As the price differences and traded volumes increase, so does the income from trade. In the Trade scenario the NorNed cable is fully utilized for exports from Norway to the Netherlands, i.e., prices are higher in NL than in NO in all load blocks, and the price differences indicate that an expansion of the capacity may be profitable.



Clear three-way division of price levels with the hydro-area, SF-NO-SE at the lower end. RES-E expansion and European trade in certificates reduce Nordic price levels, and increases price differences and congestion rents.

The results are however very sensitive to changes in the RES-E level, and to the way trade is modelled (price structures). It should also be noted that results for 2020 are not representative for the full lifetime of an interconnector. In addition, the utilization of cables vary significantly between seasons and years, and these aspects are not captured by the long-term scenario models used here.

The RES directive

Targets: In order to reach the 20% RES target, the electricity sector is set to increase RES-E generation to an estimated 30-35% from today's level of around 8,5%.

Burden sharing: Remaining potentials for RES-E generation and the ability to lift such massive investments vary across EU member states. The Commission has proposed a burden sharing which takes these factors into account. The result is that RES-E investments will be unevenly distributed among member states.

Huge challenges for national grids

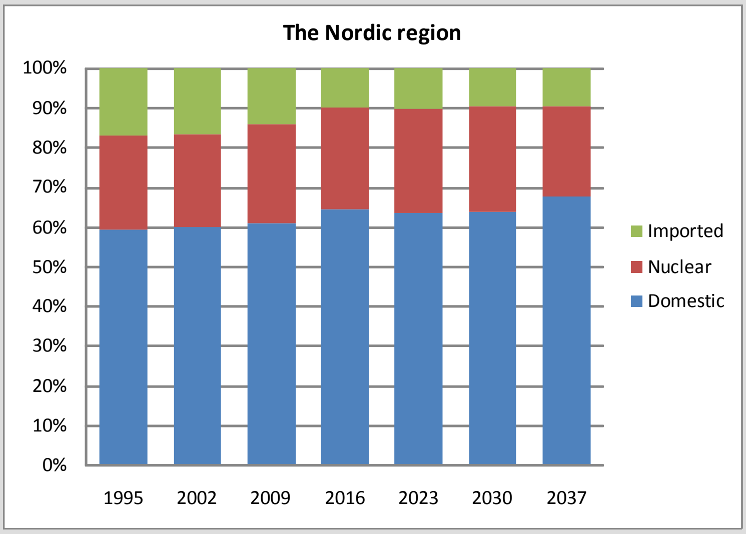
The reversal of trade patterns and the dramatic increase in net exports from the Nordics indicate that the RES-E expansion poses a huge challenge for TSOs. The description of the system in 2020 shows increased transit, particularly through Sweden and Denmark, increased intermittency as the share of wind power increases, and reduced flexibility as the share of conventional power generation is reduced.

4. Decreased import dependence with EU´s 20% goals

- the import dependence decreases in the Nordic energy system as a con-sequence of increased use of renewable energy and decreased use of fossil fuels

If EU´s goals of at least 20% renewables in the energy mix and a reduction of carbon dioxide emissions by 20% are implemented, the import dependence for the Nordic energy system (excl. transport) decreases. Preliminary model calculations by the NEP project show that the two 20% targets together increase the share of domestic energy to at least two thirds of the energy mix (calculated as primary energy).

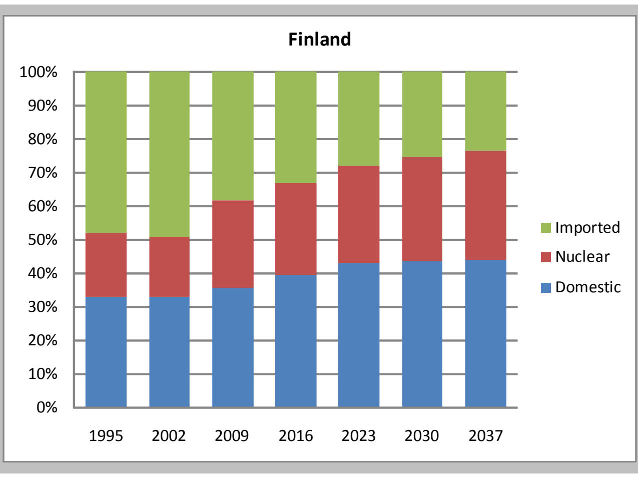
In the analyses we have made a number of simplifications in the assumptions. For the Nordic region we have – in these initial preliminary calculations – considered all oil and natural gas as being domestic (in a Nordic perspective), with reference to the resources in Norway and Denmark. All biomass has also been defined as domestic.



The share of primary energy in the Nordic energy system (excl. transport) which are imported or domestic. Nuclear is presented separately (see explanation below).

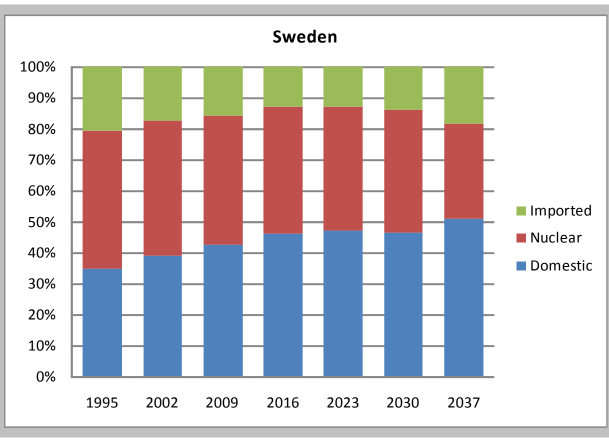
The import dependence decreases also in each country

- and would decrease even more if priority was given to security of supply



The import dependence on a national level in the Nordic countries also decreases as a consequence of the EU´s goals, in spite of the fact that oil as well as natural gas are imported fuels in both Fin-land and Sweden. The EU 20% directives leads to a decrease in the use of fossil fuels in all Nordic countries.
In Finland the use of nuclear energy also in-creases, after the start-up of the 5th reactor. By showing nuclear energy separately in the figure we would like to raise the question whether this should be regarded as imported or domestic. The fact that the uranium fuel today is imported is indisputable, but the Nordic uranium resources are also large.

In the Nordic countries there are also large resources of peat and renewable energy which are not used in the scenarios upon which the figures are based. In a scenario which is more focused on security of supply, these resources will be of great importance.



The research question regarding security of supply is of course more extensive than just analysing the import dependency. In the coming NEP analyses we will present a more complex picture. This first synthesis paper still gives a first interesting insight in the future development in this field.

Note: ETS price on CO_2 is set to 20 Euro/ton. Electricity import to Finland from Russia is set to 12-13 TWh/yr during the period studied. All oil and gas in Fin-land and Sweden are seen as imported in the national analysis but domestic in the Nordic perspective. Primary energy use increases 15% from 2002 to 2030.

5. The future for the Nordic forest industry

At present, Nordic pulp and paper companies will not invest in new mills. Even reinvestments in major repairs are being questioned.

The Nordic forest industry has historically profited from the relative closeness to both customers and raw materials. Other advantages include relatively low electricity prices and a raw material based on long wood fibres. However, a number of negative factors are now affecting the Nordic forest industry.

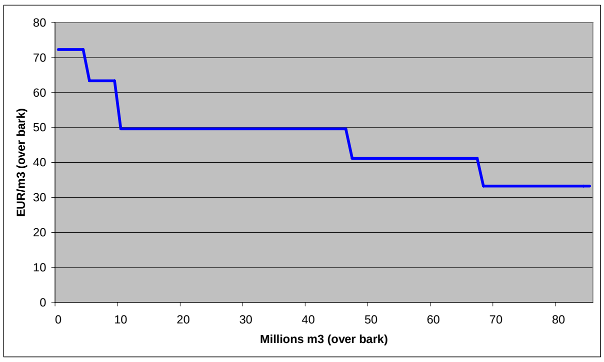
- Demand for paper products in developing countries has been met by an even faster growth in the production capacity of pulp from fast growing eucalyptus and wood from rainforests.
- The demand growth in developed countries is expected to remain low and might even decline.
- Russian exports tariffs and demand for wood from the energy sector will push wood prices in the Nordic region upwards.
- Modification of the eucalyptus fibre and Russian fibre export will result in a larger supply of newspaper qualities and therefore more competition for the Nordic forestry industry.
- The electricity price in the Nordic region has become (and may continue to be) less competitive

There are however, still factors that are favourable for the Nordic forest industry. Examples are:
- Large share of efficient integrated pulp and paper mills
- Expansion of eucalyptus plantations, new production capacity and infrastructure is time consuming
- Restrictions on wood supply from rainforests and eucalyptus plantations could result in higher wood prices in developing countries

The ability to pay for wood in the Nordic region

An approach to illustrate the forest industry's situation is to look at the industry's ability to pay (ATP) for the wood they use. In the figure below, this is illustrated by a "demand curve". The curve is based on statistics from the Swedish paper, pulp and sawmills industry for 2003 and 2005. The ATP is defined as the wood prices at which the different industries reach "break even" (the cost of investments is included in the calculation).

Without going into details the analysis indicates that the relation between ATP and present market prices are unfavourable for certain parts of the Swedish (and Nordic) forest industry. Does this mean that important parts of the Nordic forest industry will be forced to close down and that large amounts of wood will be destined to other areas such as energy? We know that the industry is currently facing problems. This is rather obvious after reading company statements and witnessing the closure of plants. However, some important adjustment measures can be expected.

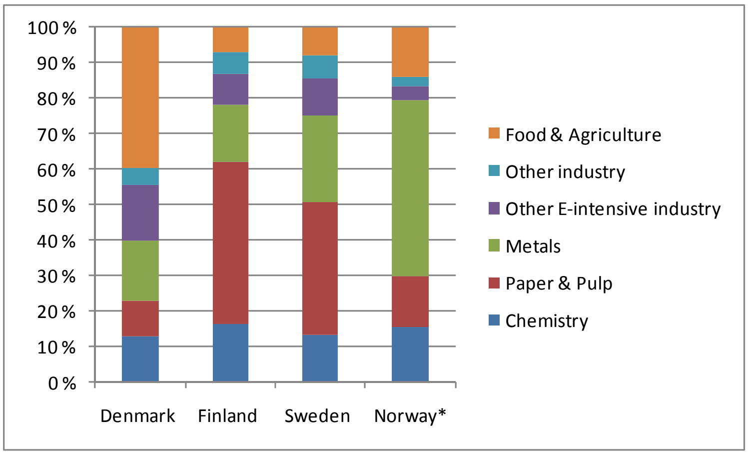


Long term demand (ability to pay) for wood fibre from the Swedish paper and pulp industry (EUR/m^3 over bark))

Closing mills will lead to a reduced demand for wood from the industry. One would therefore expect to see a downward pressure on the price of wood in the region. Some wood will be consumed by the energy sector, but their demand is limited, at least in the short run. In theory, large volumes of wood could be exported, provided the world market price of wood is sufficiently high. This will affect the Nordic forest industry's international competitors, especially competitors in countries that are dependent on imported wood.

6. Nordic industries in a global context

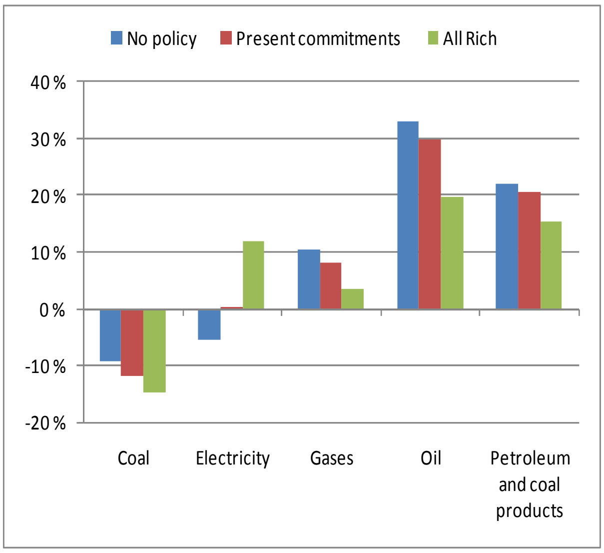
Industries in the Nordic Countries are among the most energy-intensive in the world due to the large shares of paper, metal and chemical industries in the total production. In Finland, Sweden and Norway, these sectors account for 75 to 80% of the total electricity consumption, as illustrated in the figure. Denmark, however, has clearly less energy-intensive industry structure than the other Nordic Countries, reflected in the high share of food and agriculture production. In Finland and Sweden, paper and pulp industries are clearly the largest energy users, whereas in Norway, metal and mineral industries consume half of the total electricity used in primary and manufacturing production.



Composition of total electricity use in the Nordic countries. The figure presents the shares of each industry group of total electricity consumption in production sectors, as per the GTAP data in base year 2001 (primary and manufacture product; services and energy are not included).

Increasing energy use and price

In the GTAP model simulations for the period until 2020, a considerable increase in the global energy consumption is observed. The simulations include a "no-policy" reference case, where there are no international climate policies in place and thus very high energy use growth rates are observed. In addition, different emission reduction policy scenarios for developed world are also simulated.

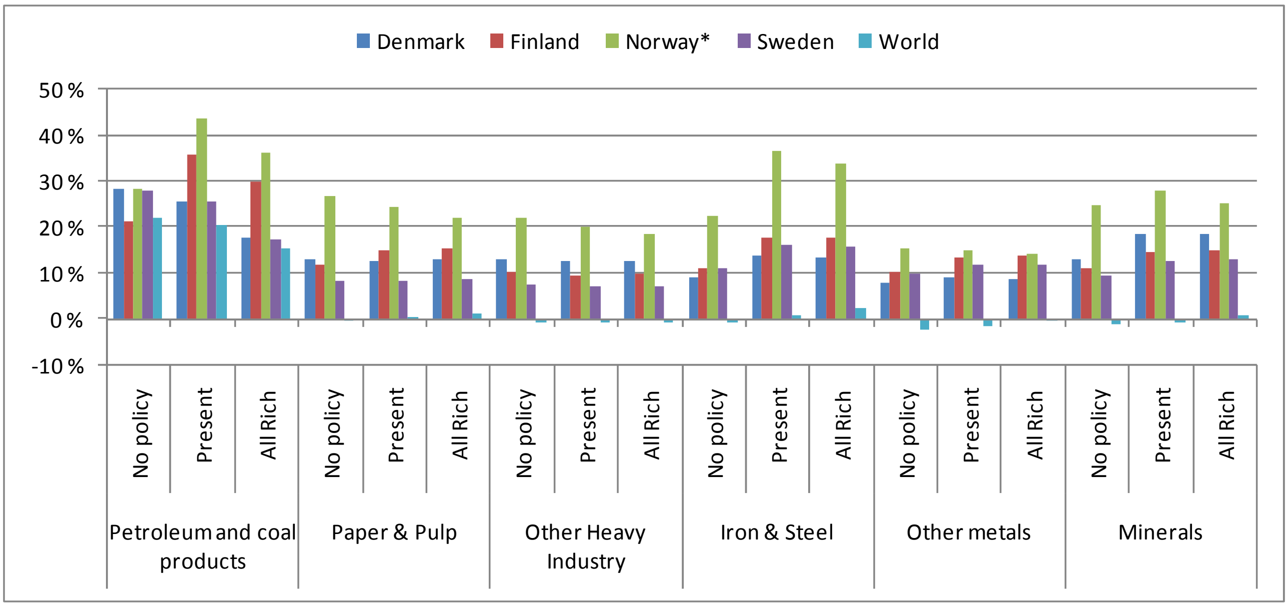


World energy commodity prices: %-change 2001-2020

The figure on the left shows the generally increasing trend in oil and gas prices, whereas the coal price is decreasing. As expected, the pre-tax world market price is highest when there are no climate policies, because the CO_2 tax increases the final price paid by industries and consumers, hence lowers the demand, which in turn causes the supp-ly prices to also decrease. The red bars show the results with EU's present climate policy commitments and emission trading scheme, whilst the green bars represent a more ambitious policy including all rich countries. The higher the reduction targets are and the more countries that are involved, the lower primary energy prices before taxes. World average electricity prices develop the opposite way, as the CO_2 tax is included in the primary energy prices paid by electricity producers.

Nordic energy-intensive industries

As illustrated in the following figure, the <u>*local*</u> supply prices of many industries important to Nordic countries increase under all the scenarios in the period 2001-2020, whilst the world market price of these commodities remains virtually unchanged. This implies that whilst the production may become more expensive, the income earned at world market does not increase in the same proportion. Therefore, especially export-oriented energy-intensive industries are, on one hand, becoming less advantaged compared to the foreign (often Chinese or Indian) competitors and, on the other hand, less profitable use of available production factors compared to other domestic industries. However, such development is largely offset by overall growth of industrial output, which stays around 2% per annum in all scenarios.

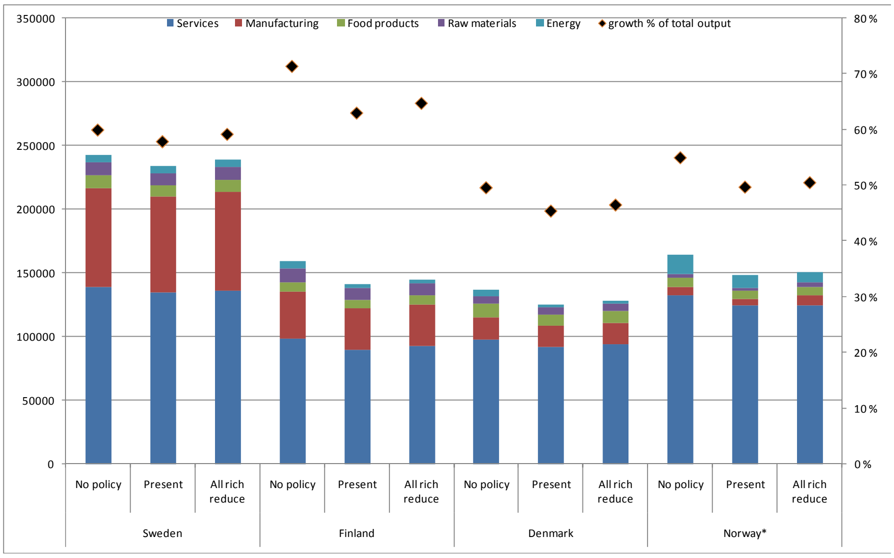


Supply prices for selected industries, %-change 2001-2020, Nordic Countries and World.

In Sweden, the overall results are similar in all three simulations. The EU emissions reduction policies trigger only minor decrease in overall industry output growth, and inclusion of other rich countries results in almost the same growth figures as in the no-policy scenario. This suggests that the Swedish energy sector is able to switch to less emissions generating production with relatively low extra costs, which gives an additional comparative advantage to energy-intensive industries.

In Finland, the impacts of emissions reduction policies are clearly more visible. However, the Finnish overall industry output growth rate is highest of all Nordic countries in all scenarios, though the difference is smaller in the scenarios with climate policies. A closer look at industry-specific results indicate that the main difference between simulations comes from Paper and Pulp sector, where the supply price grows clearly more with climate polices, unlike in other Nordic countries.

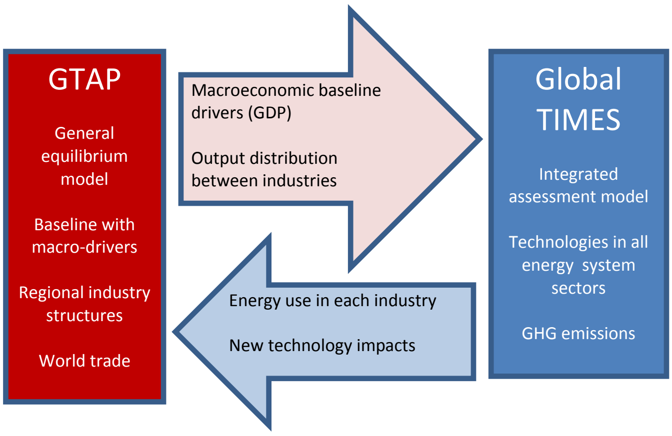
In Norway, the results have two main directions. First, a development similar to Sweden can be observed with regard to energy-intensive industries, as Norwegian electricity production has the advantage of using very little CO_2 emitting fuels. Second, Norway's petroleum sector follows the developments of world oil price. (The GTAP model is built on the premise that each country's trade balance always is zero. This implies that today's Norwegian oil policy, where the oil surpluses are invested in funds abroad, is not modelled. The lower oil prices in "Present" and "All Rich" implies a depreciation of the NOK in the model, which gives the electricity intensive industry a comparative advantage.)



Output growth in all industries, Nordic Countries. The bars show the difference between 2001 and 2020 levels and its composition by sector, measured in thousands of 2001 US dollars. The black diamonds indicate the percentage growth of total manufacturing output compared to 2001 level. Results are given for simulations with no emissions reduction policies, with current EU commitments, and with more ambitious targets for all rich countries. (figures for Norway include Iceland)*

7. Global economy scenarios

This synthesis report outlines the macroeconomic baseline results for the NEP project's global scenarios, produced with the GTAP model. The baseline simulations serve as reference results to policy scenarios and give a projection of the development trends both on local and global levels. The economy-wide and industry specific output results are also used as inputs in the Global ETSAP/TIAM energy system model.

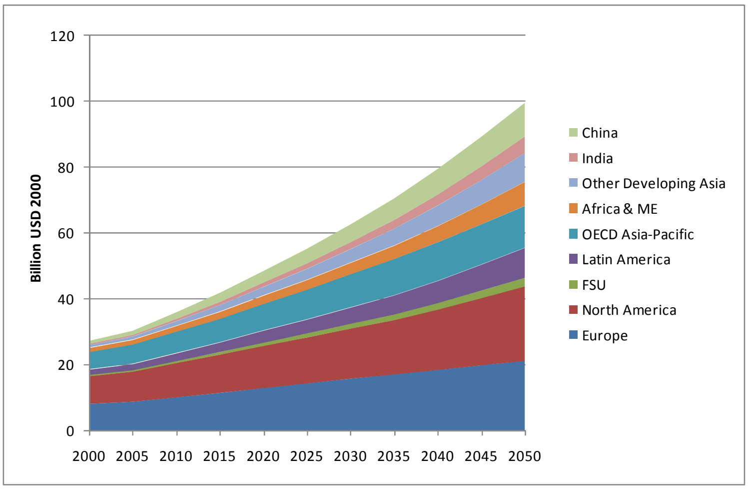


In turn, the next steps of the NEP project's global scenario work will include using the economy-wide and industry-specific results on energy use and emissions as inputs to GTAP model, as the GTAP model has no inbuilt treatment of energy systems and e.g. technological progress leading to improved energy efficiency. Thus, the results presented in this synthesis report are based on industries relying on present technologies and are only reported until the year 2020 at this stage.

At later stages of the project, the results may also provide inputs for NEP's regional models.

Macroeconomic development

The starting point for the scenario work is in the growth assumptions for various macro variables that lay the foundations for the economic and other development. These variables are an exogenous input to the simulations. The total economic growth is a product of labour, capital and productivity growths. Long-term projections exist for each of these factors, but they all contain great uncertainties, especially in estimates beyond medium-term horizon of 10–20 years.



For the purposes of NEP project scenarios, we use macro baseline drivers in line with those used in the latest IEA World Energy Outlook. Particular attention is paid on the data most relevant to the focus region and also on globally significant phenomena. Therefore, improved population data that takes into account intra-European migration has been used, and rapid productivity and skilled labour force growth in developing Asia – and China in particular – is also considered.

World GDP 2000-2050: Share of developing countries increases

The projected annual average world population growth in period 2005–2050 is 0.77% and the total population reaches 9.2 billion by the end of the projection period. However, alternative population scenarios range from 8 to 11 billion. Due to demographic differences, the labour force growth can be lower or higher than the total population growth in each region, and on global level, an increased share of working age population is observed until 2020, after which it starts to decrease.

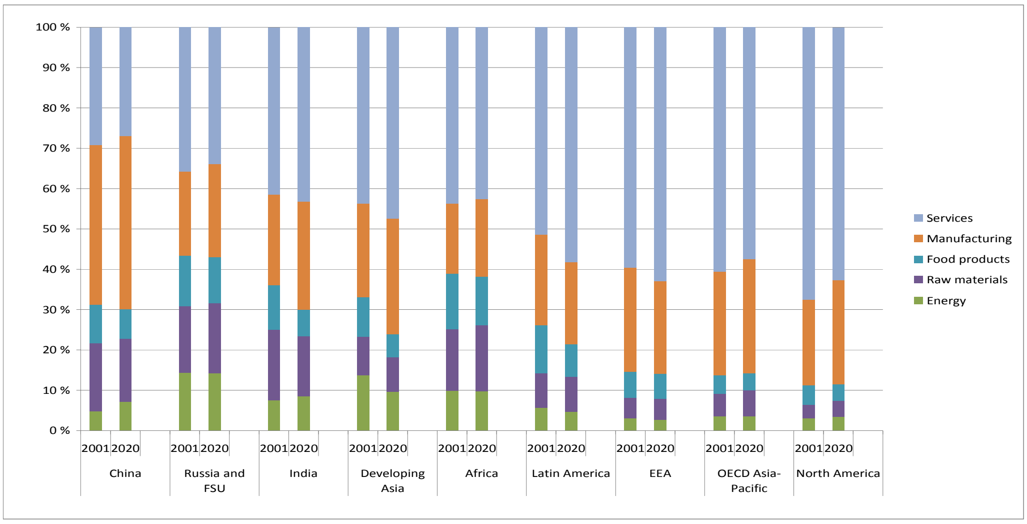
The total factor productivity growth estimates vary between 1% in some Western countries and up to 5% in fastest-growing Asian economies. This results in total annual GDP growth rates of up to 10% in countries like China and India. By the year 2050, the extreme growth figures are projected to come closer to those in developed economies, but the key question for the overall results is how fast this convergence is going to take place.

Increased demand for energy and food

The growth in macro drivers, and population in particular, triggers some fundamental changes in the world commodity markets. The products that are scarce and difficult to substitute become more expensive relative to other goods. This is particularly true for food and primary energy: whilst their share of the global value of industry output is gradually declining, their prices compared to other goods increase fast.

In rapidly industrialising regions, e.g. China, energy takes an increasing share of total industry output value until 2020, as illustrated by the figure below. Globally, however, in almost all regions the services and manufacturing with high value added are increasing their share.

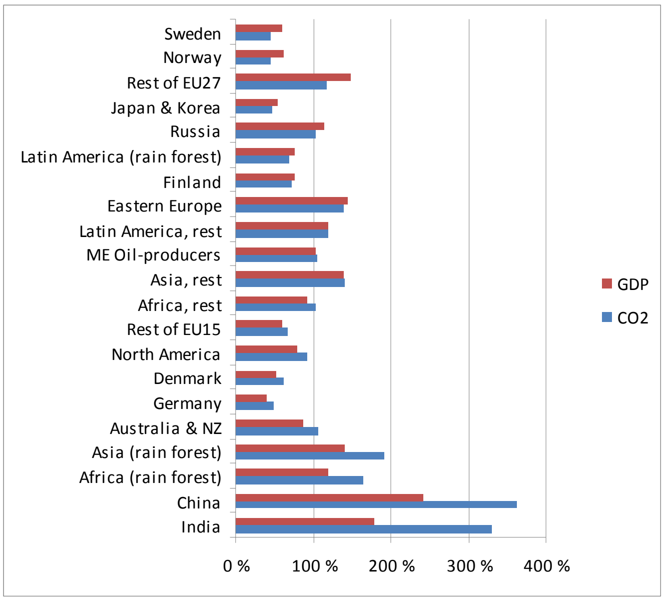
The Nordic countries follow the same general pattern, and the share of traditionally energy-intensive industries is declining in favour of services and less energy-intensive production, though the output in all sectors is still growing steadily. In Norway, the increased global demand and subsequently higher prices for energy are reflected in substantial growth of the petroleum sector.



Output shares of all industries in 2001 and 2020, World re-gions, without climate policies

GDP and CO2 growth until 2020 without climate policies. The red and blue bars show the percentage growths of the GDP and the CO2 emissions respectively for each region from 2001 to 2020 level in the hypothetical scenario without any emissions reduction policies. The regions are sorted according to ratio of GDP to CO2 growth rates from best (Sweden) to worst (India).

World economies grow, emissions grow even more



As all components of economic growth are growing, a positive GDP growth is also observed in all scenarios. However, on the global level, in absence of climate policies, energy use and thereby CO_2 emissions growth exceeds GDP growth. In India, as shown by the figure below, emissions are growing twice as fast as the economy, and similar pattern applies to many other rapidly growing developing regions.

In the developed world, instead, the GDP and emissions growth rates are much closer to one another, and often the simulated GDP growth is even slightly higher. In Finland, Norway and Sweden – with among the highest electricity consumption per capita in the world – the CO2 emissions are almost decoupled from the GDP growth. The result is hardly surprising, as more developed industries also tend to be more energy efficient, but it illustrates again the importance of global climate policies. The economic welfare loss from emissions reduction is smaller if sectors with the most polluting type of growth are targeted.

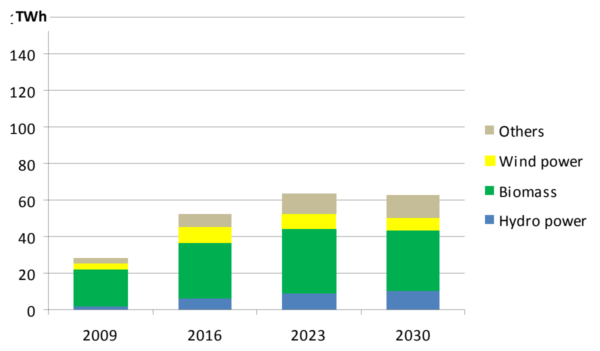
8. The use of renewable energy increases in the Nordic countries

Heat pumps very competitive when the EU's three 20 % goals are applied

The EU's 20 % goals regarding increased use of renewable energy, improved energy efficiency and reduced emissions of greenhouse gases stimulate, as expected, the use of renewable energy in the Nordic countries. NEP's continued analyses of the EU's climate change and energy package shows that the use of wind power and heat pumps increase significantly, while the use of biomass only increases slightly compared to a situation where only the present policy instruments are used.

Reference case

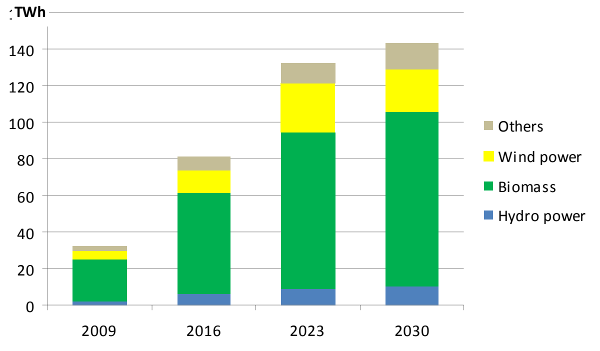
The EU's three 20% will obviously have an impact on the use of renewable energy in the Nordic countries. The effects of different combinations of the goals have been analysed within the NEP project through model calculations. During the winter 2008/09 updated and improved model calculations have been made in order to analyse the impact on the Nordic stationary energy system from the EU's climate change and energy package. Here we concentrate on results regarding the use of renewable energy. The starting point has been a calculation of the development where merely the present policy instruments are used. The calculation shows that biomass is the renewable energy source that grows fastest, while the expansion of wind power is limited. "Others" (includes heat pumps, industrial waste heat and solar heating) increases slightly.



Reference case: *Increase in the use of renewable energy in the Nordic countries, compared to 2005, without any new EU goal*

20% increased use of renewables

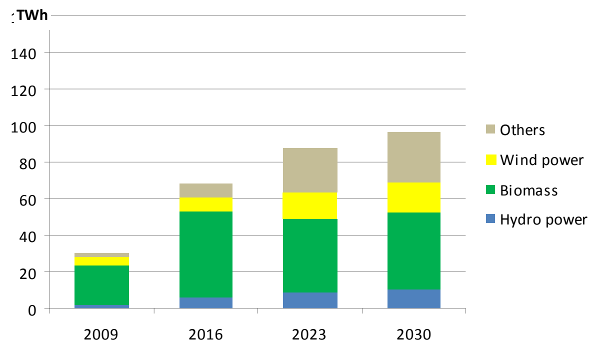
In the next calculation, the EU's goal of 20 % increased use of renewables has been added. This has been described in the model as a common Nordic effort, based on the specified national goals. As expected, the use of renewable energy increases significantly. This case shows a much greater use of biomass and wind power than when only the present policy instruments are used. The use of heat pumps also increases slightly.



EU goal of 20% increased use of renewables: *Increases in the use of renewable energy in the Nordic countries, compared to 2005, when* EU's goal of *increased use of renewable energy is applied*

All three EU 20% goals

When all three EU goals are applied simultaneously the use of renewable energy reaches lower levels than when only the goal of increased use of renewable energy is applied. This is largely a result of the reduced general use of energy through energy efficiency measures. However, the combination of goals also influences the mix of different renewable alternatives. The use of heat pumps is stimulated, while the use of biomass and wind power increases slower than in the 20 % increased renewable case. (The waste heat utilized by the heat pumps is not included in the energy amount that is to be reduced.)



All the three EU goals: *Increase in the use of renewable energy in the Nordic countries, compared to 2005, when EU´s goals of renewable energy, greenhouse gas reduction and energy efficiency are applied together*

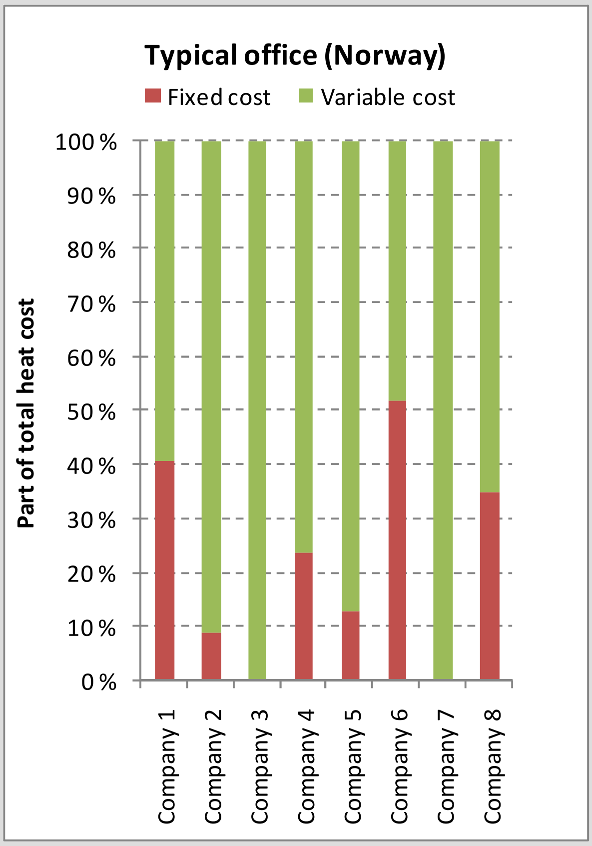
9. The development of district heating in the Nordic countries
- impact of pricing structures

Results from NEP studies of district heating (DH) in the Nordic countries indicate that the pricing strategies used by the DH companies may be of great importance for the future development of the business. One challenge is competing with local alternatives like heat pumps.

Pricing strategies for District Heating (DH)

Cost: A substantial part of the cost for heat is related to investment in heat producing equipment and a distribution system. Also labor is a fixed cost. The variable cost is to a large extent fuel cost. For a lot of the base load technologies (waste incineration, waste heat and heat pumps) the fuel cost is low. For CHP (in Sweden), the income from electricity and green certificates reduce the cost for heat production. Thus, fixed cost is a major part of the total cost of heat production in most plants. In Finland, the total cost of CHP is divided between power and heat using different methods, none of which is based on incomes. Electricity is not seen as a side product of heating.

Price: In Sweden, the variable price for DH is as an average comparable to the average marginal cost. The technologies for marginal production differ during the year, and vary for different DH systems. Many DH systems have low cost alternatives during the summer (waste heat, waste incineration, heat pumps). During the winter the high cost alternatives are only used for short periods (e.g. oil boilers). Cost of heat from CHP is Cost (heat + el) – income (el). CHP gives a relatively low cost heat during high load due to high el prices. Several DH systems operate with differentiated prices for summer and winter.



Fixed and variable cost, district heat (Norway)

In Norway most companies have a large variable part of the DH tariff, independent of either base load or peak load technology. DH price is often linked to the electricity price, due to the price regulation (DH price not allowed to be higher than electricity for heating). Marginal production during winter is electric/oil fired boilers. In large plants a low cost technology is usually used during summer, but often maintenance must be done in this period, thus the marginal cost may be high.

In Finland, Usually one large solid fuel (coal, biomass, peat) boiler or a CHP plant is sized to meet 40-60% of the heat load. The peak load amounts to only 10% -15% of total heating energy. The peak is often managed by heavy and light fuel oil burners, cheap to invest in and expensive to run. Availability of low cost alternatives may be weak in the summer, and especially during annual maintenance, in small CHP networks. In larger DH networks there is usually enough load for one CHP unit to be running. The DH pricing is mostly set against long term heating alternatives of customers.

In Denmark, DH is regarded as a natural monopoly, and thus DH prices are regulated. Small scale gas fired CHP typically consist of several gas-motors, with gas boilers are used as peak load. The marginal cost could then be as high during summer as in winter.

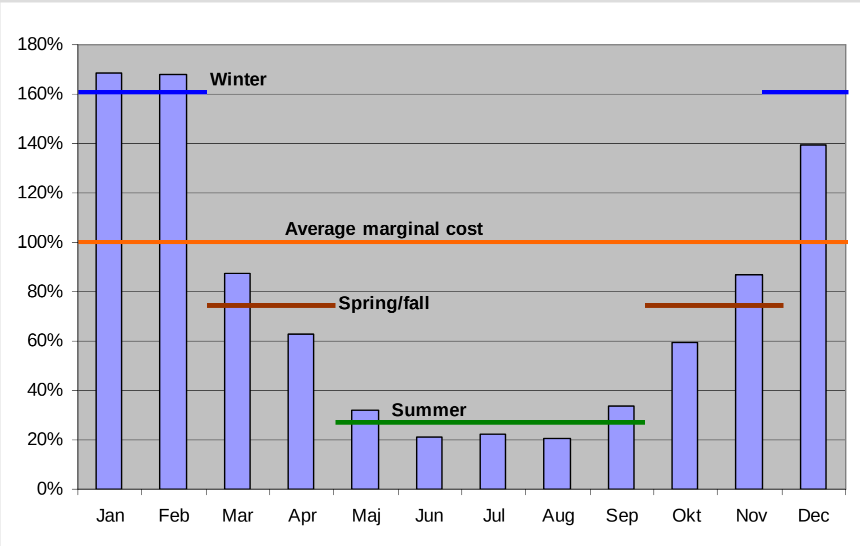
District heating production costs differs between seasons

Due to the structure of the district heating production mix, the variable costs differ between seasons. The marginal costs for district heating in Sweden varies according to the figure below. (Although the differences may be smaller in the other countries the basic trends, e.g. high costs during winter, are the same.) Far from all DH systems operate with differentiated prices for summer and winter, and if they do, price differences are typically small. In order to become more cost-correct the analyses show that the price should reflect the variable costs and the seasonal differences in production costs better. If not, there is a risk that suboptimal behaviour by the customers are encouraged.

In recent years Swedish DH systems have experienced decreasing specific heating demands from their existing customers and competition from increasingly efficient heat pumps. This competition is influenced by how the district heating price is designed, e.g. regarding the balance between fixed and variable parts and whether the variable price is season differentiated or not.

If we take the example that a district heating customer introduces a heat pump that covers the base load, corresponding to one third of the total heat cosnumption, it is obvious that the structure of the district heating price influences the economy of this action. If a 100 % variable district heating price without season differentiation is assumed the customers cost reduction for the district heating part of the heating decreases by twice the amount compared to a case where a more cost-correct district heating price (with a fixed part and substantial season differentiation of the variable part). The heat pump investment could therefore be profitable in the first case but not profitable in the second case (where the district heating price much better reflects the real costs for the district heating company).

The introduction of the heat pump, profitable or not, would also cause less economical disadvantages for the district heating company if the remaining delivery results in an income that corresponds to the costs for the supply of this district heating. For that purpose the cost-correct district heating price is much better than e.g. the 100 % variable price.



Marginal cost in winter, spring/fall and summer relative to the average marginal cost (Sweden)

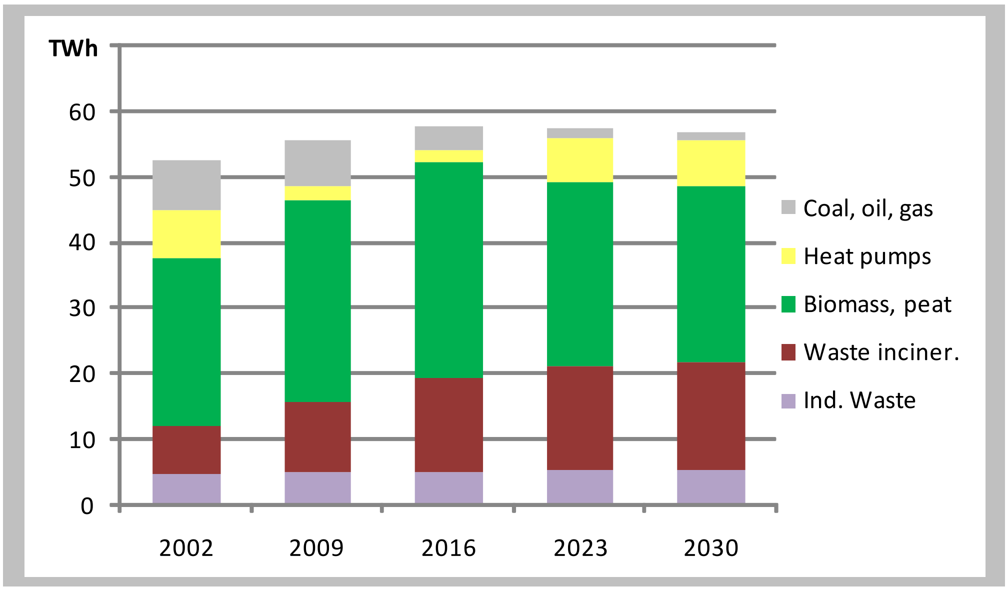
10. Less district heating when the EU's three 20% goals are applied!

Strong competition for biomass from waste incineration, heat pumps and stagnating district heating use in Sweden

The EU´s three 20% goals will obviously have a large impact on the development of the energy systems in the Nordic countries. District heating is an important energy carrier in the Nordic countries and it is therefore interesting to study how district heating production will be influenced by the targets. During the first months of 2009 updated and improved model calculations have been made within the NEP project in order to analyse the impact on the Nordic district heating production from the EU's climate change and energy package. Although the main trends can be found in all Nordic countries the development differs somewhat between the countries. Here we have chosen the calculated development of Swedish district heating production as an example.

Calculations where only the present policy instruments are applied show an increasing use of district heating in Sweden, with biomass as the dominating source for heat production. When the EU´s 20 % targets regarding increased use of renewable energy, increased energy efficiency and reduced emissions of greenhouse gases are added, the use of district heating stagnates in Sweden and the use of biomass starts to decrease after an initial expansion.

When only the present policy instruments are applied the use of district heating continues to grow. The production mix shows increases for waste incineration and biomass, while the use of fossil fuels and heat pumps decreases somewhat. This development changes significantly when all three EU goals are applied. The energy efficiency goal leads to a general decrease in heating demands. This can also be seen for district heating, where the use stagnates or even decreases slightly after the year 2016. At the same time the three goals make heat production based on fossil energy sources even less competitive. Waste incineration is still competitive, largely due to waste treatment sector policies. The definition of the goals also makes heat pumps increasingly attractive. This leads to a situation where the use of biomass, after a period of rapid growth, could decrease. (On the Nordic level there are, however, larger quantities of fossil fuels to substitute, which could give room for long term increased use of biomass also in the case with all three EU targets.)



Total district heating production in Sweden in the scenario with all three EU 20 % goals, i.e. the EU's goals of increased use of renewable energy, greenhouse gas reduction and improved energy efficiency are applied simultaneously (also keeping the current emission trading system (EU ETS) and national policy instruments)