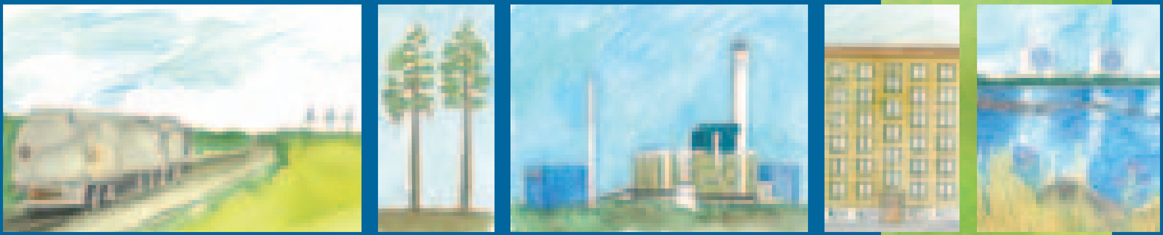
Towards a
Sustainable Nordic Energy System



20 Perspectives on Nordic Energy
10 Opportunities and Challenges

NEP 2010
Nordic Energy Perspectives

Final report for the second phase of the Nordic Energy Perspectives project

Towards a

Sustainable Nordic Energy System

20 Perspectives on Nordic Energy
10 Opportunities and Challenges

April 2010

Bo Rydén (ed.)

Håkan Sköldberg
Thomas Unger
Anders Göransson
Peter Fritz
Per Erik Springfeldt
Andrea Badano
Anders Sandoff
Gabriela Schaad
Janne Niemi
Juha Honkatukia
Hans Ravn
Tiina Koljonen
Göran Koreneff
Raili Alanen
Berit Tennbakk
Monica Havskjold
Bendecite Langseth
Tobias Jakobsson
Antti Lehtilä
Martti Flyktman
Esa Pursiheimo
Miika Rämä

Nordic Energy Perspectives

The report can be ordered from:

Elforsk
SE-101 53 Stockholm, Sweden
Phone: +46 (0)8 - 677 25 30
E-mail: kontakt@elforsk.se

Towards a Sustainable Nordic Energy System
20 Perspectives on Nordic Energy, 10 Opportunities and Challenges
Layout: Profu
Illustrations: Ebba Löfblad
Printed by: PR-Offset, Mölndal

ISBN: 978-91-978585-8-8

Preface

The Nordic Energy Perspectives project has clarified several economically significant opportunities and challenges for Nordic energy actors. With an interdisciplinary approach, involving research groups from four Nordic countries and different traditions, the opportunities of EU policy and market integration have been explored. The aim of the project is to provide a better basis for decisions on energy and environmental policy at both national and international levels. It is intended to contribute to constructive dialogue between researchers, politicians, authorities and actors in the energy markets.

A second phase of the project has been carried out during 2007-2010. This book summarises important results.

More than 20 organisations financed the second phase of the project. Many of them were represented on the board of directors. The board holds the overall responsibility for the project. The research leaders have led the scientific work. The project managers have been responsible for co-ordination of the project. Together we have striven actively for rapid and extensive dissemination of results. The board can happily note that the researchers have delivered interesting results, meeting expectations as well as time schedules.

The research issues of the second phase are related to targets and measures of the EU's energy and climate policy package. Examples of areas that have been analysed are the function and development of the energy markets and infrastructure, effective measures to reduce carbon dioxide emissions – renewable energy and other energy with low CO_2 emissions, together with energy efficiency and resource management – as well as security of supply issues.

Core research activities have been the synthesis work of different perspectives, results and models of the research-groups from different countries and scientific disciplines.

Results produced by the project's researchers have been examined and quality-assured. They are not only reviewed by the project directors from a scientific perspective, but also challenged at several conferences and workshops with participating, external experts from relevant fields.

The board has not interfered with the scientific freedom of researchers. Thus, the researchers, not the project as such, are accountable for the contents of this book.

An objective of Nordic Energy Perspectives has been to create a forum for fact-based discussion between politicians, civil servants, industrialists and other energy actors from different disciplines and countries. This forum is active. We are eager that these discussions shall continue on the themes dealt with by Nordic Energy Perspectives. Hence, for each of the result sections below, we identify the researchers whom the reader can contact for further dialogue. Another means of contact is the project's web site: www.nordicenergyperspectives.org.

We extend warm thanks to the project management as well as to all the researchers who have contributed to the project's second phase. As this is written we look forward to the final seminar and the enlightening discussions we hope will follow!

For the project board in April 2010

Tomas Kåberger
Chairman

How to read this book

Nordic Energy Perspectives (NEP) is an interdisciplinary Nordic energy research project which, from a holistic perspective, has analysed and created new insights into the consequences for energy markets and energy systems of the goals and instruments of energy policy in the light of new environmental conditions. The project's aim has been to provide better bases for decisions on energy and environmental policy at both national and international levels.

This book is one part of the documentation of the project. It is truly a challenge to present the results from such a large project in the compact form of a book. We have chosen an approach where we highlight certain aspects in the form of short chapters that presents conclusions and syntheses based on the project's results and analyses. We call them "20 perspectives on Nordic energy". In addition to these chapters we present ten sections, which are a translation of these perspectives into "opportunities and challenges" for the Nordic energy systems.

20 perspectives on Nordic energy

This book presents the following 20 perspectives on Nordic energy:

- Significant impact of meeting the EU energy and climate package on Nordic energy markets
- Future options for large-scale stationary energy production with low CO_2 emissions in the Nordic countries – nuclear in the near future, CCS a new long term option
- The EU renewable target is the main driver for reducing Nordic emissions of CO_2 by 20 %
- Large renewable energy resources in the Nordic region - but the extent to which the use of these resources can be increased varies significantly from country to country
- Energy efficiency measures in the entire energy system leads to synergies
- Large, profitable efficiency improvement potential in end-use - existing programmes and simple measures give significant improvements in efficiency

- The development of the Nordic electricity system: Towards zero CO_2 emissions?
- Can we expect electricity demand to grow?
- Millions of electric vehicles will have manageable impacts on the Nordic power system
- Huge opportunities for Nordic electricity export in a widened European electricity market
- Scenarios for the Baltic Sea Region
- District heating – an important part of a sustainable Nordic energy system
- District heating price model – important for future competitiveness
- Proactive strategies for environmental sustainability of municipal energy companies – pathways of sustainable development in the stationary energy system
- Leading indicators in successful facilitation schemes for Clean Tech companies with an extensive operating history – the case of increasing growth and export volumes in the Swedish biomass combustion manufacturing industry
- International climate policy participation critical for Nordic industry competitiveness
- The forest industry in the Nordic region – a temporary dip or the beginning of a structurally driven decline?
- Broader participation required for successful emissions reduction as global energy demand increases
- Global climate challenge – a stimulant for a new Nordic business?
- Perspectives on security of supply issues in the Nordic countries?
- Is nuclear power a threat to security of supply?
- Potential effects on the Nordic region of a gas shortage in Europe - increased demand of gas in EU and decreased production gives increased dependence of imports

Ten opportunities and challenges

This book also includes ten sections concentrating on related challenges and opportunities:

- The challenge of implementing the EU climate and energy package in the Nordic countries
  - Identifying synergies is the key to cost-efficient solutions, and opens for opportunities
  - New technology gives new opportunities
  - A large share of the CO_2 reductions are taken by the trading sector

- Utilize CO_2 lean electricity and district heating as measures in the transformation of the energy system
  - Measures that transfer the responsibility from the non-trading sector to the trading-sector are important
  - Measures that reduce more than one greenhouse gas at the same time

The sections presenting the **"Opportunities and Challenges"** in this book are marked with green bars.

- The Nordic renewable energy resources provide opportunities, but also challenges
  - Opportunities for Nordic cooperation in order to effectively utilize the renewable resources – within the Nordic region
  - Effective use of the Nordic renewable energy resource – the EU perspective
  - A proper balance between different demands for the biomass resource

- Three energy efficiency challenges
  - Choose a policy that gives equivalent incentives to improve efficiency in the whole energy system
  - The choice of policy instruments – finding a good balance
  - Large incentives might be required to reach the 20% efficiency target

- The challenge of making Nordic electricity (almost) CO_2 free
  - A strict marginal perspective
  - Intermittent electricity production, e.g. wind power, is a challenge for the Nordic electricity market
  - Electricity disclosure and trade in guarantees of origin (GO)

- Finding the balance between politics and markets - a recurring theme in the Nordic Energy Perspectives
  - The Nordic electricity market is increasingly policy-driven
  - Successful deregulation requires adequate reregulation
  - The market cannot always be blamed

- Important issues to consider in a further integration of the electricity markets in Northern Europe
  - The Nordic renewable energy resources are valuable in an European perspective
  - A further integration is likely to further expose differences in national policy measures
  - Electricity-price volatility is likely to rise as the share of intermittent production is increased

- The district heating challenge – how to remain competitive and contribute to a sustainable development if/when energy demand starts to decline
  - Increased efforts towards a more efficient use of energy in buildings tends to reduce heating demand

- Increased competition from increasingly efficient heat pumps may also decrease total district heating demand in the Nordic countries
- Climate and energy policies influence district heating demand and production, both positive and negative

- Industrial and export development for Nordic industry – opportunities and challenges
  - Macro economic changes
  - Can energy also in the future support the global competitiveness of Nordic industry?
  - Case study: Time consuming physical presence in local markets is often necessary

- The challenge to use energy systems modelling in a "wise and appropriate" manner in large multidisciplinary research projects
  - Success factors, based on lessons learned in NEP

It has also been a challenge for the project to reach its overall goal of "demonstrating means for stronger and sustainable growth and development in the Nordic countries". By showing all these opportunities we are convinced that the project's results and conclusions can – if they are taken into consideration – contribute to strengthening the development in the Nordic countries and Nordic cooperation.

"It has also been a challenge for the project to reach its overall goal"

Other NEP reports

In addition to this book the results from the NEP project are presented through a number of additional channels:

A book describing experiences from the extensive use of energy-system models: *Coordinated use of energy-system models in energy and climate-policy analysis – lessons learned from the NEP project.*

A booklet concentrating on the opportunities and challenges that has been identified for the Nordic energy systems: *Ten opportunities and challenges for Nordic Energy – towards a sustainable Nordic energy system.*

A number of research reports and presentations from workshops and conferences that can be found on the project's web site: *www.nordicenergyperspectives.org*. These reports provide more comprehensive and detailed descriptions of the project's results and analyses within different areas.

Content

1. Introduction

Nordic Energy Perspectives (NEP) is an interdisciplinary energy research project with the overall goal of demonstrating means for sustainable growth and development in the Nordic countries. The Nordic energy system is the point of departure, seen from a European and a global perspective.

The second phase of the project has been carried out during 2007-2010. This book summarises the most important results and conclusions.

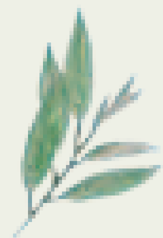
NEP analyses the national and international political goals, directives, and policy instruments within the energy area, as well as their influence on the Nordic energy sector. The analysis includes the impact on energy markets, energy systems, infrastructures and institutional structures. NEP aims at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

This second phase is characterized by:

- The most important market actors have participated
- Experienced researchers involved
- Cross scientific cooperation and process of synthesis
- Professional energy models
- Intense dissemination of results.

The aim is to make better and more well-balanced decisions between competing ends possible. The project also presents ways for the Nordic countries and their energy actors to meet the demands from the rest of the world regarding environmental adjustments and security of supply in a cost efficient manner.

THE EU ENERGY AND CLIMATE PACKAGE



On January 23 2008 the EU Commission presented its energy and climate package and in December 2008 an agreement with the EU Parliament was reached. The goal for the policy package is to reduce emissions of greenhouse gases by at least 20 % compared to 1990 and to increase the renewable share in the EU energy mix from 8.5 to 20 % until the year 2020.

The target for CO_2 emissions reduction of 20 % compared to the 1990 level corresponds to a reduction of 14 % compared to the 2005 level. The reduction should be reached partly within the system for emission trading and partly through measures in other sectors. The trading system will be expanded and the number of emission allowances will gradually be reduced in a way that the emissions covered by the system decreases by 21 % until 2020, compared to the 2005 level.

Within the sectors not included in the emission trading system the emissions should, as an average, be reduced by 10 % compared to the 2005 level. For these sectors a burden sharing has been applied, taking each country's specific prerequisites into account.

In order to reach the 20 % target for increased use of renewable energy until 2020 the EU Commission has assigned individual and mandatory targets for all EU countries. The policy package also includes the target that at least 10 % of all fuels in the EU´s transport sector should be biofuels.

The EU's energy and climate package also includes a requirement for energy efficiency improvements of 9 % by 2016, and a proposal for 20 % energy efficiency improvements by 2020.

The EU Commission has also issued new guidelines for governmental support to environmental protection which should help the member states to develop a sustainable European energy and climate policy.

Towards a sustainable energy system

A common aspiration in the EU´s and the Nordic countries´ policies is to develop the society in a sustainable direction. The future energy system is an important part of such a society. In the NEP project we have a general view of a sustainable development of the society, but our focus is directed towards the demands such a society will put on the energy system.

Since 2001 the EU has a general strategy for sustainable development. A key element is that environmental protection, social cohesion and economic prosperity must go hand in hand. The strategy should, according to its aims, found a basis for reviews and development of EU policy within different areas during the coming years. The EU´s energy and climate policy package could be seen in this perspective.

The EU´s energy and climate policy package has been viewed as an operational expression of an energy policy for the EU, based on the general strategy for sustainability. The analysis in the project is based on the targets of the package.

Research focus

The research focus of NEP is described below under four headings (A-D), which agree well with the orientation of the EU's energy and climate policy package.

A. Markets and structures *(infrastructure and institutional structure)*

NEP is intended to demonstrate consequences and values of continued development and integration of the energy markets (for electricity, gas, district heating and fuels) in a Nordic perspective. In the event of continued integration with the rest of Europe, NEP also aims at demonstrating a number of possible paths of development.

This is done by analysing how the Nordic energy markets can be developed within the framework of new changes in the surrounding world, how the functions involved can be improved, and which types of incentives and political control/planning are required for carrying out necessary investments in the infrastructures. Central is also the trade-off between the different infrastructures' expansion and the mutual balance of network, production and use. Emphasis is also placed on the institutional structures, including e.g. the question of a common Nordic ISO/TSO.

B. Lower carbon dioxide emissions, more renewable energy, and more energy with lower CO_2 emission

NEP indicates ways to meet the demands for lower carbon dioxide emissions, and describes the consequences for the Nordic energy system. We analyse both the existing and more long-term requirements. In particular NEP clarifies the consequences of increased use of renewable energy and energy solutions with low CO_2 emissions. The consequenses for CO_2 reductions are seen both in a Nordic and a global perspective. In addition, the consequenses for the development of the energy markets and industrial progress in a Nordic and a European perspective.

Impact analyses are made using NEP's comprehensive model toolbox, supplemented with more traditional qualitative analyses. We demonstrate the consequences of both current and alternative political goals, controls for CO_2 reduction and greater use of renewable energy. The project aims at clarifying how the development can benefit the Nordic region. Moreover, we elucidate the roles of the different kinds of energy in future development. It is of interest to find out how increased use of renewable energy in the energy sector influences and competes with other sectors/activities and to identify opportunities for industrial development in the Nordic countries.

C. Security of supply and energy resources

NEP indicates how we can increase the security of supplies of energy, by making our Nordic energy-system infrastructures safe as regards operation and delivery, and by helping to decrease the dependence on imports in the Nordic region and the EU/Europe. Moreover, NEP clarifies which roles our own energy resources and our Nordic energy markets can play for supply security in a Nordic and a European perspective.

The analyses of security of supply are not made separately in NEP. The analyses of import dependence are integrated with the energy-system analyses made under B and D. In these analyses NEP's models are used extensively and are supplemented with qualitative analyses. The analyses of the function of the energy system are integrated with the market analyses in A.

D. Energy efficiency and resource management

NEP indicates means for improved efficiency and resource management at all levels (supply, distribution and use) in the Nordic energy system. The project describes how these influence the development of the energy markets and CO_2 emissions, and the role played by increased efficiency at the different levels in the energy system. It also demonstrates the consequences of the political requirements (goals and policy tools) for increased energy efficiency which have been set up by the EU and the Nordic countries.

This is done through impact analyses using NEP's comprehensive toolbox of models, supplemented with more traditional analyses. Analyses of the potential for energy efficiency are conducted at an aggregated level and with data from other experts' detailed analyses throughout the energy system. Thereby we analyse the roles played by different types of energy efficiency measures, ranging from end-use measures to the utilisation of surplus heat in the district heating system. Moreover, we show the consequences of formulating goals for improved energy efficiency as requirements for reducing the use of energy (e.g. primary energy) or as reducing environmental influence (e.g. CO_2).

Important points of departure

The project has the following important points of departure for development of the Nordic energy markets and energy systems. These points of departure are also central for the interdisciplinary synthesis work in the project.

Welfare development in the Nordic countries and the significance of energy for it.

The project's overall ambition is to contribute to strengthening economic growth and welfare development in the Nordic countries. Therefore, the welfare perspective is fundamental for NEP. A central research question for the project's synthesis work regarding energy and welfare is what the Nordic countries require in order to continue to be a growth region.

For the development of welfare, seen from a perspective of energy policy, three dimensions and driving forces are central:

- **Efficiency and competitiveness – the role and function of energy markets**
  The role of the liberalised energy markets for welfare development in the Nordic countries and the European Union is a key focus in the project. In the interdisciplinary synthesis, the role and function of the energy markets is analysed both in terms of the markets and from the viewpoint of welfare economics (efficiency and distribution effects). Different energy markets (electricity, biomass, peat, district heating, gas etc.) also have different logics and the interplay between markets is important, as is interplay with the markets for EU ETS and green certificates.

- **Security of energy supply**
  Developments in other countries have led to increased emphasis on security of supply. The project's focus is on the consequences this has for the Nordic countries. Are there reasons for a special role of the Nordic countries in Europe, such as being a "centre for renewable energy"?

  Security of electricity supply has particularly high political priority. This issue raises a number of important research questions. If a power deficit occurs, what will receive priority? How is the power capacity influenced by increased integration of Europe's electricity network? Can the Nordic countries' easily regulated hydro power acquire greater importance as a balancing/peak load in an integrated European electricity system?

- **Climatic and environmental considerations**
  Long-term development of welfare must also take climate and environment into account. The third dimension, and driving force for this development, is thus policy on climate and environment. A special focus is laid in the second phase of the project upon climate policy after 2012 and its consequences for the energy markets and energy systems. The development of EU ETS during 2008-2012 is also a main topic for the project's analyses. The development is analysed from the perspective of what will make the trade-based policy instruments (EU ETS and green certificates) function in the long time perspective (both during and after the Kyoto agreement's term of validity).

In energy policy, continual assessments and prioritisations are mad between these three dimensions and driving forces. Political visions, goals and policy instruments clarify these priorities for the short and long run.

- **Energy policy: national, Nordic, and within the EU**
  NEP follows and analyses energy policy regarding the political trade-offs between competitiveness/efficiency, security of supply and climate/environment, as well as the prioritisations between the energy sector and other sectors. We also analyse and clarify the advantages of increased coordination of energy policy between the Nordic countries and coordination with EU policy. As a point of departure the political goals and visions in the Nordic countries and the EU are emphasised. A question is whether current political goals and policy instruments will lead to an effective and desirable development of the energy markets in the Nordic countries and northern Europe.

  Our joint effort toward *sustainable development*, is often expressed in the three factors of economic, social and ecological sustainability. These have clear connections with the three dimensions described above: competitiveness/efficiency, security of supply and climate/environment. In the project's analyses and syntheses, sustainable development is thus a pervasive concept.

Other points of departure for NEP

- **The Nordic dimension**
  The project is Nordic and asks both what is best for the Nordic countries and what it means to deviate from the rest of Europe and/or global developments. Globalisation and the international energy markets are also important geopolitical dimensions.

- **All kinds of energy and the entire chain from supply to consumption**
  The whole Nordic energy system with all kinds of energy is in focus. The entire chain from supply through transmission/distribution to use, is treated by the project's analytical tools.

- **Infrastructures and institutional structures in interplay and competition**
  An important research focus is on the interplay and competition between different infrastructures, including the institutional structures and the control of systems driving the expansion of infrastructures. The balance between markets and politics has been a recurring theme in the second phase of the NEP.

- **Time horizons, short- and long-term**
  The time perspective in Nordic Energy Perspectives is both short- and long-term. However, the research focus throughout is on current issues, for which the short- and long-term consequences are analysed. This is essential since the influence on energy systems and markets is often both short- and long-term. It is also important because different actors are at different stages or "time windows" in their decision processes. The project's ambition is to produce adequate fact and decision bases for all the collaborating actors.

- **Energy models as decision support in the Nordic countries and the EU**
  The project makes use of a unique array of professional energy-system models which ensures high-quality analysis of the Nordic energy systems' development. Moreover, we have excellent possibilities of comparing the models with each other and understanding their special properties. This insight is important since the models are continuously used for political and strategic decisions on energy in the Nordic countries.

Objective

Nordic Energy Perspectives has the overall goal of demonstrating means for stronger and sustainable growth and development in the Nordic countries.

Important sub-goals for achieving the overall goal in a Nordic perspective are:

- To identify advantages of continued integration of the energy markets in the Nordic countries, and identify obstacles to strengthen the Nordic countries as a common marketplace.
- To identify advantages of continued integration and its influence on the energy markets between the Nordic countries and the rest of Europe (as well as globally).
- To identify opportunities of business development in the Nordic countries, for new business development within the field of energy/climate, and to increase the competitiveness of existing business.
- To clarify how the EU energy policy influences the Nordic countries (on both policy and markets) and how the Nordic countries can contribute to realising the EU energy policy not only for market development, but also for:
    - reduction of carbon dioxide emissions;
    - increased use of renewable energy;
    - increased efficiency of energy;
    - greater security of supply.
- To identify advantages of an increase in Nordic energy-policy cooperation and shared outlook.

Furthermore:

- The research activity has a scientific basis.
- The project contributes to a constructive dialogue between politicians, authorities, the energy industry and the energy users.
- It generates results that contribute to improved support for the political decisions both nationally and internationally.
- It actively disseminates the results to decision-makers, opinion-builders and others concerned in our Nordic countries.
- It develops or refines purposive and credible analytical methods and modelling tools which are used for the impact analyses within the project. The methods and tools can be used for the stakeholders' analytical needs outside the project.

- It is a forum for fact-based discussion and dialogue between decision-makers and other energy actors from different disciplines and countries. The project's researchers and experts are also a resource for investigations and fact compilations which the stakeholders need outside the project.
- It increases the collaboration and knowledge transfer between researchers in the Nordic countries, as well as contributing to the reinforcement of Nordic knowledge centres.

Method

The research work of Nordic Energy Perspectives is distinguished by:
Experienced researchers: nearly all of the research work is performed by senior researchers at universities, institutes and consultancy companies, who are well-accustomed to research collaboration and result-oriented research.

Interdisciplinary collaboration and synthesis work: a large part of the research work consists of collaboration between researchers from different scientific disciplines. The synthesis work is also the basis for "dialogue and influence", in other words for the project's "outward face".

Professional energy models: the project has at its disposal a unique set of around ten well-established energy models with different features, system boundaries and model approach. This model "toolbox" is applied to a wide range of problem issues within the project. Thereby, problem issues can be tackled in a far wider manner than would have been possible with the use of only a single model or a few models. The multitude and strength of this model tool-box distinguishes this project from other related Nordic energy- and climate-policy research. The models, and the modelling process, is described in a separate report, "Coordinated use of energy-system models in energy and climate-policy analysis – lessons learned from the NEP project".

Traditional research methods: established analytical methods (literature search, surveys, deep interviews, statistical processing and analyses, calculations etc.) from the respective scientific disciplines are used.

Intensive distribution and communication of research and results: substantial resources are allocated to result distribution and dialogue with the project's stakeholders, not only at the end of the project but also continuously during the project. The latter enables frequent feedback from all project participants into the research process.

The broad choice of research methods and models listed above was proven very successful in the first phase of this project. In that phase research methods were tested and energy models were partly synchronized and adapted to different research issues.

Main scenarios

In this book we present results from model calculations of the development of the Nordic energy systems. The NEP model toolbox has been used for the calculations. A certain focus has been on the EU energy and climate package. The following scenarios have been calculated:

The reference scenario

The reference scenario includes existing policy instruments such as energy and CO_2 taxes and selected support schemes such as the Swedish electricity certificate system and direct subsidies in other Nordic countries. Furthermore, the EU emission trading scheme (EU ETS) is included as an exogenously given EU emission allowance (EUA) price of 25 EUR/t.

The EU policy scenario

The EU policy scenario includes the same policy instruments as the reference scenario but, in addition, a requirement to reach the renewable target defined for Denmark, Finland and Sweden in accordance with the EU energy and climate package, and an assumed target for Norway. The scenario also includes an EU emission reduction target of 20 %, also applied for the Nordic region.

The extended EU policy scenario

The extended EU policy scenario includes the same policy measurements as the EU policy scenario but, in addition, the target of increasing energy efficiency by 20 % until 2020 adapted to the Nordic countries.

The global policy scenario

The global policy scenario includes a new global climate policy agreement where the EU CO_2 emission reduction target is increased to 30 % and the renewable target is met. The emission reduction target is included both in the form of different global emission reduction targets and in the form of the EU emission trading scheme (EU ETS). The scenario also includes existing policy instruments. (The scenario does not include the increased energy efficiency target.)

Alternative scenarios

A number of additional scenarios are also defined, calculated and analysed. They are designed to illustrate the effect of certain specific factors or situations. These scenarios are explained in the chapters where they are referred to.

More detailed descriptions of the scenarios can be found in the different chapters of this book, and in the research reports from the NEP project.

Participants and organisation of the project

Nordic Energy Perspectives is led by a board of representatives from the financial supporters. The project's group of researchers is cross scientific, including researchers within energy system technology, economics, business administration, state planning and law. The host for the project is Elforsk. The board has the following regular members and deputy members. Sweden's Energy Agency's Director General is the chairman of the board.

- Swedish Energy Agency (chairman)
- Nordic Council of Ministers
- Nordic Energy Research
- SwedEnergy and its' member companies and Svenska Kraftnät
- Elforsk
- Swedish District Heating Association
- Svebio, The Swedish Biomass Association
- The Swedish Gas Association
- Confederation of Swedish Enterprise
- Finnish Energy Industries
- Tekes, the Finnish Funding Agency for Technology and Innovation
- Finnish Ministry of Trade and Industry
- Finnish Forest Industries Federation
- Association of Finnish Peat Industries
- The Federation of Finnish Technology Industries
- Enova
- Energy Norway, former Norwegian Electricity Industry Association (EBL & EBL Kompetanse)
- Statnett
- Statkraft
- Norwegian Water Resources and Energy Directorate (NVE)
- DONG Energy
- Danish Energy Association

The sub-project KOMPAS, which is a part of the NEP project, has also been financed by the The Research Council of Norway.

The project's research group is interdisciplinary with researchers within energy systems technology, economics, business administration, state planning and law. The research group consists of the following universities, and research institutes/companies:

- VTT Technical Research Centre of Finland
- Profu, Gothenburg
- Sweco/EME Analys, Stockholm
- ECON Pöyry, Stavanger and Oslo
- Gothenburg School of Business, Economics and Law
- Xrgia, Oslo
- VATT – The Government Institute for Economic Research, Helsinki
- RAM-løse edb, Copenhagen

The project leader is Profu.

The NEP research group has also had a close cooperation with researchers at:
- Chalmers University of Technology, Gothenburg
- Stockholm University

A Nordic venue and a forum for dialogue

Nordic Energy Perspectives has become a venue and a forum for discussions and dialogue, based on unbiased facts, among politicians, decision-makers and other participants from the Nordic energy field.

An important objective is to serve as a "Nordic energy forum" where market participants, researchers and authorities within the Nordic energy field can meet and, objectively and freely, discuss, analyze and exchange information and research results concerning the development of the Nordic energy systems and markets, and concerning energy and climate-policy issues.

An intensive distribution of results is given priority in Nordic Energy Perspectives, among other things in order to ensure that the dialogue striven for is achieved and proves effective, and that relevant questions are confronted to the greatest extent possible.

Nine NEP conferences

The project has arranged nine conferences, four during the first phase (2005-2006) and five during the second phase (2007-2010):

- Copenhagen October 5th 2005: Nordic Energy Policies
- Helsinki January 24th 2006: Nordic Energy Policy Perspectives; Tradable quotas for CO_2 and renewables. Development of Nordic Energy Systems
- Stockholm May 4th 2006: Policy and Market Perspectives
- Oslo September 27th 2006: Ten Perspectives on Nordic Energy
- Gothenburg November 27th 2007: Nordic and European perspectives on Pathways to Sustainable Energy
- Helsinki May 14th 2008: Nordic Energy Scenarios; Significant impacts on the Nordic energy system of the EU energy and climate policy package
- Oslo March 17th 2009: Nordic Energy Futures; Perspectives on the development of Nordic energy
- Helsinki January 21th 2010: Nordic Energy Post Copenhagen; also including support schemes for renewable energy in the Nordic countries
- Stockholm April 27th 2010: Towards a Sustainable Nordic energy system

The conferences have been well attended and the purpose of them has been fulfilled, i.e. to *"stimulate a dialogue with the users of the project, where results and knowledge from the project may be spread and a feedback on the results may be received."*

A brief presentation of the contents of each conference can be found on the project's website (www.nordicenergyperspectives.org).

> *... and the purpose [of the conferences] "to stimulate a dialogue with the users of the project, where results and knowledge from the project may be spread and a feedback on the results may be received" has been fulfilled.*

2. Significant impact of meeting the EU energy and climate package on Nordic energy markets

The European Union has set three climate and energy targets to be met by 2020. The targets are a reduction in EU greenhouse gas emissions of at least 20 percent below 1990 levels, 20 percent of EU energy consumption to come from renewable resources, and cutting energy consumption by 20 percent of projected 2020 levels by improving energy efficiency. If the Nordic countries manage to meet these targets total carbon dioxide (CO_2) emissions in the Nordic region may be reduced by around 30 percent by 2020 compared to emissions in 2007. All three targets will have a significant impact on the energy systems of the four Nordic countries, and it is likely that all energy sectors will be included, albeit to different extents, in achieving these targets.

CO_2 emissions may be reduced by 30 percent

Three main scenarios have been investigated with the use of advanced energy-systems modelling. The scenarios are briefly described in Table 2.1. The scenarios differ from each other with respect to the degree to which the targets of the entire EU climate and energy package (including also the energy efficiency target which, contrary to the other two targets, still is non-binding) are met. Also the reference scenario includes several of the most important existing policy instruments. Figure 2.1 below shows that in the reference case CO_2 emissions from the energy systems of the four Nordic countries are reduced - but only by around 5 percent by 2020 compared to 2007. Thus, additional policy measures are required if emissions are to be brought down beyond that. If all three policy targets are met ("Extended EU Policy"), CO_2 emissions are reduced substantially - by around 30 percent by 2020 compared to 2007 levels. In this scenario, the energy-efficiency target is applied to the entire energy system, i.e. energy conversion, transmission and end use in different sectors. If only the climate and renewable targets are met ("EU Policy"), CO_2 emissions are reduced by around 15 percent by 2020 compared to 2007. Thus, fulfilling the EU's energy-efficiency target has a significant impact on CO_2 emissions in the Nordic countries.

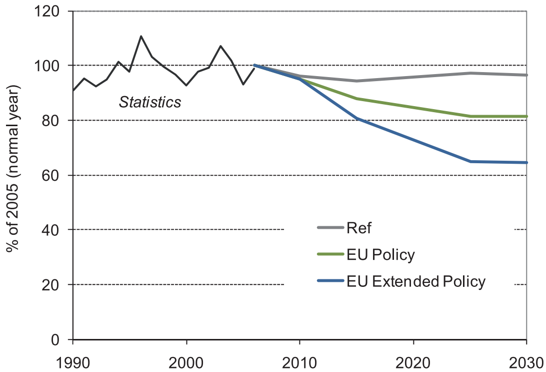


Figure 2.1: The three investigated scenarios and their impact on total Nordic CO_2 emissions from the energy system.

Table 2.1: Brief description of the three investigated policy scenarios (EV=Electric vehicles)

Scenario	EU-ETS	Renewable Directive	Efficiency Target	Transports
Reference	25 EUR/t	Not implemented	Not implemented	Biofuel Directive not reached
EU Policy	25 EUR/t	Nordic target	Not implemented	Biofuel Directive is reached
Extended EU Policy	25 EUR/t	Nordic target	Nordic target	Biofuel Directive + EVs

Renewables and energy efficiency are the most important CO_2-reduction measures

The significant reduction of CO_2 emissions by 2020 and beyond in the "Extended EU Policy" scenario is achieved mainly through increased use of renewables in all sectors and through energy-efficiency measures at the end-use side as well as at the supply side of the energy system. But also nuclear power plays a significant part in the reduction measures identified through model analyses. This includes a fifth reactor in Finland and repowering and increased availability in Swedish nuclear power plants by 2020. The individual contributions of these measures are shown in Figure 2.2 as CO_2-reduction "wedges". These contributions are estimations related to a trend projection until 2030, based on the years 1990-2007.

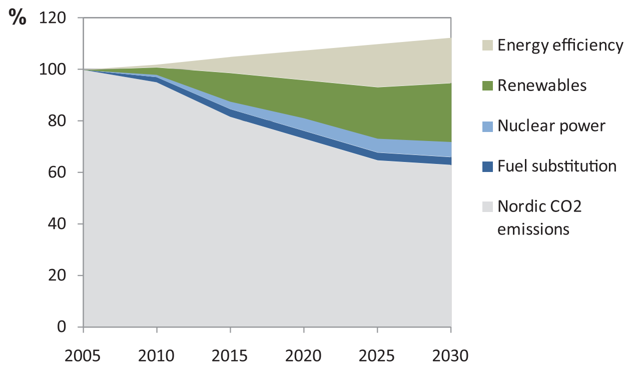


Figure 2.2: CO_2-reduction measures in the entire energy system of the Nordic countries in the "Extended EU Policy" scenario put in relation to an assumed trend projection, based on 1990-2007, by 2030.

All sectors will be involved

Extensive analyses show that the EU climate and energy package will have significant impact on the energy systems of the four Nordic countries, and that all sectors within the energy systems are likely to be involved in meeting the policy targets. Figure 2.3a (see next page) illustrates the impact of sectorial CO_2 emissions (in Mton CO_2, aggregated over the four Nordic countries) resulting from meeting the entire climate and energy package (i.e. the "Extended EU Policy" scenario that includes the efficiency target). The results are based on model calculations and clearly show that electricity and district heating account for the largest absolute contribution towards reducing CO_2 emissions by 2020. This is true for all three scenarios (Figure 2.3b). The relative reduction is, however, also very large for the residential and commercial sectors. In the same way as for electricity and district heating, the residential and commercial sectors reduce their emissions by around 50 percent compared to 2007 levels in the "Extended EU Policy" scenario.

In this analysis, the transport and stationary energy sectors have been analyzed separately using different approaches. For the transport sector, future emissions have been estimated using a simulation approach where emission reductions are a result of what may be possible to achieve, within reasonable limits, given the inertia in transforming the road transportation capital stock (assuming e.g. average lifetimes of cars). For the stationary energy sector, a cost minimizing model with a very large amount of technical, economical and environmental constraints has been used (the MARKAL-NORDIC model). Thus, in the "Reference" scenario it is assumed a priori that road transportation increases its emissions despite the fact that the use of biofuels increases. Increasing demand for road transport explains this, which outdoes the inherent efficiency improvements of new cars. In the "Extended EU Policy" scenario, the introduction of approximately 1,5 million electric vehicles (e.g. plug-in hybrids) and the fulfilment of the Biofuel Directive yield a reduction of around 5 percent compared with projected 2020 levels of total Nordic emissions. However, with an alternative demand for transports this figure may become larger than that.

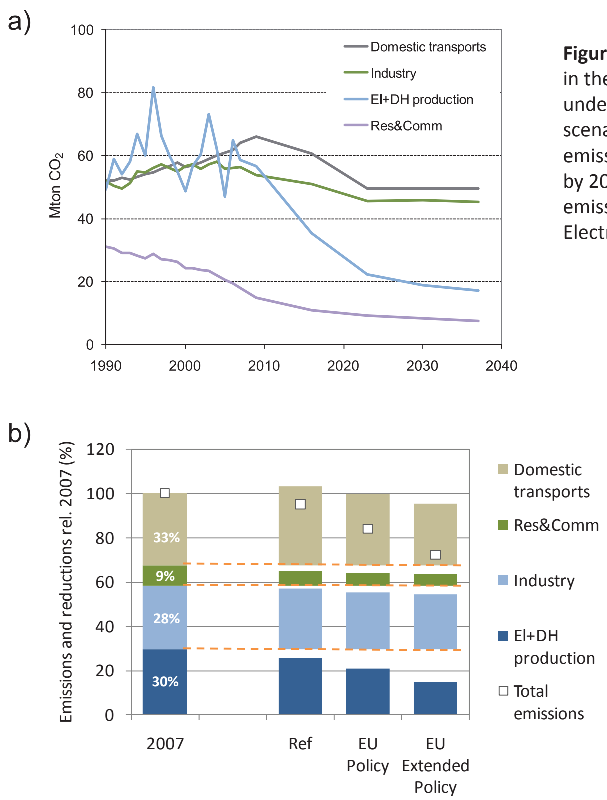
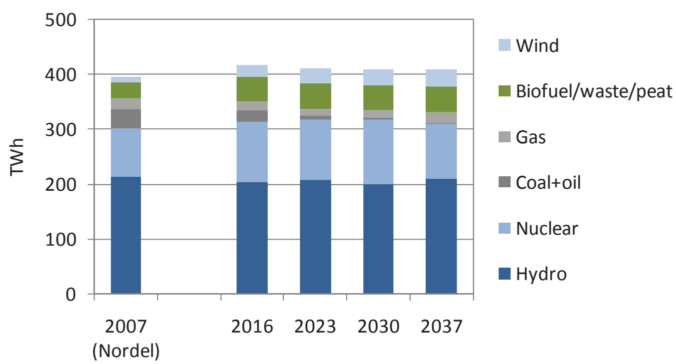


Figure 2.3: Sectorial CO_2 emissions in the Nordic countries as a whole under the "Extended EU Policy" scenario (2.3a), and sectorial CO_2 emissions and reductions achieved by 2020 in relation to total CO_2 emissions in 2007 (2.3b). El+DH = Electricity and District Heating

Nordic electricity supply almost CO_2 free by 2020

The share of fossil-based (excluding peat) electricity production in the Nordic electricity market currently amounts to around 15 percent. This is a very low figure in an international comparison. Moreover, model calculations indicate that by 2020, this share may shrink to less than 5 percent under "Extended EU Policy" scenario assumptions (Figure 2.4), to slightly over 10 percent in "EU Policy" and to slightly less than 15 percent in the reference scenario. These figures are backed by an expansion of nuclear power (ongoing Swedish capacity increases and a fifth reactor in Finland) along with significant increases in wind and biomass power (CHP). Existing coal power is gradually replaced while gas power is maintained roughly at today's level. The "EU Policy" scenario results in the largest electricity production and the largest output from renewables in absolute numbers. Combined with a relatively modest increase in electricity demand, this implies that large volumes of electricity may be exported out of the Nordic countries. In the "Extended EU Policy" scenario, a lower demand for electricity and an assumed efficiency pressure on the supply side (in addition to demand-side efficiency measures) gives a relatively smaller total elec-

a)



b)

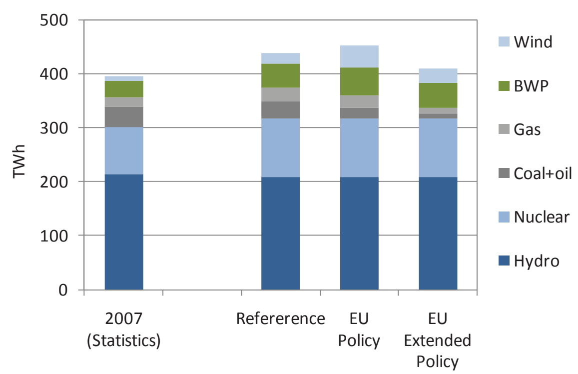


Figure 2.4: Nordic electricity production in the "Extended EU Policy" scenario (2.4a) and in all three scenarios for model year 2023 (2.4b)

tricity production. Even in this case a significant amount of electricity may be exported due to the lower demand. However, we must keep in mind that the final outcome of the power balance will depend on the impact of the EU targets on electricity demand and price in the Nordic region's neighbouring EU-countries.

CCS is generally not a cost-efficient option in the model runs for the Nordic electricity system. Relatively low assumptions on CO_2-prices (generally around 25 EUR/t), a growth in nuclear power and a significant expansion of renewable electricity (in "EU Policy" scenario) in combination with stagnating demand (in "EU Extended Policy" scenario) leaves few options for a significant penetration of CCS in the Nordic countries according to these model results.

Significant CO_2 reduction also in district heating

The EU climate and energy targets also have a considerable impact on the share of fossil fuels in the production of district heating in the Nordic countries. In 2005, the share of fossil fuels (excluding peat and the fossil part in waste incineration) used for the production of district heating was close to 50 percent in the Nordic countries as a whole. It should be noted, though, that the share of fossil fuels varies widely in the four countries. All three scenarios analyzed show that the share of fossil fuels declines by 2020 (see Figure 2.5). In the "Extended EU Policy" scenario, the share

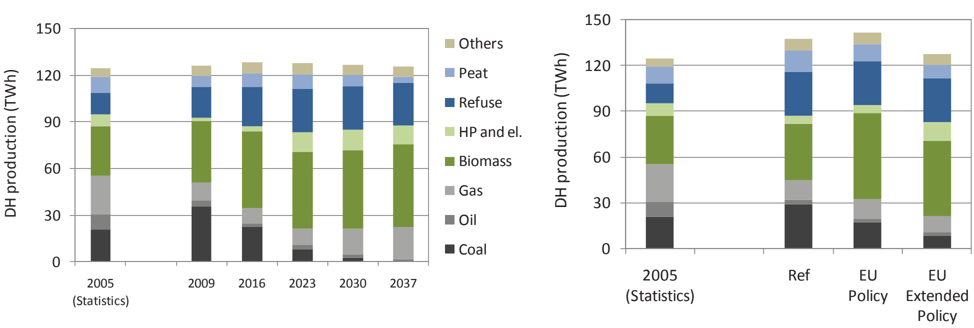


Figure 2.5: District heating production by energy carrier aggregated over all four Nordic countries in the "Extended EU Policy" scenario (left) and in all three scenarios for model year 2023 (right). The allocation of fuels between district heat and electricity in CHP schemes has been estimated according to default assumptions on the electricity-to-heat-ratio (electricity generated by CHP is included in Figure 2.3).

amounts to approximately 15 percent. Even the “Reference” scenario, despite meeting neither the renewable target nor the efficiency target, shows a clear decline in the share of fossil fuels used for district heating (down to around 30 percent by 2020). This can be explained by relatively high fossil-fuel prices, the EU ETS, and existing tax and support schemes.

The EU policy goals affect each other

The analyses carried out by the NEP project frequently show that the various climate and energy targets affect each other. Sometimes, they may even counteract. For instance, the CO_2 reduction target results in a higher electricity price through the EU ETS, while the renewable target may reduce wholesale electricity prices due to investments in renewable capacity, everything else held constant. This makes other non-renewable, but nevertheless lean-carbon, options such as coal-to-gas fuel shift and CCS less viable. If costs for renewable electricity are not incurred on the consumer electricity bills this would also work in the opposite direction of the ambitions of the efficiency target, where demand for energy services is to be dampened. In Figure 2.1, it was shown that the energy efficiency target (given by the “Extended EU Policy” scenario) had a significant impact on CO_2 emissions in the Nordic countries. It is likely that this also is true on a European level. Thus, the energy efficiency target may have dramatic consequences for the EU ETS with a possible oversupply of emission allowances since significant emission reductions are initiated also by the other policy goals.

Figure 2.6 shows the increased use of renewables in the four Nordic countries as a whole for the three policy scenarios. The Directive on the promotion of energy from renewable sources (The “EU Policy” scenario) foresees that the use of renewable energy sources increases by around 160 TWh by

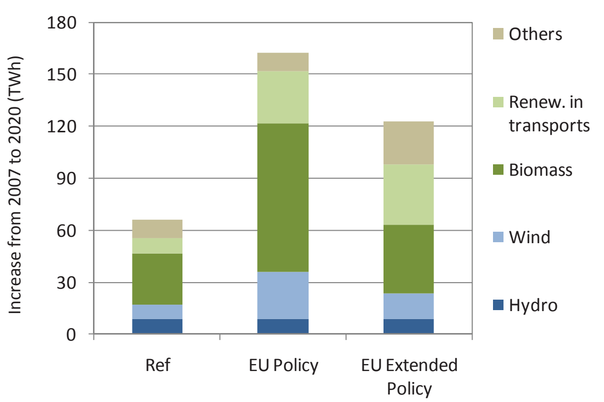


Figure 2.6: Increase in use of renewable energy in the Nordic countries in 2020 compared to 2007 for the three scenarios investigated.

2020 compared to 2007 levels (specific asssumptions have been made for Norway). At least half of that increase will come from biomass used in different sectors (biomass is mainly supplied through domestic resources but also import is considered if the market price exceeds a certain level). If the energy efficiency target is also achieved ("Extended EU Policy" scenario) the increase in renewables is reduced to around 120 TWh. Specifcally, the use of biomass is significantly smaller than in the "EU Policy" scenario, but, of course, larger than in 2007. This is due to lower energy demand but also efficiency measures on the supply side. Biomass use is especially affected by efficiency measures, since biomass is generally associated with lower overall (applied) efficiencies than e.g. heat pumps and wind power, which are also included in the Directive. This is important since, as mentioned earlier, the efficiency target in this study is applied to the entire energy system and to all energy resources. However, the efficiency goal will only affect the use of renewables in their absolute numbers. Since the renewable target is expressed as a relative target (percent of gross demand), it is still being reached by 2020 in the "Extended EU Policy" scenario.

For further information:
Thomas Unger and Bo Rydén, Profu

The challenge of implementing the EU climate and energy package in the Nordic countries

Fulfilling the energy and climate package of the EU and the Nordic ambitions within the energy field has a decisive impact on the development of the energy markets and systems of the Nordic countries. In the previous analyses it was shown that all sectors and all energy markets are likely to be affected. Such far-reaching changes of the energy systems will present a number of challenges but also opportunities.

It is a challenge in itself to redirect the energy system in order to meet the political requirements at the EU level and at the Nordic level. CO_2 emissions are reduced by more than 30 percent and renewable energy is increased by around 100-150 TWh. Moreover, if energy efficiency also is increased by 20 percent until 2020, primary energy consumption is reduced by up to 200 TWh (compared to the outcome of a "Business-as-usual" scenario).

Identifying synergies is the key to cost-efficient solutions, and opens up for opportunities

Meeting the targets in the energy system is costly but identifying synergies is the key, and an opportunity, to reduce the additional costs. It is, however, a challenge to identify and promote such synergies. This may be achieved through:

- choosing policy instruments and other political decisions that in a cost-efficient way promote measures that contribute in reaching all three EU goals at the same time. Wind power is a good example. It is renewable and reduces CO_2 emissions in the Nordic electricity market. At the same time, a shift from e.g. coal power to wind power implies significant efficiency gains at the electricity-supply side.
- considering policy measures at all levels of the energy system in order to include system effects. Energy efficiency measures are not only associated with end use but also with the supply side.

- recognizing a certain degree of flexibility in the commitments of the different parts of the energy system. This means that sector-specific goals for e.g. renewables should be used with care. Instead, including as many sectors as possible in an overall target reduces compliance costs.
- international cooperation and trade, for instance among the Nordic countries. The analysis and results of the NEP project largely comply with a scenario where the Nordic countries initiate a far-stretched cooperation in order to collectively meet the EU energy and climate package.

New technology gives new opportunities

Cost reductions may also be achieved by using a basket of many technological options. The NEP project has shown that the path towards meeting the energy and climate package of the EU involves many measures, options and technologies at all levels of the energy system. Therefore, ruling out specific technological choices out of e.g. political reasons is likely to increase the compliance cost. However, in certain cases climate and economic considerations must be balanced with considerations related to public acceptance (e.g. nuclear power or wind power), other environmental pollutants (e.g. biomass) and so forth. Opening up, and promoting, a wide range of measures in the Nordic countries may create business opportunities for Nordic industry. This may not only involve technological development where the Nordic countries already today are at the very edge within several areas – district heating, biomass, heat pumps, wind power etc - but also within areas related to e.g. systems planning and development, management and markets.

Synergies are also achieved though the encouraging of structural changes of the energy systems where, for instance, grid-distributed energy such as electricity, district heating and gas (e.g. biogas) are made practically CO_2-free and largely renewable, and subsequently become used as “measures” in the development of the energy systems.

A large share of the CO_2 reductions is taken by the trading sector

The analyses of the NEP project clearly show that meeting all three energy- and climate-policy goals of the EU implies significant impact on the Nordic energy systems and a reduction of CO_2 emissions by around 30 percent by 2020. The work presented here also shows that a large share of the emission reductions take place in the trading sector of the EU ETS which indicates that the Nordic region may become a net exporter of emission allowances. However, at the same time the reduction commitments applied to the non-trading sector may become tougher to meet without additional policy incentives. This should in particular involve the transport sector.

Measures that transfer the responsibility from the non-trading sector to the trading-sector are important

– an opportunity advocated by the NEP project

Model analyses of the NEP project have shown that electricity and district-heating supply are only to a small extent still dependent on fossil fuels by 2020 if all three EU targets are met. The European Commission has also formulated a vision of CO_2-free electricity production in Europe by 2050. This means that electricity and district heating, in itself, become important reduction measures in climate-change mitigation. Such measures could, for instance, include switching from oil heating to district heating in dwellings or switching from a gasoline car to an electric car. At the same time, a switch from gasoline to electricity or from oil to district heating means that the reduction responsibility is transferred from the non-trading sector to the trading sector of the EU ETS. The NEP analyses reported in this book indicate that such a transfer of responsibility may account for up to half of the emission reductions set up for the non-trading sectors of the Nordic countries (see e.g. chapter 10). This is a very important conclusion which may play a decisive role in the fulfillment of the Nordic countries' domestic commitments.

Several of the measures and options that may contribute in transferring the responsibility for emission reductions from the non-trading sector to the trading sector, such as district heating, electricity and electric cars are more thoroughly discussed in other chapters of this report.

Our climate is a very complex system

The Earth's climate system is a complex, interconnected system formed by the atmosphere, the oceans and other bodies of water, land surface, snow and ice cover together with all living organisms, and linked by flows of energy and matter. Changes in the Earth's climate are influenced mainly by changes in the atmospheric composition of gases and particles, but also by changes in solar radiation and surface albedo.

The most important component to influence the atmosphere is CO_2, which stands for 70 % of the global warming potential in the atmosphere. Other gases of great importance are long-lived gases like CH_4 (20 %), N_2O (5 %) and fluor-containing gases like HFC, PFC and SF_6 (5 %). All act on a global scale. Mitigation of greenhouse gases must consider not only CO_2, but also the other long-lived greenhouse gases. (The non-CO_2, gases are included in the commitment of the non-tradable sector).

Measures that reduce more than one greenhouse gas at the same time

It is therefore important to seek measures that may reduce more than one greenhouse gas at the same time. These "synergies" will make the measures much more cost-efficient. Such measures identified by the NEP include for instance:

- waste incineration
- biogas (e.g. from manure).

Scenarios including a reduction of all greenhouse gases at the same time are presented in Chapter 20.

3. Future options for large-scale energy production with low CO_2 emissions

– nuclear in the near future, CCS a long term option

The renaissance of nuclear power in Finland and Sweden is up for debate. In Finland, a fifth reactor is under construction, and three companies are seeking permission for a new reactor. A sixth and seventh reactor would have similar effects on CO_2 emissions from European electricity production as roughly half of each new nuclear power plant's production might be exported. This means that CO_2 annual emissions in continental Europe could be reduced by approximately 6-7 Mt CO_2 per new nuclear power plant. Nordic emissions would go down relatively less, as nuclear energy would not only replace condensing power production but also combined heat and power (CHP). Besides investments in nuclear power, another option for cutting CO_2 emissions in large-scale energy production is to implement carbon capture and storage (CCS) at condensing power and CHP plants. In theory, CCS can also be implemented in plants using biomass, resulting in "negative net emissions". In the Nordic region, only Norway and Denmark have suitable storage sites for CO_2, which means that international collaboration is a prerequisite for the implementation of CCS in Finland and Sweden. Further, the CCS-technology must be proven to be technically and commercially viable before it can be implemented on a large scale.

Improved energy efficiency and increased use of renewable energy are two of the most obvious measures to reduce CO_2 emissions in the short term. Both are discussed in detail in other NEP chapters. In this chapter, we concentrate on two other measures which by and large have the same goal – to reduce CO_2 emissions in energy production. These measures are nuclear power and carbon capture and storage (CCS).

The future role of nuclear power in the Nordic region will depend on national policies

- new Nordic nuclear power could contribute to reduce emissions in Central Europe

Nuclear power has increased quite significantly in Finland and Sweden since the 1980's. This is true even before Finland's fifth reactor, Olkiluoto 3, comes into operation and is a result of upgrades to existing reactors. Not even the shutdown of the two Barsebäck units in Sweden has been a severe set-back for nuclear power. Output increases in the remaining reactors will compensate for Barsebäck's shutdown by 2020.

However, old capacity will start to phase-out by 2030, both in Finland and in Sweden. It is still being debated whether Sweden will replace old nuclear plants with new nuclear plants. At the moment, public opinion is not contrary to nuclear power but this might change as it has in the past. In Finland, the Government is expected to make a decision concerning construction permits for new reactor(s) by December 2010. Three companies, Fennovoima, Fortum and Teollisuuden Voima, are seeking permission to invest in a new reactor. The Finnish Government will probably grant at least one new licence as nuclear power is seen as one of the most powerful tools to mitigate CO_2 emissions. It is also likely that increased concern about security of supply an increasing consumer prices of electricity will benefit nuclear power.

It is difficult to say how many nuclear plants would be viable in the Nordic system in the long term. The number will depend on the growth of electricity demand in the Nordic area, especially by energy-intensive industries, and in the future contribution from other energy sources, especially renewables. Moreover, investments in transmission capacity to help promote the integration of the European electricity markets could facilitate exports and increase nuclear energy's viability. Electricity demand can be expected to grow, even taking into account the EU's 20-20-20 targets, (see e.g. Chapters 10 and 20). In Finland, Fortum is also including an option to produce district heating for the Helsinki area at the Loviisa nuclear power plant, making the picture even more complex to analyse.

Within the scope of this study, we have studied three scenarios: 2008, 2020 reference and 2020 policy scenarios (see Chapter 1 for the scenario descriptions). The 2008 scenario corresponds to the existing energy system, i.e. current electricity production capacities. In both the 2020 reference and 2020 policy scenarios Finland's Olkiluoto 3 is assumed to be operational and included in the base case. The share of renewable energy sources has been considerably increased. In each scenario an extra nuclear capacity of 1600 MW or 3200 MW is compared to the base case having no extra nuclear capacity.

Figure 3.1 shows the impact of new nuclear power plants on the Nordic market price of electricity. Simulations of the electricity market show that the market price of electricity decreases by 4% ±0.5% for each 1000 MW of new capacity. This means that consumers could benefit from 600 M€ annual savings for each 1000 MW of new nuclear capacity.

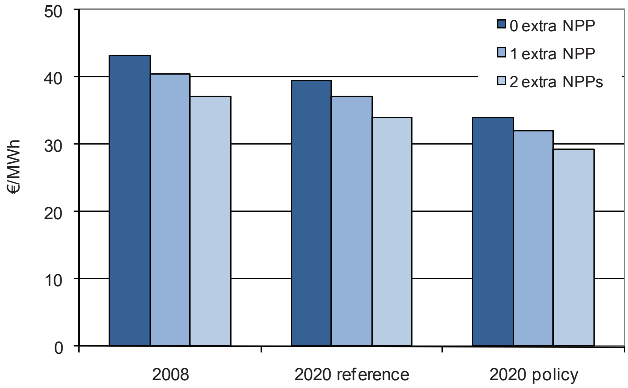
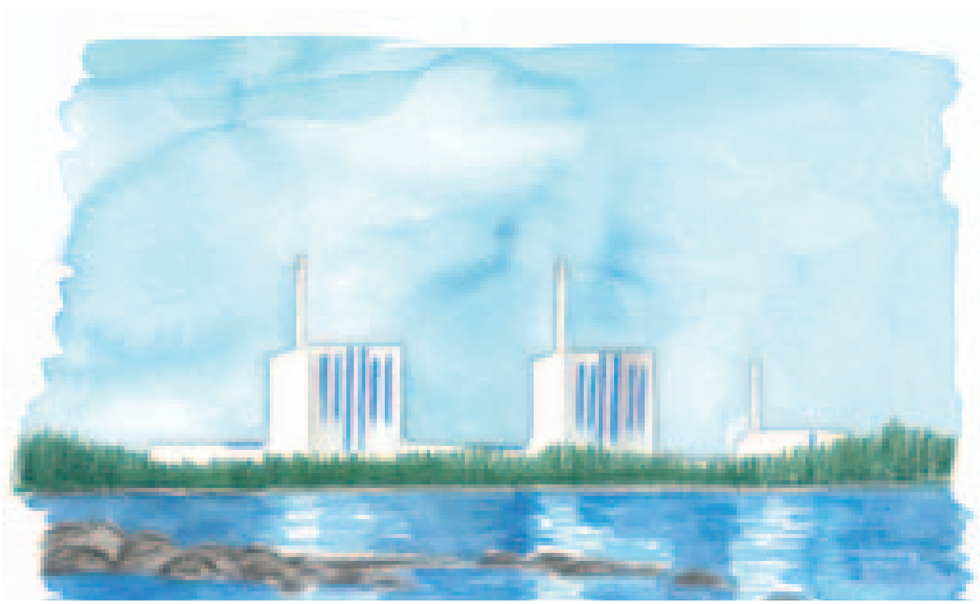


Figure 3.1: The impact of additional nuclear power plants (NPP) on the Nordic market price of electricity in the different scenarios. The decrease in the market price is 4% ±0.5% per 1000 MW new NPP capacity. ("0 extra NPP" refers to four Finnish NPPs in 2008 and to five NPPs in 2020)



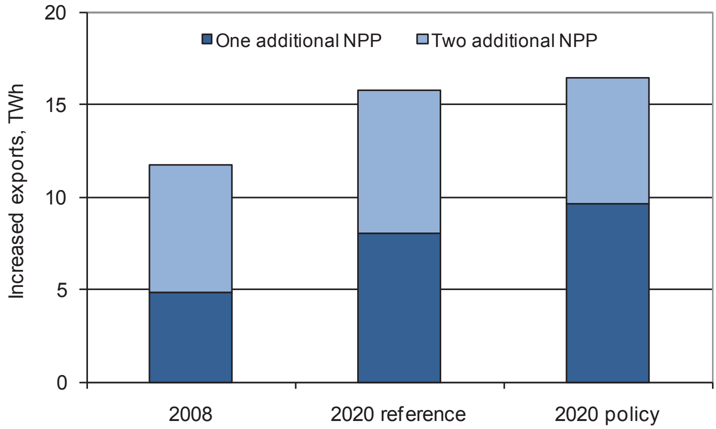


Figure 3.2: Increase in electricity exports according to the number of new nuclear power plants in the different scenarios. In the simulation for 2008, less than half of all new nuclear capacity would result in exports, whereas the share is well above 50% in the reference and policy scenarios.

Figure 3.2 shows the increase in electricity exports resulting from the increase in electricity from new nuclear power, given that all the other conditions are kept constant (i.e. fuel prices, cross border electricity prices outside Nordic area, production capacities other than nuclear, and the price of emission allowances). New nuclear power also replaces other Nordic production. As the increase in renewable energy sources by 2020 is assumed to be substantial, less room is left for condensing power. Exports increase with 16 TWh by 2020 in the case that two new nuclear power plants are added. The overall annual reduction in European CO_2 emissions could be substantial — in the order of 6 Mt CO_2 per new nuclear power plant — if Nordic exports replace fossil condensing production. Furthermore, if demand for electricity increases more steeply than assumed, for example due to an increased use of heat pumps or electric vehicles, significant CO_2 emissions reductions could also be achieved in the Nordic countries.

Nordic countries have good possibilities to implement CCS

- but the final benefit of CCS in emission reduction would depend on the development future energy and emission markets

The largest potential storage sites for CO_2 in Europe are located in the North Sea off the coast of Norway. CO_2 can be transported to these sites by pipeline or by ship. CO_2 can also be stored in the Danish oil and gas fields in the North Sea. Conversely, both Finland and Sweden lack suitable storage sites so these countries would have to transport carbon cross-border. However, all Nordic countries are currently actively involved in CCS R&D, and energy companies operating in the Nordic region are getting involved in large-scale CCS demonstration projects. StatoilHydro has been storing CO_2 in Norway since the early 1990's by capturing 1 Mt CO_2/per year from natural gas and injecting it into a saline aquifer in the North Sea. StatoilHydro has also been storing carbon since 2008 at the Snøhvit gas field. Vattenfall, Fortum, and E.ON are also all looking into CCS. Fortum has joined forces with TVO in a planned demonstration project that combines post-combustion carbon capture at the Meri-Pori condensing coal-fired plant with CO_2 transportation by ship to the Danish oil or gas fields. Vattenfall has a pilot plant in Germany to demonstrate oxyfuel-combustion carbon capture and is also involved in Nordic demonstration projects in Norway and Denmark. E.ON is investing in carbon capture projects in the UK, Sweden and Denmark.

Before the numerous large-scale CCS demonstration projects currently underway have been completed it is very difficult to analyse CCS's cost-effectiveness as compared to other emissions mitigation options. With current capture technologies, the energy penalty is large, which is in conflict with energy efficiency targets. On the other hand, global mitigation scenarios indicate that long-term, CCS could be one of the main technologies to cost-effectively reduce CO_2 emissions (see Chapter 20, Figure 20.1). Bio-CCS with "negative net emission" is also expected to become viable in the future. Figure 3.3 shows the CCS potential in each of the Nordic countries calculated using the Nordic TIMES model. In the calculations, carbon capture was assumed to be implemented in energy plants (large scale condensing power and CHP) as well as in the pulp, oil refining, metal and cements industries. Bio-CCS was assumed to be implemented in the pulp industry and in large scale co-firing coal or peat plants.

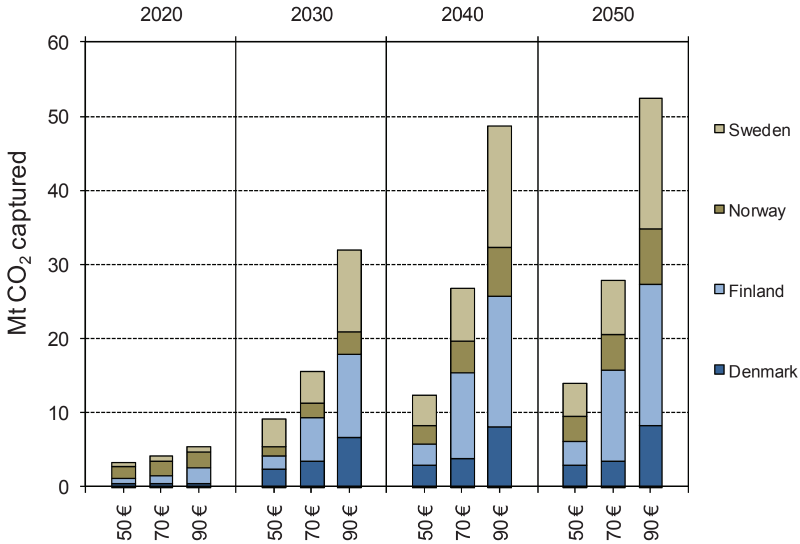


Figure 3.3: CCS potential in each Nordic country indicated as Mt CO_2 captured from the total CO_2 emissions in each country. The assumed CO_2 price increases linearly from 20 €/t in 2020 to the indicated price levels in 2040.

The Nordic scenarios indicate that CCS could be a viable option after 2030 in all the Nordic countries given a CO_2 price above 50 €/t CO_2. By 2050, about 60% of the total Nordic CO_2 emissions could be handled by CCS compared to the Baseline emissions in the 90 €/t CO_2 case. The scenario results indicate that the largest CCS potential is found in Sweden and Finland as these countries have good opportunities to implement bio-CCS. Also, CCS seems to be more cost-effective in CHP because a better integration of heat streams lowers the energy penalty of the capture process. However, before bio-CCS can be considered a viable option, the rules of the EU's Emissions Trading System must be changed to take into account emission reductions which don't originate from fossil fuels.

Table 3.1 gives an example of the set-up by showing emission reductions as calculated using VTT's electricity market model. In the first case, two Norwegian combined cycle gas turbine plants (CCGT) are assumed to have implemented CCS by 2020, leading to a capacity drop from 700 MW to 560 MW. The power output is less with CCS as the plants' efficiency is impaired. The second case is a coal condensing power plant (coal PP) that sees a drop in capacity from 550 MW to 440 MW due to the implementation of CCS. According to the policy scenario (see Chapter 1 for scenario descriptions), the plants are not fully exploited in 2020 regardless of CCS, as the need for condensing power is quite low. This means that CO_2 emissions cuts are quite low in 2020, at best 0.8 Mt CO_2. A higher CO_2 price (50 €/t

CO_2) limits emissions reductions even further due to the lower operating time of the power plants. In 2030, the coal PP runs at full capacity both with and without CCS given a CO_2 price of 20 €/t. This influences CO_2 reductions, at around 3 Mt CO_2. However, only slight decrease in emissions were obtained with 50 €/t. The differences come not only from the implementation of CCS, but also from how well the different plants fit into the market, and from changes in their capacities.

Table 3.1: Changes in CO_2 emissions for the different CCS cases compared to emissions from same plants without CCS

	20 €/t		50 €/t	
	2020	**2030**	**2020**	**2030**
Coal PP Mt CO_2	-0.8	-3.0	0.0	0.2
Gas CCGT Mt CO_2	0.0	-0.5	-0.1	-0.7
SUM Mt CO_2	-0.8	-3.4	0.0	-0.5

In this study, the combination of CCS and condensing power plants was found not to be a very effective solution for the Nordic countries if the EU target of 20% renewables by 2020 is fulfilled. The need for condensing power in the future may be high, but also very narrow. Thus CO_2 emissions cuts would not be that remarkable unless the production replaces high-emission condensing power production in continental Europe. As indicated above, because of higher operating times it might be better to combine CCS with CHP rather than with condensing power in the Nordic countries. On the other hand, if only very limited investments in new nuclear power are undertaken (and old nuclear power is phased out), CCS would be fundamental for achieving large emission reductions in energy production due to the greater use of other condensing plants.

For further information:
Tiina Koljonen,
Göran Koreneff, VTT

4. The EU´s renewable target is the main driver for reducing Nordic CO_2 emissions by 20 %

Existing policy instruments used in the Nordic countries will lead to a significant increase in the use of renewable energy in the region. The use of renewable energy will rise even further if measures to reach the EU renewable target are implemented. If these measures are implemented, our calculations show that renewable energy sources will account for a further 50 TWh by the year 2020, compared with the case with only existing policy instruments. Biomass and wind power, in that order, are the renewable energy sources that contribute most to these higher levels of use. The combination of current policy instruments and the EU renewable energy target also leads to a reduction of CO_2 emissions from the Nordic stationary energy system by 20 percent over the period 2005-2020. So this combination is by itself sufficient to meet the EU emissions reduction target of 20 percent for the stationary energy system. If measures dedicated to meeting the EU energy efficiency targets are also implemented, CO_2 emissions decrease even further. However, these measures also reduce the use of renewable energy sources.

In early 2008 the EU commission published a directive containing measures and targets for the increased use of renewable energy sources in member countries. At about the same time, a proposal for a directive concerned with reducing greenhouse gas emissions by 20 percent was published. The EU has also set a target to reduce energy use by 20 percent through improvements in energy efficiency. These three separate targets will have a profound effect on the energy systems of the Nordic countries. To analyze the consequences of these targets on the energy systems, a series of calculations with the energy model MARKAL-NORDIC have been performed. The analysis concerns the stationary energy sector - the transport sector is not included in the analysis. In this NEP perspective we focus on the effects on the use of renewable energy.

The reference case – current policy instruments will lead to a significant increase in the use of renewable energy

As a point of departure for the analysis, a calculation of the energy system's development assuming only already existing policy instruments has been carried out. This analysis does not, therefore, include the renewable target. [Examples of current policy instruments that have a stimulating effect on the use of renewable energy are high taxes on fossil fuels, the European Union Emission Trading System (a CO_2 price of 25 €/ton has been assumed), investment and operation support for different renewable alternatives, and the Swedish electricity certificate system.] Figure 4.1 shows how the use of renewable energy in the Nordic region increases in the reference case. The figure reveals that, given current costs for different renewable energy technologies, the reference case especially leads to strong growth in the use of bio-fuels. The increased use of bio-fuels will be only partially driven by the effects of current policy instruments – an assumed expansion of the Nordic forest industry is another important factor. The figure also shows that the use of wind power and hydropower also increases in the reference case, but only moderately.

The heading "Others" in the figure covers other energy sources that are regarded as renewable energy sources in the EU directive. The most important category is heat pumps, but industrial waste heat and solar heat are also important.

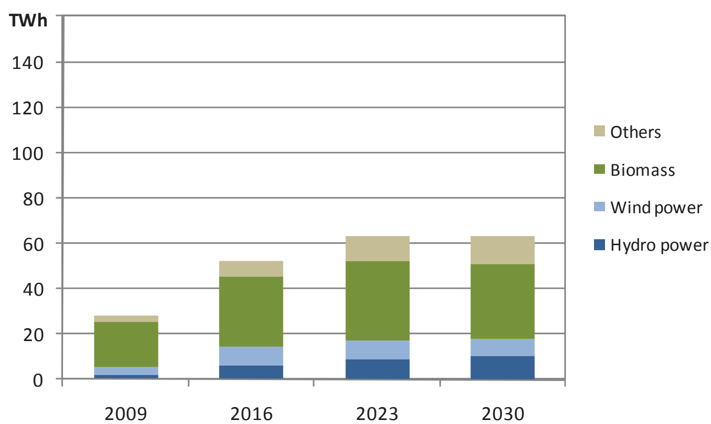


Figure 4.1: Increased use of renewable energy technologies in the Nordic region relative to 2005, with no new EU targets (but keeping current emission-rights trade and national policy instruments)

The RES directive – the renewable target

In the next step of the analysis we studied what would happen if measures put in place to fulfill the EU's Directive on the promotion of the use of energy from renewable sources (popularly known as the RES Directive) were implemented. The Directive sets individual targets for each member state. The target is expressed as the share of total energy use that must be met by renewable energy. We have assumed that a proportional part of the target will be met by measures directed at the transport sector. The country-specific targets imply that just over 120 TWh of renewable energy must be added to the stationary energy system of the Nordic region by the year 2020 if the combined targets of the Nordic countries are to be met. We have assumed that the renewable energy target will remain in place at the same level in the period following 2020. (Since Norway does not belong to the EU there is no specific EU renewable energy target for Norway. We have assumed that Norway is given a target corresponding to the average value of the targets for the other three countries.)

To analyse the effects of the renewable target we modified the model by adding a condition that 120 TWh of renewable energy production is added to the region as a whole. Thus, we have not imposed country-specific targets, but instead allowed the total amount to be produced in the most effective way in the region as a whole. (The discussed common Swedish/Norwegian electricity certificate system is an effort in this direction.)

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.

Measures: An EU wide market in Guarantees of Origins have been rejected by major member states. Certificate trade in the form of joint target compliance, joint projects of transfer certificates will be permitted.

Bioenergy and wind power – a large increase due to the renewable target

The result of our analysis of what would happen if the RES Directive was implemented in the Nordic countries is shown in Figure 4.2. It turns out that the use of renewable energy in the Nordic region increases substantially. The outcomes for the individual renewable energy technologies vary significantly. The use of hydropower is virtually unaffected, since its expansion is constrained by conditions stipulated in the model. The use of bio-fuel increases considerably. Most of the bio-fuel is used for heat production in industry and district heating systems, often through combined heat and power production. Demand for district heating and industrial process heat places a limit on how much bio-fuel heating can be introduced in a profitable manner. Moreover, the bio-fuel price is described with a "supply stairway", where the bio-fuel range becomes gradually more expensive as the amount used increases. At the same time, the results show that the use of bio-fuel is strongly stimulated by current policy instruments.

The EU's renewable target also leads to more wind power. In the reference case, wind power production growth does not exceed 10 TWh, but in the scenario where the renewable target is included, the growth reaches 30 TWh. Most of the new wind power plants will be built over the next 10-15 years.

The growth of other renewable energy technologies in the renewable scenario is similar to that of the reference scenario.

To summarize, there will be a marked increase in the use of renewable energy in the Nordic countries if the RES directive is implemented. Renewable energy use will be 70 TWh larger than in the reference case by the year 2020,

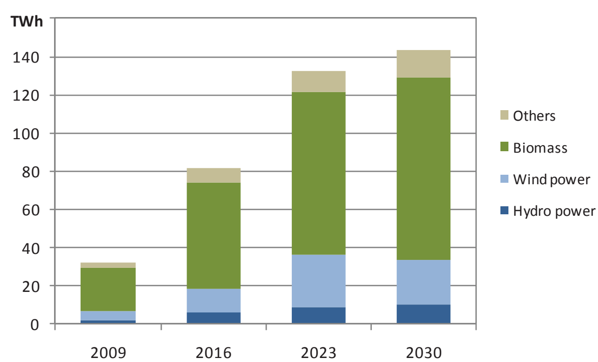


Figure 4.2: Increase of renewable energy technologies in the Nordic region relative to 2005, when measures for the EU renewable energy target are applied (also keeping current emission-rights trade and national policy instruments)

which is 15 percent higher. However, it is worthwhile to note that even in the reference scenario where only measures relating to existing policy instruments are implemented, the use of renewable energy increases by 60 TWh over the period 2005 to 2020.

The use of renewable energy country by country – both similarities and differences

How does the use of renewable energy develop in each of the Nordic countries if the RES Directive is implemented? This is shown in Figure 4.3 (see next page) where the levels of renewable energy use in 2020 are shown, broken down by both technology and country. As can be seen, the outcome is quite different for different countries. These differences are to a large extent attributable to the countries' dissimilar energy systems. For example, we can see that Norway currently has very little district heating and that this will not increase in the future. The only clear trend that is present in all four countries is that the use of wind power increases.

In absolute terms (in TWh) bio-fuels is the renewable energy technology that increases the most by 2020 (compared to 2005). The use of bio-fuels will increase in the industrial sectors of Finland and Sweden, in the housing sector of Norway, and especially in the electricity and district-heating sectors of Sweden, Denmark and Finland.

Also noticeable is the increased use of heat pumps (these dominate the category "Others") for heat production in Norway and Sweden, and to a lesser degree in Finland.

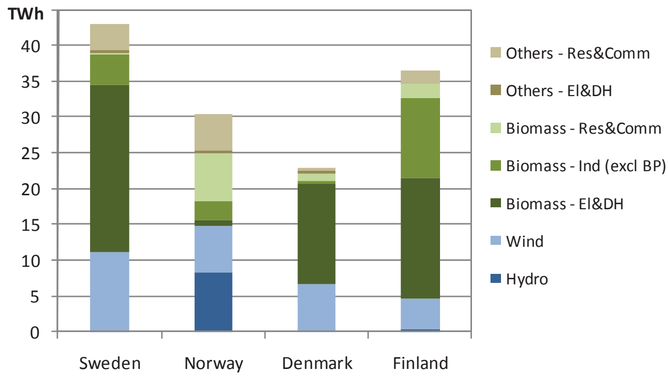


Figure 4.3: Increase of renewable energy in the Nordic countries by 2020, assuming the EU renewable energy target in combination with current policy instruments

Consequences of a decline in Nordic forest industry

In the calculations presented so far in this chapter we have assumed that the Swedish forest industry will grow 5-15 percent over the period 2007-2020, and that the Finnish forest industry will grow by 10-15 percent in the same period. Recently, however, the Nordic forest industry has suffered a number of setbacks because of events such as the global downturn and the threat of increased Russian export duties for timber. Problems in the Finnish forest industry have been particularly severe due to the strength of the Euro. These setbacks may very well have long-term consequences for the industry.

To analyse the consequences of these events an additional scenario where the forest industry in Sweden does not grow at all and the forest industry in Finland shrinks by 5-10 percent has been studied. The current outlook for the industry is even worse than this, but since our focus is on the year 2020, and since there is a risk that prognoses tend to exaggerate the impact of recent events, we have chosen these relatively modest changes.

The figure 4.4 shows that the decline of the forest industry leads to considerably less growth in the use of biomass in industry, especially in Finland. The remaining increase of biomass in the industrial sector is a result of a fuel switch, mainly from peat to biomass. Lower use of biomass means that use of other renewable energy sources must grow by a corresponding amount if the targets are to be met. These increases are split between different technologies and different countries. Reduced energy consumption in the forest industry also reduces total energy demand in the region. Since the renewable energy target is a fractional target, the total levels of renewable energy use will be considerably lower in this scenario. So reduced levels of renewable energy use in Finland are not altogether balanced by higher level of use in the other countries.

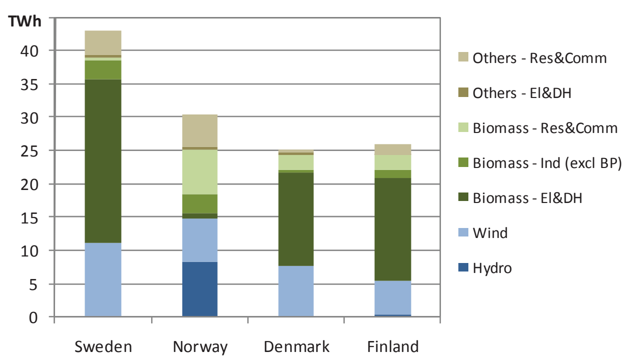


Figure 4.4: Increase of renewable energy in the Nordic countries by 2020, assuming the EU renewable energy target, current policy instruments, and a decline of the Nordic forest industry

CO_2 emissions are reduced by more than 20 percent when the renewable target is implemented

If the RES Directive is implemented and if existing policy instruments are kept, CO_2 emissions from the Nordic stationary energy system are reduced by approximately 20-25 percent by the year 2020. This means that if the emissions target is that CO_2 emissions should be reduced by 20 percent by that year, no further policy instruments are needed.

The transport sector is not included in this analysis. If, as is widely predicted, it becomes impossible to cut emissions by 20 percent in the transport sector, the total reduction of Nordic emissions will not be as large as the reduction shown for the stationary energy system, and the total emission reduction could in that case be lower than 20 percent.

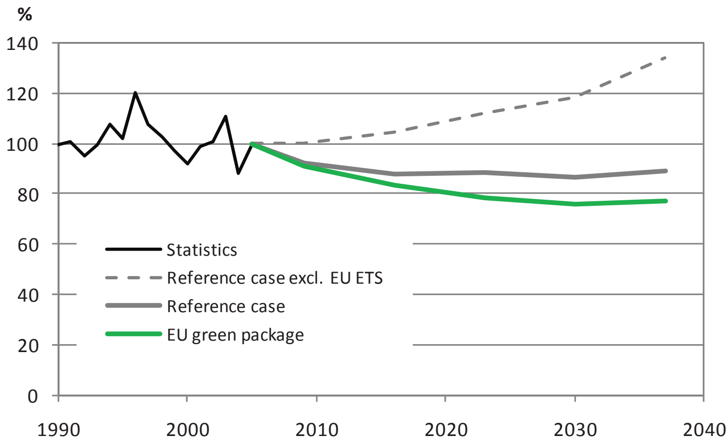


Figure 4.5: CO_2 emissions from the Nordic stationary energy system with present policy instruments ("Reference case") and the EU renewable energy target ("EU green package")

Implementing energy efficiency measures reduces the use of renewable energy

In this section we discuss what would happen if a policy mix consisting of current policy instruments and the EU's renewable target is combined with measures related to the EU's energy efficiency target. The energy efficiency target aims at a 20 percent reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency. How the energy efficiency target has been expressed in the models is discussed in detail in Chapters 2 and 6.

Implementation of energy efficiency measures leads to lower overall energy use, and to lower use of renewable energy. A combination of energy efficiency and renewable energy measures leads to the proliferation of heat pumps. This happens because the waste heat that is used in heat pumps' heat production is not included in the energy amount that is to be reduced. Conversely, the use of bio-fuels is expected to fall in the presence of energy efficiency measures. For instance, certain bio-fuel boilers may be replaced by heat pumps and even by natural gas boilers that are more efficient (the energy efficiency target places no distinction between reduced use of fossil-fuel based energy and reduced use of renewable energy). Improved energy efficiency also leads to reduced demand for heat, which in turn leads to reduced demand for bio-fuels in district heating production plants. Finally the use of wind power is reduced since improved energy efficiency leads to a reduced demand for electricity.

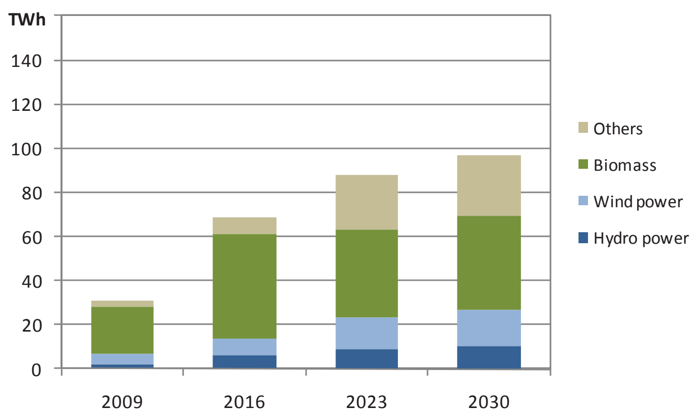


Figure 4.6: Increase of renewable energy technologies in the Nordic region between 2005 and 2020, when the EU renewable target is applied together with the EU energy efficiency target (also keeping current emission-rights trade and national policy instruments)

To conclude, when renewable energy measures are implemented in combination with energy efficiency measures in the Nordic countries, the use of renewable energy is clearly higher than in the reference case when only current policy instruments are assumed to be in place.

However, in the scenario that includes energy efficiency, the use of renewable energy is clearly lower than that found in the scenario where current policy instruments are combined with renewable energy measures. It is mainly the use of bio-fuels that decreases when energy efficiency measures are added to the mix.

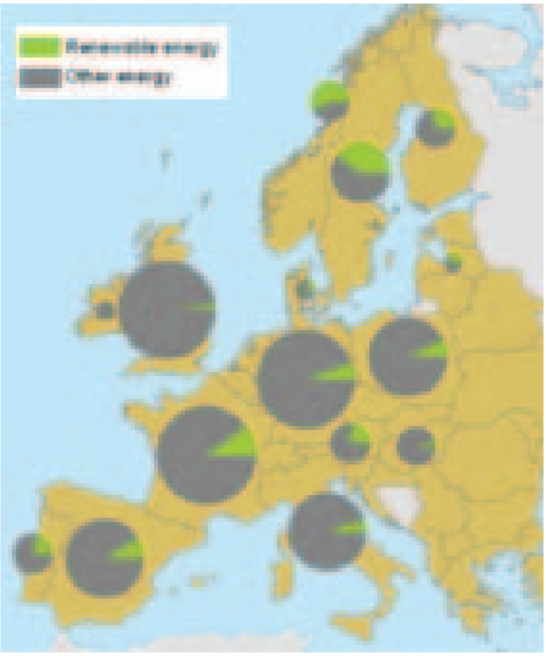
The EU's energy efficiency target contributes to further reducing CO_2 emissions. This issue, and the consequences of including the transport sector in the analysis, are discussed further in other chapters of the "20 perspectives".

For further information:
Håkan Sköldberg and Thomas Unger, Profu

The Nordic renewable energy resources provide opportunities

- but also challenges

The EU target for increased use of renewable energy, often referred to as the RES Directive, will be a challenge to meet for many EU member states. It will lead to challenges also for the Nordic countries, but it also creates opportunities here. The RES Directive includes a burden sharing scheme since different countries have different sizes of their renewable energy resources. The Nordic region is unique in the sense that both renewable energy potentials and present renewable energy use is large in an EU perspective. (The Nordic renewable energy potentials are discussed in more detail in Chapter 5.) The present use of renewable energy in relation to total energy use is shown for a selection of European countries in the adjacent figure.



The dominating Nordic renewable energy sources, both presently and during the coming 10-20 years, are hydro power and biomass. In the future the use of other renewable sources is likely to grow substantially. Wind power is an example of this. Future Nordic use of renewable energy is discussed in detail in Chapter 4, where three different policy scenarios are analysed.

Hydro power and wind power are naturally directly associated with electricity, whereas biomass could be used for a number of purposes, e.g. electricity production, heat production and production of bio-fuels for the transport sector. Biomass could also be used for non energy purposes, e.g. as a raw material for the pulp and paper industry.

The renewable energy issue highlights a number of opportunities for the Nordic energy systems, but also challenges. The challenges are typically related to the question of making the most effective use of the Nordic renewable energy resources.

Opportunities for Nordic cooperation in order to effectively utilize the renewable resources – within the Nordic region

The first question is where, geographically, the renewable energy resources should be used. Although the RES Directive includes a burden sharing scheme in order to define national targets for renewable energy use that corresponds to the prerequisites of each country, there may still be different marginal costs for the use of renewable energy in different countries. This indicates that it would be cost effective for some countries to utilize more renewables than the national target specifies, while other countries use less. The RES Directive offers such possibilities. This is an opportunity for cooperation between the Nordic countries. The challenge is to find effective ways to implement such cooperation. The proposed Swedish / Norwegian electricity certificate system is in line with this.

Effective use of the Nordic renewable energy resource – the EU perspective

Opportunities for Nordic cooperation in order to effectively utilize the renewable resources are relevant both within the Nordic region and in relation to neighbouring countries. The relatively large resources for renewable energy in the Nordic region will of course provide opportunities in a situation where renewable energy will be an increasingly valuable resource in Europe. Electricity trade between the Nordic region and the rest of EU and how this relates to the RES Directive is analysed in Chapter 11.

Increased renewable electricity production and stagnating electricity use lead to Nordic export

The Nordic targets for renewable energy use probably results in a large increase in renewable electricity production. In combination with stagnating electricity use in the Nordic region this will put pressure on the capabilities to export electricity to other EU countries. This can be seen as another challenge for the Nordic region that is closely related to the opportunity mentioned directly above. In order to facilitate such export it could become necessary to increase capacity in cables to neighbouring countries as well as in the national electricity transmission grid. If the export capability is very limited the described situation would result in low electricity prices in the Nordic region ("supply and demand").

The optimal national mix of where to introduce the renewable energy

A challenge will be to find the optimal national mix of where to introduce the renewable energy that the EU target specifies. The most effective way to find this balance is probably identified by the market itself. Here it is, however, important that the policy instruments that are used in order to get the desired renewable energy use does not distort the balance. In order to mobilize an even larger part of the Nordic renewable energy potential, more powerful policy instruments will have to be implemented. Existing policy instruments will not be powerful enough to reach the EU renewable targets. The balance between policy and market is discussed further in the section "The challenge of finding the balance between policies and market".

A proper balance between different demands for biomass

Finding a proper balance between different demands for the biomass resource can be seen as the next challenge. Since this is a limited resource, both in the Nordic region and globally, not all future demands may be possible to satisfy, at least not at the historical price levels. The increased demand for biomass for energy purposes in the Nordic region, encouraged through different policy instruments, has not only increased the use of felling residues, but also imposed an upward pressure on the price of wood qualities that typically have been used as pulp wood. This may lead to decreased international competitiveness for the Nordic pulp and paper industry if corresponding raw material price increases does not occur in other regions. A balancing factor is here that the pulp and paper industry also could benefit from the renewable energy target, e.g. through combined heat and power (CHP) production based on biomass. The Nordic pulp and paper industry is subject to a number of structural threats and the future of this industry is discussed further in Chapter 18.

Public acceptance and permitting procedures

Another challenge is related to public acceptance and regulations and permitting procedures for land use. Utilization of parts of the renewable energy resources lead to conflicts with other interests. Hydro power and wind power are examples of this. The theoretical potential to increase hydro power production is large, but public acceptance and political goals limits further development. Much of the increase in hydro power production comes from refurbishment and enlargement of existing hydro power plants. Norway is probably the only country where a significant increase in hydro power production can be expected. (Sweden also has large unexploited hydro power resources, but they are strictly limited through political goals.) Public acceptance and permit procedures are also important issues in connection with wind power development. There are currently large uncertainties as to how these factors will influence the possibility to build large quantities of wind power.

Intermittent electricity production, e.g. wind power, is a challenge for the Nordic electricity market

Increased use of renewable energy often includes significant expansion of wind power. Wind power can be seen as an intermittent production source, since it relies on wind that cannot be stored. (The operation of the Nordic power system with increasing volumes of intermittent power is discussed further in the section "The challenge of making Nordic electricity CO_2 free".) The introduction of wind power contributes to reduced operation of condensing plants, which will eventually lead to phasing out of such plants due to economical reasons. Although wind power plants will most likely be spread geographically over the entire Nordic region, there will be periods with high demand and unusually low wind generation. This will increase the risk for capacity shortage in the region. To balance this risk can be seen as a security of supply challenge related to renewable energy. This issue is touched upon in Chapter 22.

Renewable energy also creates other opportunities for the Nordic region

All in all it is, however, probably correct to look upon the issue of renewable energy more in terms of opportunities than threats. The challenges presented above are often directly associated with opportunities for the Nordic region. Here follows some additional examples of such opportunities:

- Increased use of renewable energy decreases CO_2 emissions in the Nordic region.

- The Nordic renewable resource can contribute to lower CO_2 emissions in other countries, either through export of primary energy or through electricity export. This is valuable for the receiving countries and therefore represents an asset for the Nordic region.
- Increased use of renewable energy reduces Nordic import dependency, especially for fossil fuels.
- Increased use of renewable energy in the Nordic region stimulates development of new technologies and industries that produce equipment related to the utilization of renewable energy. It may also create export opportunities when the demand for such equipment outside the Nordic region grows.
- Improved energy efficiency when electricity production in condensing plants is substituted by CHP production and wind power.

5. Large renewable resources in the Nordic region

- but the extent to which the use of these resources can be increased varies significantly from country to country

The countries in the Nordic region have ample potential to increase their use of renewable energy in the stationary energy and transport sectors. However, investments are still constrained because renewable energy production is still more expensive than conventional production. In some cases, investments are also hampered by immature technologies. Denmark is the only country that has significant wind power use today, but there is excellent potential for substantially increased use of wind power in all countries in the region. The use of biomass in energy production is already high in Finland and Sweden, and this use is expected to grow due to large forest resources in these two countries. In Denmark, field biomass could also notably contribute to energy production in the future. However, the assessment of future bioenergy production has great uncertainties due to future policies of Nordic countries, which might lead to increased exports of biomass or biofuels to those countries which have higher supports for renewable energy. On the other hand, EU's sustainability regulations could limit import of liquid biofuels to the EU area from South America of South-East Asia, which have large potential to increase their bio-fuel production. The share of hydropower is already above 50% of total electricity production in the Nord Pool area, and the theoretical potential to increase hydropower production is also large. However, public opinion in the region is currently opposed to further exploitation of rivers, so further hydropower development will probably be limited. Given these constraints, in the absence of stronger renewable energy support schemes very large increases in renewable energy production cannot be expected until 2030. If existing support schemes are strengthened, and/or new support schemes introduced, the process could be speeded up.

The theoretical potential to increase renewable energy use in the Nordic area is large but techno-economic potentials depend on a number of factors, e.g.:

- Accelerated support mechanisms and/or increased fossil fuel prices.
- Changes in environmental legislation for the future utilization of rivers for hydropower.

- Changes in regulation and procedures for acquiring permits to build land-based wind power plants.
- Sustainability criteria for biomass.
- The future of the forest industry (biomass).
- Technology development.

Ambitious plans for new wind power in each country

- but also concerns for lack of public acceptance and conflicts over criteria for land use

Denmark has the longest tradition in wind power in the Nordic region. The share of wind power in Denmark's total electricity consumption is currently about 20% and the Danish target is to increase this share to 50% by 2030. In the other countries, wind power makes up less than two percent of total electricity consumption. However, Norway and Sweden have plans to radically increase wind power production. Sweden has set a national planning target for 30 TWh annual wind power production by 2020, of which 10 TWh would be offshore. Norway has plans for 3 TWh (~1000 MW) by 2010, and the target for 2020 is approximately 20 TWh of wind power production. In Finland the new energy and climate strategy targets include a 2000 MW (~5 TWh) increase in wind power production by 2020 in order to fulfil the renewable energy targets set by the EU. Figure 5.1 shows a summary of the investment plans for each country (taken from several country-specific studies). In Denmark, much of the onshore capacity increase shown in the Figure 5.1 is coming from the modernization of old turbines, but most of the new capacity is coming from offshore wind farms. In Norway and Sweden a large number of wind power projects are either in the planning or development stages. However, there is no guarantee that any of these projects will be completed. Financial considerations are not the only obstacle. Just as important are lack of public acceptance and conflicting land use criteria.

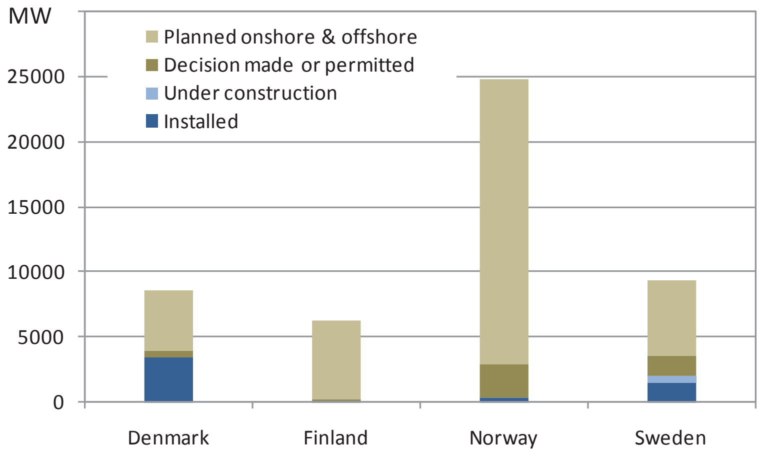


Figure 5.1: Installed and planned wind power plants in the Nordic countries. Sources: The European Wind Energy Association, Swedish Wind Energy, Norwegian Water Resources and Energy Directorate, VTT.

The theoretical potential of biomass and waste is large, but economic potentials have large uncertainties

Biomass is feasible for the production of heat, electricity, and liquid or gaseous bio-fuels. In the Nordic area, wood resources are largely utilized by forest industry, which also produce industrial waste liquors (i.e. black liquor) and solid biomass by-products suitable for energy production. A large share of these industrial side products are utilized at site but some solid by-products (i.e. saw dust, bark, wood chips) may be also considered as a biomass resource for energy or bio-fuel production. On the other hand, biomass from thinning and felling of forests (i.e. forest residues) represent a large share of wood resource potentials, which could be used more effectively than today. However, the future techno-economical potential is very difficult to estimate and the reported Nordic estimates therefore vary significantly. The techno-economic biomass potential of expected biomass and biofuels export areas, such as South America, South-East Asia and Russia, are even more difficult to estimate, especially because of sustainability criteria set by the EU and other barriers for extended biomass or biofuel production. Transportation distances limit the use of wood for large-scale energy production, so the use of wood can be complemented with agricultural residues, energy crops, and bio-wastes. Production and trade of pellets can be increased significantly.

The EU and several other OECD countries have set targets for renewable energy production in order to ensure security of supply and to combat climate change. To meet these targets, renewable energy support schemes must be implemented. As national targets for renewables and the levels of incentives for bioenergy have significant variations, biomass trade could increase. It can be expected that in the near future, bioenergy will become an internationally traded energy resource, and not just a local energy source. There is already competition for fibre wood between the energy sector and the forest industry in some countries, and competition for agricultural land can be expected to become more intense in the future.

Figure 5.2 summarizes information about domestic biomass and waste resources in the Nordic countries drawn from selected literature resources. The line segment indicates the variation of estimates, which clearly shows the great difference between the different analyses.

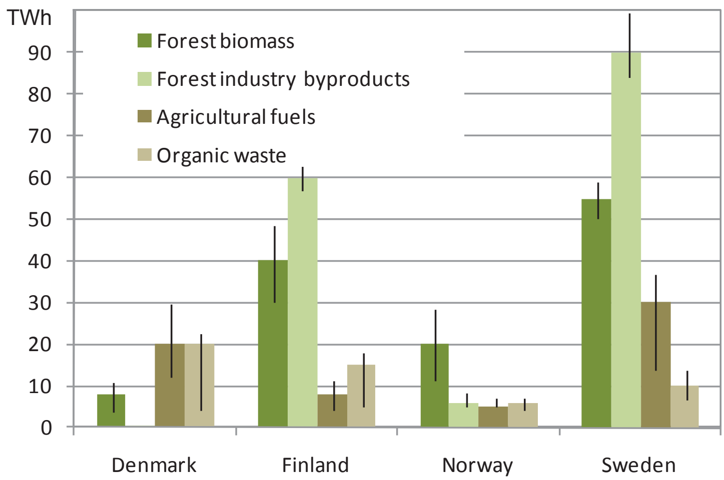


Figure 5.2: Estimated biomass resources reported in selected literature resources. The line segment indicates the upper and lower estimates.

National environmental protection legislation limits investments in new hydropower production

- but in the longer term climate change can increase the potential of hydropower

The theoretical potential to increase hydropower production in the region is large, but further hydropower development will probably be limited because of legislative constraints and widespread opposition to further exploitation of the river system. Much of the increase in hydropower production would come from refurbishment and enlargement of existing large-scale

hydropower plants in Finland, Norway and Sweden.

In the long-term climate change could lead to increased hydropower output since climate change is expected to lead to more rainfall in the region. This is especially the case in Norway where an additional 10 TWh of hydropower production is expected by 2025. Increased precipitation is expected to account for 6 of these 10 TWh. In Finland, it has been estimated that it is technically and economically feasible to increase hydropower production by 1 TWh by the year 2020. Approximately a quarter of this energy will probably be realized by refurbishment of existing large scale hydropower plants. In Sweden, the government has drawn up guidelines for the future utilization of rivers for hydropower. These imply that the major part of rivers and individual stretches of rivers, which have not yet been claimed for development, will remain undeveloped. What then remains to be developed include small-scale hydropower plants and refurbishment and enlargement of existing large-scale plants. The unexploited Swedish rivers account for about one-third of the hydropower potential that is presently unexploited and estimated to be economically feasible, and about half of the technically viable remaining hydropower resources.

Increasing role of solar and geothermal energy in the residential sector, ocean energy a new longer term option

The use of renewable energy resources other than wind, biomass or hydro will definitely increase in the future as technologies evolve and fossil fuel prices increase. They are, however, not expected to contribute significantly to the total energy balance in the coming 20 years. Solar and geothermal energy have the largest potential in the residential sector. In fact, Sweden is already the world's second largest user of geothermal heat after China. The existing photovoltaic capacity in the Nordic region is small (a total of approximately 20 MW compared to 5400 MW in Germany). Thermal solar collectors are common in Denmark and Sweden, with both countries having approximately 300 MW of installed capacity. In the future, solar energy could have a larger role as passive energy homes become standard. Another long-term option is the exploitation of different types of ocean energy. Both Norway and Denmark are developing wave energy in the North Sea. However, the potential of ocean energy in the primary energy mix will obviously remain marginal in the Nordic region in the next 20 years.

By 2050 the share of renewables could increase to 50% of total primary energy

Figure 5.3 shows the long term development of primary energy resources in the Nordic region with different emission allowance price levels calculated with VTT's Nordic TIMES energy system model. As the scenario's focus extends to 2050, the different support schemes (i.e. green certificates and feed-in tariffs) have not been included in the calculations. Also, the EU's renewable target for 2020 has not been taken into account in these simulations. The figure clearly shows that the use of wood fuels accounts for the largest increase while the increase of wind power is not as large. This indicates that support schemes are needed to fulfil national renewable energy targets. However, it should be noted that wood fuel includes residues from the pulp and paper industry including solid biomass by-products from imported log wood. Since the future of the Nordic forest industry and the cost of imported raw materials are presently uncertain, the prospects for using wood as fuel may be smaller than shown. The sector "other" includes waste fuels and renewables other than hydro, wind and wood fuels, and it is obvious that this sector increases rapidly. By 2050, the share of renewables from total primary energy could be close to 50%, if high emission allowance prices are assumed, even without additional support schemes for renewables.

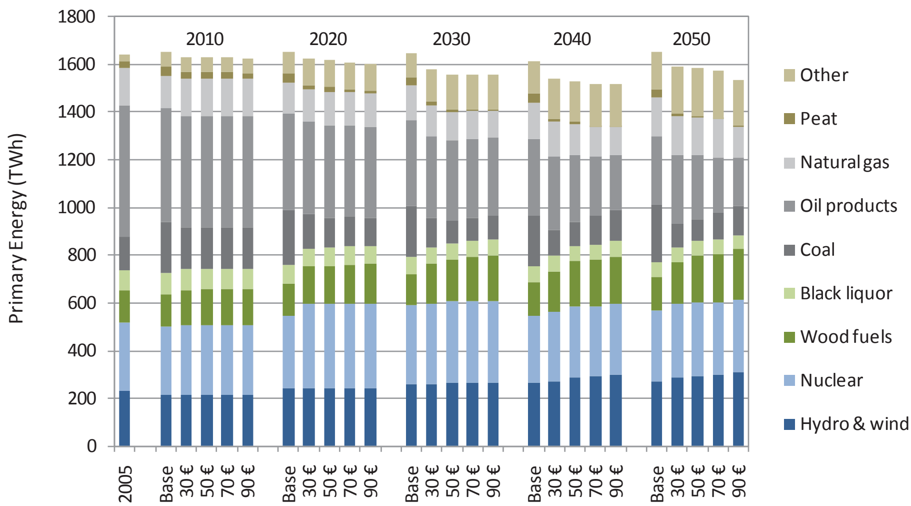


Figure 5.3: Total primary energy supply in the Nordic countries.

Other scenario calculations from the NEP project that incorporate the EU renewable energy target and existing policy instruments supporting renewable energy show similar results (see figure 5.4). The similarities are most obvious if these results are compared to the results presented above for relatively high CO_2-prices. In these scenarios the use of renewable energy in the Nordic region increases substantially. Outcomes for the individual renewable energy technologies vary significantly. The use of hydropower increases but the expansion is constrained by political conditions stipulated in the model. The use of biofuel increases considerably. Most of the biofuel is used for heat production in industry and district heating systems, often through combined heat and power (CHP) production. Taken into account the EU renewable target also leads to more wind power, which is expected to reach 30 TWh. (These calculations are described in more detail in Chapter 4, “The EU renewable target alone will reduce Nordic CO_2 emissions by 20 percent”.)

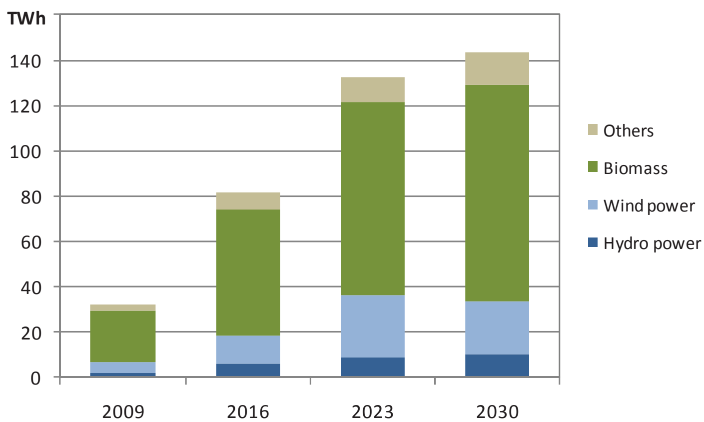


Figure 5.4: Increase of renewable energy technologies in the Nordic region relative to 2005, when measures for the EU renewable energy target are applied (also assuming current emission allowance trade and national policy instruments)

For further information:
Tiina Koljonen and Martti Flyktman, VTT

6. Energy efficiency measures in the entire energy system leads to synergies

Implementation of the 20 % energy efficiency target with maximum profitability by aiming for increased efficiency in the entire energy system – leads to synergies between energy efficiency measures and measures related to climate and renewable energy obligations.

A cost-effective implementation of the 20 % target for energy efficiency by 2020 should in-clude all parts of the energy system, from supply to end-use. NEP's analysis shows that in this case about half of the energy efficiency improvement measures will be energy conversion measures and half will be end-use measures. Most of these energy efficiency improvement measures will reduce greenhouse gas emissions and lead to increased use of renewable energy sources in addition to increasing energy efficiency. These synergies will make the measures much more cost-effective.

Important energy conversion efficiency measures include conversion from electricity produced by condensation to cogeneration and wind power, and measures to replace electrical heating by heat pumps. End-use measures would mostly include more straightforward measures with relatively low investment costs.

The EU's energy and climate package includes a requirement for energy efficiency improvements of 9 % by 2016, and a proposal for 20 % energy efficiency improvements by 2020. The EU is now discussing making this 20 % target binding for all member states. One way to formulate the target could be as requirement to reduce the use of primary energy by 20 % by 2020. For the Nordic energy system, a 20 % reduction of primary energy use in the energy system (excluding the transport sector) means a reduction of approximately 200 TWh. This is relative to primary energy use in 2020 calculated assuming a business-as-usual scenario. NEP participants have conducted comprehensive consequence analyses of the 20% target.

A cost-effective package of measures to achieve the 20 % energy efficiency target

NEP's analyses show that a cost-effective package of energy efficiency measures designed to achieve the 20% efficiency improvement by 2020, includes approximately equal amounts of energy conversion efficiency measures and end-use measures:

- 4-5 % is efficiency measures in the large-scale energy conversion., e.g. more electricity produced in cogeneration plants, wind power plants etc. instead of a production in condensing plants. This corresponds to 40-50 TWh primary energy.
- 6 % is substitution in the building sector and industry, e.g. change from electrical heating to heat pumps in small houses. This corresponds to around 60 TWh.
- 9-10 % is conservation measures in the building sector and industry, corresponding to 90-100 TWh primary energy. Most of these measures are relatively straightforward and with modest investment costs (see Chapter 7).

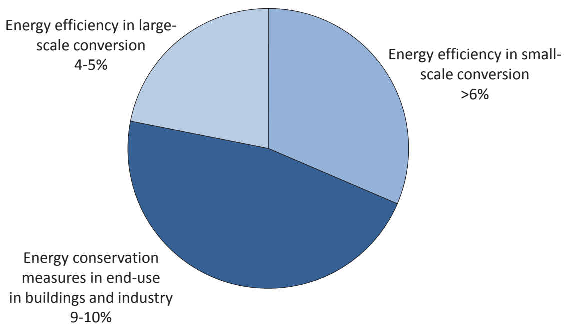


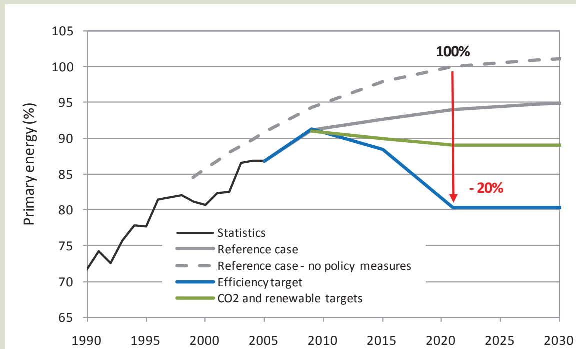
Figure 6.1: The "NEP package" of measures to achieve 20 % improved energy efficiency in the Nordic countries.

The NEP energy efficiency package has been developed by means of a comparative analysis of energy conversion efficiency measures and end-use efficiency measures. Potential benefits and costs (including transaction costs) for end-use measures have been calculated in a traditional manner (see Chapter 7). Potential benefits of energy conversion measures have been computed using MARKAL-NORDIC modelling. The MARKAL model has also been used to calculate (marginal) costs of energy conversion measures.

The NEP energy efficiency package was then constructed by adding measures one by one, sorted in order of decreasing profitability, until a 20% reduction in primary energy use had been achieved. Included in the profitability of each measure is the savings in energy purchases that can be attributed to that measure. By using MARKAL modelling in the construction process we were able to model the fact that the most profitable measures that are implemented early affect the profitability of other efficiency measures that are implemented later (and the profitability of other changes to the energy system). At any point in time the model takes the current energy balance into account when it computes the profitability of a measure.

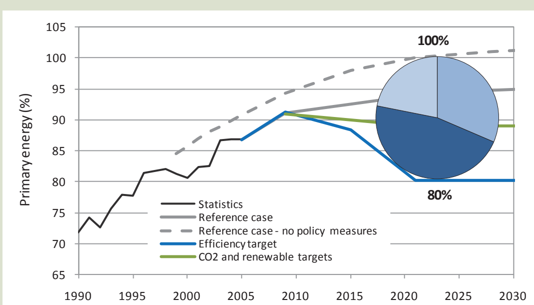
CALCULATION OF REFERENCE LEVEL FOR THE 20% TARGET

By means of the MARKAL model, we have established the primary energy use that will form the reference level for the 20 % target for the Nordic energy system. Model calculations were used to make a reference case – or business as usual scenario — in which the policy measures and instruments that directly influence the size of the primary energy use are not included. We can call it a reference case without policy measures. The figure to the right shows that the primary energy use in this scenario for the year 2020 is approximately 12-13 % above the actual 2005 primary energy use level.

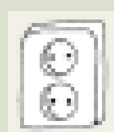


The definition of the energy service directive that prescribes 9 % energy efficiency until 2016 – the ESD-directive – allows member countries to take credit for the improved energy efficiency which is brought about by already implemented policy measures/instruments. We have used the MARKAL Nordic model to calculate the primary energy reduction that will be achieved by today's policy measures in the Nordic countries by 2020. This is done by comparing the primary energy use in the reference case to the case with fewer policy instruments ("reference case – no policy measures" in the figures). The comparison shows that today's policy measures will result in a decrease of primary energy by about 5 % in 2020.

Another important experience from the MARKAL analyses, illustrated in the figures by the scenario that include the targets of 20 % renewable energy and 20 % reduction of CO_2 emissions, is that in reaching these two goals, the primary energy use is reduced by another 5% in 2020.



The remaining 10 % energy efficiency therefore has to be achieved through new policy measures. All together, the "NEP package of energy efficiency" described above fulfills the 20 % target. The "package" is schematically included in the figure to the left.



Which energy efficiency measures are most important?

Some of the measures described above are noteworthy in several ways. Not only do they lead to significant improvements in energy efficiency, they also contribute towards achieving targets for reduced CO_2 emissions and increased use of renewable energy. These synergies improve the cost-effectiveness of implementing the EU's climate change and energy package.

Large-scale energy conversion

Cogeneration and wind power are the most important large-scale energy conversion efficiency measures. Low production efficiencies in older coal- and oil-powered plants lead to high CO_2 emission rates. When these are replaced by biofuel- or gas-fired cogeneration plants, energy efficiency is vastly improved. At the same time, CO_2 emissions are greatly reduced and the share of renewable energy is increased.

Nuclear power has been handled in NEP's analyses with a primary energy weight of 1, i.e. without losses in energy conversion (see sections below).

Large-scale conversion is mainly electricity and district heating production, and distribution.

Small-scale energy conversion

Heat pumps and district heating are two examples of small-scale energy conversion efficiency measures. In the transport sector, a large-scale introduction of electric cars would result in a considerable efficiency increase. However, these measures do not always yield a reduction in primary energy use.

Replacing oil-fired boilers by district heating often yields a reduction in primary energy use, and an improvement in efficiency. This improvement is significant if the district heating is produced with a large share of waste heat. Large and clear-cut energy efficiency improvements are also achieved when heat pumps replace electric heating. Heat pumps are included in NEP's efficiency package mostly as a substitute for electric heating. When heat pumps are used to replace other energy sources such as oil-fired boilers and district heating, it is necessary to consider the efficiency of the energy source being replaced in order to determine if the replacement yields improvements or not.

Small-scale conversion is mainly heating and process energy in housing, services and industry.

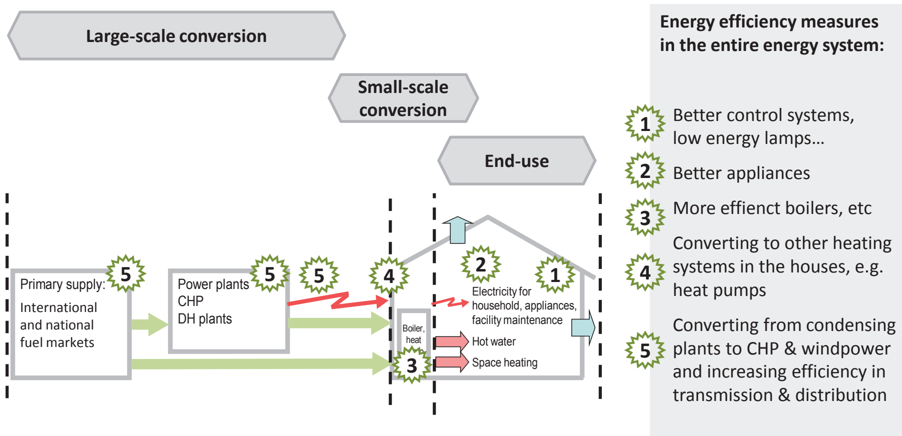


Figure 6.2: Energy efficiency measures in the entire energy system

End-use: useful energy in households, service and industry

The cost-efficient potential for energy efficiency in useful energy is large, but naturally the profitability differs between the different measures. A very large part of the measures are actually quite straightforward to implement, and many of them require no investment. Examples of such measures are:

- Adapting air flows and operation times for ventilation and illumination to the times when premises are used. This often only requires the right adjustments of existing clocks or the like.
- Electricity efficiency in households, buildings and businesses, by using best available technology when changes are to be made anyway. Change to low-energy lamps.
- Insulation of attics.

These simple and inexpensive measures constitute more than half of the entire gross potential, and can lead to an energy efficiency of around 10-15 %.

In order to reach the 20 % target it is sufficient to implement these simple measures as long as energy conversion measures that yield improvements on a similar scale are also carried out.

For further information on end-use efficiency measures, see Chapter 7.

Energy efficiency in the entire energy system

In NEP, we are calculating with primary energy. (The EU does the same on its documents on a 20 % energy efficiency improvement target by 2020). Primary energy should include all energy losses in the paths that precede the final use. This is intended to reflect all energy which is used, from the fuel market (or equivalent) to the end user. By measuring efficiency improvements in terms of primary energy, it becomes possible to include efficiency improvement measures in the whole energy system and not just in end-use (as is the case of the 9% target).

The primary energy weighting is important

Since the EU's 20% energy efficiency target relates to primary energy, primary energy weighting is done at this level in NEP and not at the level of final energy as is the case for the 9 % target (the ESD Directive). We have weighted all fuels and energy resources in our main scenarios by the factor one (1), with the exception of the free (heat) energy which is utilized in heat pumps, which has been weighted by zero (0). As far as we can tell, this is similar to the factors used by the EU. This means that free renewable energy, such as hydropower and wind power, has also been assigned a weight factor of 1.

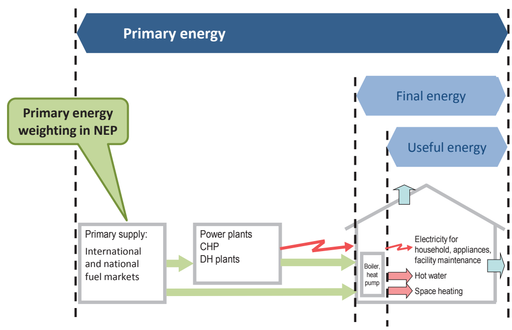


Figure 6.3: The concepts of primary energy, final energy use and useful energy. In NEP, primary energy weighting has been performed for each fuel and energy resource.

For nuclear power, we have used two alternative methods:

1. Weighting based on the energy content of the fuel (uranium), by a factor 3
2. Weighting electricity output by a factor of 1

1. Nuclear becomes an efficiency measure

The NEP analysis show that if nuclear power is primary energy weighted from the uranium energy content point of view, a phasing out of nuclear power becomes a cost-effective "energy efficiency measure". The efficiency target can then be largely met by phasing out nuclear power.

2. Nuclear is not an efficiency measure as such

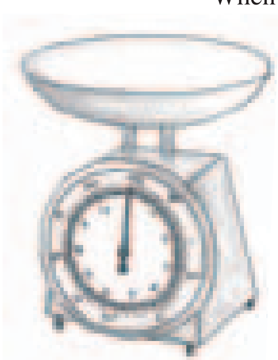
If nuclear power, on the other hand, is primary energy weighted from the electricity produced in nuclear power, a phasing out of nuclear power becomes not a cost-effective efficiency measure.

PRIMARY ENERGY WEIGHTING

Within NEP, primary energy weighting is done for each fuel and energy resource. No explicit weights have been assigned to the energy carrier's electricity and district heating. Their primary energy weighting is instead based on how the production of electricity and district heating will develop over the period studied – which is a result from the NEP model calculations - and can change from one year to another.

- Fuels: oil, coal, gas and bio-energy were assigned a weighting factor of 1.
- Wind power, hydropower and other free renewable energy sources were also assigned a weighting factor of one, in the main scenarios.
  - In some NEP scenarios wind power was assigned a factor zero.
- Nuclear power was assigned a factor of one
  - In some NEP scenarios a factor three (3) was used instead
- Free (heat) energy for heat pumps was assigned a weight factor 0.

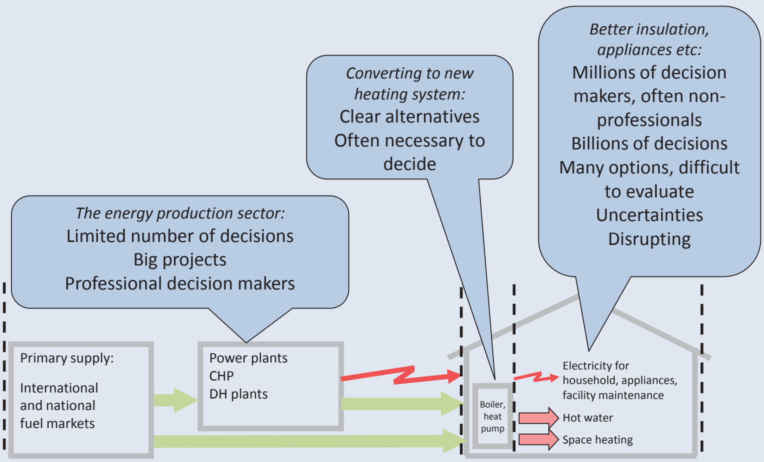
In this analysis we thus demonstrate how important it is to select an appropriate weighting for nuclear power since the choice of weighting method has profound effects on the selection of measures for the EU's 20 percent energy efficiency target. When we constructed the NEP package of energy efficiency measures we selected the second weighting method for nuclear power – the one where the produced electricity is assigned a weight factor of 1.



One important reason for this choice is that the NEP project does not consider energy efficiency in isolation, but in combination with the climate change and renewable energy programs where nuclear power is identified as a key technology for reaching the CO_2 emission reduction targets by the EU. Since nuclear power is free from CO_2 emissions (at least in the energy conversion stage) we do not see that the purpose of the energy and climate policy package is a phasing out of nuclear power.

DIFFERENT DECISION POWER IN DIFFERENT PARTS OF THE ENERGY SYSTEM

It is generally easier to get measures and decisions implemented in energy supply, distribution, and large-scale conversion, than on the demand side. Construction of power plants, heating plants or power grids is handled by professional organizations in a limited number of (rational) decisions. Realizing the efficiency improvement potential on the user side often requires millions of decisions by millions of residence owners, tenants, and people in owner and administrator organizations, for whom energy is often only a fraction of all the issues they must deal with.



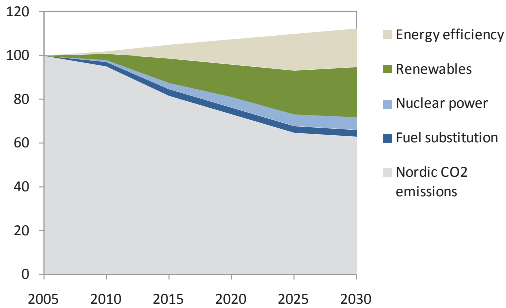
Decision making: the demand side is more complex

Synergies with the CO_2 and renewable targets

The vast majority of the energy efficiency improvement measures will, with the exception of resource management measures, also reduce CO_2 emissions and/or increase the use of renewable energy sources in the Nordic countries. Such synergies naturally make these efficiency measures more cost-effective.

The CO_2 target

The efficiency measures that reduce the use of fossil fuels also reduce CO_2 emissions. Over the period up to 2020, most measures fall under this category, especially in the EU.



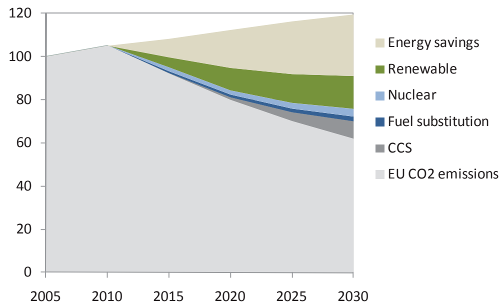


Figure 6.4: Improved energy efficiency is an important CO_2 measure in the Nordic region, and even more so in the rest of Europe. The figure on the left shows measures that reduce carbon dioxide emission in the Nordic countries, while the figure on the right is for the EU (as shown in by the Chalmers Pathways project), when the EU climate and energy package is implemented

The renewable energy target

Energy efficiency improvement measures also have a positive impact on renewable energy targets in the Nordic countries. This happens in two ways:

- The renewable energy target is a percentage target, measured in relationship to the amount of consumed energy, here called final energy. With improved energy efficiency, the total amount of energy used decreases, and thus the amount of renewable energy that must be added to the system.
- Many of the energy conversion efficiency measures also contribute towards increasing the share of renewables, if, for example:
  - biofuel cogeneration and wind power replace electricity production in coal powered plants;
  - buildings that are oil-heated are connected to district heating, given that the district heating is produced with renewable energy sources;
  - heat pumps are installed, as the free heat to heat pumps counts as renewable according to EU's directive.

For further information:
Bo Rydén and Anders Göransson, Profu

Three energy efficiency challenges

How to accelerate the implementation of the energy efficiency potential and use the most cost-efficient measures in the entire energy system.

The EU's energy and climate package includes an increase in energy efficiency by 20 % by 2020. The EU has plans to make this target binding and to formulate it as a reduction in primary energy. Previous research shows that there is a large and profitable efficiency potential in all sectors, both in the Nordic region's and the EU's energy systems. The research also warns that political programmes and clear incitements are needed if this potential is to be realised.

In previous section we have described a package of energy efficiency improvement measures. This package results in increased efficiency by 20 % and includes the measures that are most cost-effective for the Nordic energy system. However, it is not obvious that these measures will be the ones that are chosen to be implemented if the EU makes its 20 % target binding. NEP has identified three major challenges for the Nordic and European energy systems that need to be met:

1. Formulate a policy that gives equivalent incentives to increase efficiency in the whole energy system, in energy conversion as well as in end-use, so that the most cost-effective measures are chosen.
   a. Possible distribution of responsibility between the different sectors in the energy system (buildings, industry, etc.) should be open and not locked by fixed percentage targets.
   b. It is also important that individual efficiency measures are allowed to transfer responsibility between sectors, as for example, an increase in use of heat pumps, district heating and electric cars can do.
2. Balance policy instruments for improved energy efficiency with other policy instruments, including carbon emissions and renewable energy profiting from the synergies that arise from the different targets.
3. State clearly that efficiency measures – especially in end-use – require clear incentives in order to be carried out. Do not believe that it is enough that a

calculation model shows profitability. That there is an economic viable efficiency potential is not a guarantee that a measure will be actually carried out.

Choose a policy that gives equivalent incentives to improve efficiency in the whole energy system

A cost-effective implementation of the 20 % energy efficiency improvement by 2020 target in the Nordic energy system should include all parts of the energy system, from supply to end-use. NEP's analyses show that cost-effectiveness is attained with approximately equal amounts of energy conversion efficiency measures and end-use measures. Most of these energy efficiency improvement measures will, in addition to increasing energy efficiency, also reduce greenhouse gas emissions and lead to an increased use of renewable energy sources in the Nordic countries. These synergies will make the measures more cost-effective.

In both Nordic and European energy policy, the reasoning for energy efficiency improvements have traditionally been brought forward by the energy users. The consequence can be seen in the European Commission's document on efficiency, where end-use measures get the most attention. Many cost-effective measures on the supply side are overlooked, resulting in a sub optimization that can be expencive. However, if the EU and the Nordic countries are to achieve a 20 % efficiency improvement in the 10 years until 2020, sub optimization cannot occur. Key challenges in order to avoid sub optimization include:

- To formulate energy efficiency targets so that they provide incentives for improving efficiency in the whole energy system. The most apparent way is to formulate targets focused on reducing primary energy. The EU's document has also primary energy as a starting point.
  - Focusing on final energy, as the EU's energy services directive does with a requirement of 9 % energy savings by 2016, limits the outcome and does not promote large-scale energy conversion measures.
  - Working with weighted primary energy carriers like electricity and district heating is not an answer, as it does not promote large-scale energy conversion measures.
- The definition and measurement of primary energy is important. A discussion on which energy types are to be included is currently going on within the EU:
  - NEP has shown that the weighting factor of nuclear power is of crucial importance in the Nordic energy system, see further Chapter 6.

- It is also important to decide whether renewable energy sources like wind power, waste heat and free heat for heat pumps are to be regarded from the same primary energy perspective as fuels like coal and oil.
- The trading sector should be included, as it covers many cost-effective energy efficiency measures. Wind power, industrial waste heat and large heat pumps are good examples of cost-effective measures to improve efficiency in the trading sector.

The choice of policy instruments – finding a good balance

The above reasoning shows that there seems to be large possibilities for improved energy efficiency, and that this would justify the introduction of policy instruments. The items below are a more general reasoning about policy instruments for effective energy use. Common arguments for policy instruments are:

- The price of energy is too low
- The costs of energy are not paid directly by those who can influence the use of energy.
- In order for us as consumers to be able to make rational decisions, knowledge is needed, but it is sometimes effective instead to limit the choices by having the state place requirements on the products that are sold.
- A certain type of activity yields positive diffusion/external effects.

Align energy efficiency policies with other policy instruments

Policy instruments such as the EU's Emission Trading System (ETS), CO_2 emission taxes, green certificates, and feed-in tariffs are examples of policy instruments that are designed to reduce CO_2 emissions and increase the use of renewable energy sources. At the same time, these policy instruments provide incentives to improve energy efficiency, especially through energy conversion measures. An effective approach to achieve improved efficiency through energy conversion could therefore be to strengthen related policy instruments. NEP has not made a detailed analysis on the best way to do this. Instead, we merely list a couple of measures that might contribute to energy efficiency:

- Dedicated support for wind power as a complement to existing certificate systems.
- Feed-in-tariffs that are higher than the levels required to meet renewable targets.

Examples of policy instruments for more effective use of energy – in the end use sector

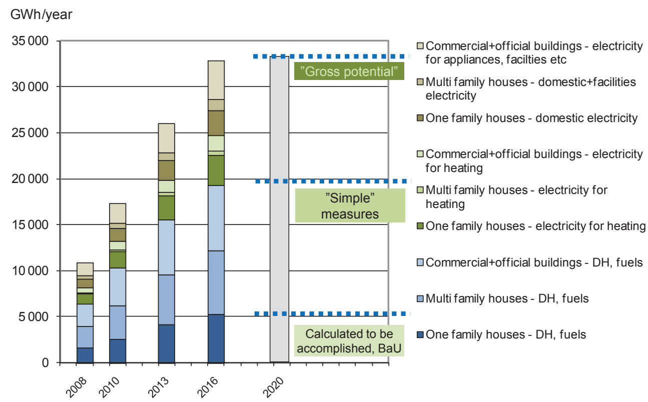
Policy instruments for more effective use in the end-use sector must of course also be implemented. Below is a list of examples of possible policy actions in order to eliminate or mitigate the effects of the obstacles described above:

- Different types of taxes, price regulations or competition laws.
- Voluntary agreements with energy users to reduce energy consumption.
- Regulation can also be an efficient method to reduce costs for information gathering or as an alternative to taxation.
- Strengthened status and prominence for energy declarations.
- Building codes with energy-conservation requirements for rebuilding.

Large incentives might be required to reach the 20 % energy efficiency target

– especially if the EU places the focus on end-use measures

NEP's analyses show that only a small fraction of all profitable energy efficiency improvement measures are carried out unless specific policy instruments are put in place. Clearly articulated political programs are therefore required if these measures are to be carried out.



Calculation of potentials for efficiency improvement. Insulation, appliances etc in the Swedish building sector. Final energy (end use). From the Swedish NEEAP

Go for the simple measures!

Evaluations of previous efficiency programmes show two types of outcome:

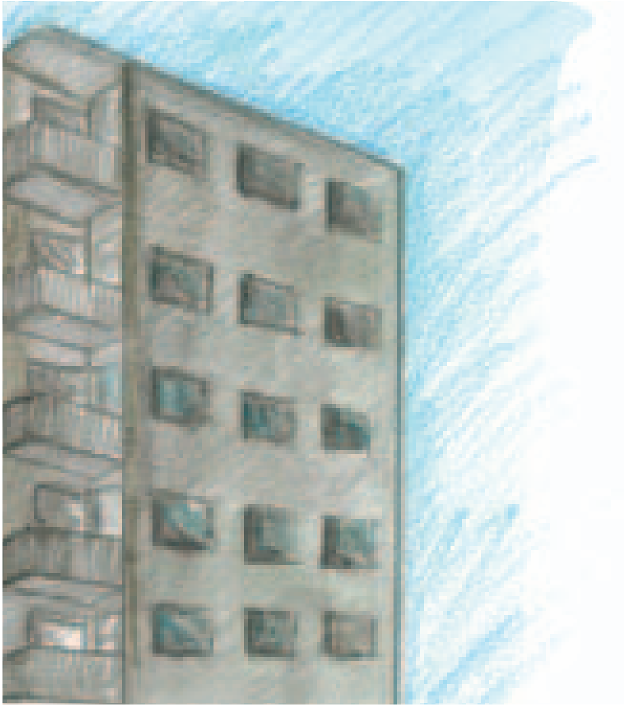
1. Even modest economic incentives give rise to substantial improvements in energy efficiency. This is confirmed by the volontary agreements in Finland and the Enova program in Norway, see Chapter 7 for details.
2. Significant incentives are required for all measures to be carried out fully. This is confirmed by several Swedish energy efficiency programs from the 1990's.

The NEP project has not had the opportunity to analyze these outcomes further. However, an initial analysis indicates that a strongly focused political program might be required to reach the 20 % energy efficiency target by 2020. Such a program might be necessary despite the fact that current energy and climate policy, which includes a 9 % energy efficiency target, already includes energy efficiency incentives, and despite the fact that many energy efficiency measures give rise to synergies with other programs because they also contribute positively to CO_2 emission reduction and renewable targets.

If the EU decides to focus energy efficiency improvements on end-use while retaining high ambitions for reductions in primary energy use, more expensive measures will be required. We know by experience that strong incentives are required for such measures to be implemented. Compared to a policy in which the most cost-effective measures for the entire energy system, the ones included in the NEP energy efficiency package, are selected, such a restricted policy leads to a higher total cost for reaching the 20 % energy efficiency target.

Lessons learned from efficiency improvement programmes of the 1990s and 2000s

Energy efficiency has been a prioritized area in the Nordic region ever since the oil crises of the 1970s. For instance, Sweden carried out a very successful heating savings programme in the 1980s, which was followed by an electricity efficiency programme in the 1990s. In Denmark and Finland, voluntary energy efficiency improvement programmes directed at the industrial sector have received a lot of attention. In Norway, the ENØK-programmes, where funds were earmarked for energy efficiency measures, grew strongly in the 1990s. The responsibility for these programmes was then transferred to Enova in the early years of the new millennium.

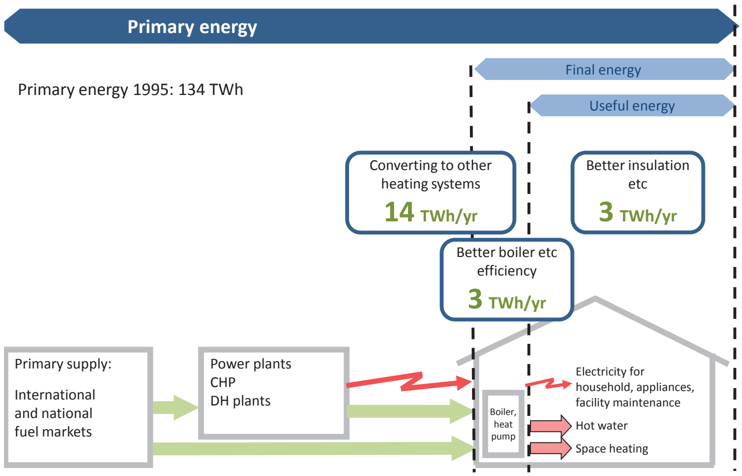


At the same time, other energy and environmental policies have provided incentives for energy efficiency measures, both in end-use measures and energy conversion measures. This has especially been the case when it comes to programmes such as energy and carbon taxes, renewable energy programmes, and the EU Emission Trading System (ETS).

The National Energy Efficiency Action Plans (NEEAPs) of the Nordic countries also provide a good illustration of the extent of end-use energy efficiency improvements in the Nordic region in the 1990s and 2000s.

Improved efficiency due to energy conversion measures – an example from Sweden

In the Swedish housing and services sector, energy efficiency has improved by approximately 1% per year in the last two decades. Detailed NEP analyses show that a very large part of this improvement cannot be attributed to measures that reduce final consumption of useful energy. Instead, most of the improvement can be attributed to energy conversion measures such as replacement of electrical heating by heat pumps. This is noteworthy since NEP analyses show that energy conversion measures will be very important components of energy efficiency programs in the future as well.



Energy consumption in the Swedish housing sector is calculated to have fallen by approximately 20 TWh over the period 1995-2004. This amounts to a decrease of 10-12%. End-use consumption has fallen, but only slightly, so energy conversion accounts for most of the reduction. The large increase in the number of heat pumps is an important reason for this.

7. Large, profitable efficiency improvement potential in end-use

- existing programmes and simple measures can result in significant improvements in energy efficiency

As described in Chapter 6, the EU's ESD-directive sets a 9 % indicative energy efficiency target, to be achieved by 2016. Existing programmes allow the Nordic countries to reach this target.

EU has, within its climate and energy package, adopted a framework for energy end-use efficiency and energy services. This includes an indicative energy savings target of 9 % to 2016 for the Member States, as well as obligations on national public authorities with regards to energy savings and energy efficient procurement and measures to promote energy efficiency and energy services.

The potential and programmes for increased energy efficiency in the Nordic countries, which has been identified to fulfil this 9 % target, are shown in the table. It has been calculated from the National Energy Efficiency Action Plans (NEEAP:s) and other national efficiency plans for the Nordic countries. The potential will, as shown in Table 7.1, reach above the 9 % energy efficiency target in 2016 in the end-use sectors, so-called final energy. Industries and other plants that are included in the EU's emission trading scheme (EU ETS) are not included in the table. For further information, see NEP research report on energy efficiency.

Table 7.1: The programmes for increased energy efficiency in the Nordic countries to 2016, which has been identified to fulfil this 9 % target

	TWh	%
Final energy use, 2003	700	
Early actions and existing policy instruments	21	3.0%
Suggested efficiency programmes to 2016	71	10.2%
Total	**92.0**	**13.2%**
- above the 9% level	30	4.2%

Existing programmes and simple measures

In addition to the ESD directive, the EU has a target for 20 % improved energy efficiency until the year 2020. This target is, in principal terms, included in the EU climate change and energy package from December 2008. At present, the target for 20 % improved energy efficiency does not include any legally binding targets. In a memorandum published during 2009, the EU presents the prerequisites for this 20 % target. The EU is now discussing making this 20 % target binding for all member states. The target might be formulated as a requirement to reduce primary energy by 20 % by 2020, as explained in Perspective 6.

It is however, not only the target level and the final year that separates the EU targets for 9 % and 20 % improved energy efficiency. The base year to which the target refers is also different: the base year of the 9 % target in the ESD directive consists of an average for the first years from 2000, while the base year for the 20 % target is 2020 and a projected level of primary energy use for a business-as-usual scenario for that year.

THIS EU DIRECTIVE ON ENERGY END-USE EFFICIENCY AND ENERGY SERVICES (ESD)

The purpose of Directive 2006/32/EC on energy end-use efficiency and energy services, from the European Parliament and the Council, and the repealing of Council Directive 93/76/EEC is to make the end use of energy more economic and efficient by:

- establishing indicative targets, incentives and the institutional, financial and legal frameworks needed to eliminate market barriers and imperfections which prevent efficient end use of energy;
- creating the conditions for the development and promotion of a market for energy services and for the delivery of energy-saving programmes and other measures aimed at improving end-use energy efficiency.

The Directive applies to the distribution and retail sale of energy, the delivery of measures to improve end-use energy efficiency – with the exception of activities included in the greenhouse gas emissions trading scheme – and the armed forces, to a certain extent. It targets the retail sale, supply and distribution of extensive grid-based energy carriers, such as electricity and natural gas as well district heating, heating oil, coal and lignite, forestry and agricultural energy products and transport fuels.

A cost-effective package of measures to achieve the 20 % energy efficiency target

It is a challenge to go from the ESD directive's target for 9 % improved energy efficiency to the EU's more ambitious target of 20 % improved energy efficiency in only the four years from 2016 to 2020. The analyses carried out by NEP show that a cost-effective package of energy efficiency measures designed to achieve the 20 % efficiency target for primary energy by 2020, should include all parts of the energy system, from supply to end-use, in approximately equal amounts of energy conversion efficiency measures and end-use measures. This is described in detail in Chapter 6.

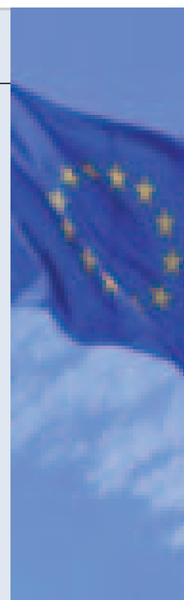
The menu of conservation measures in the building sector and the industry

The conclusion from our calculations of the energy efficiency measures, set up to fulful the 9 % target in the ESD-directive, is that there is – in the NEEAP's and other efficiency plans – additional potential for cost-efficient measures presented above 9 %, large enough to contribute to reaching a target of 20 % improved energy efficiency calculated as primary energy use from a business-as-usual scenario for the year 2020. We can call this "the gross potential".

ENERGY EFFICIENCY: DELIVERING THE 20% TARGET

European leaders committed themselves to reduce primary energy consumption by 20 % compared to projections for 2020. Improving energy efficiency also addresses the key energy challenges of climate change, energy security and competitiveness.

Current energy efficiency legislation alone will not deliver sufficient energy savings to meet the 20 % saving target. Main obstacles to energy efficiency improvements are the poor implementation of existing legislation, the lack of consumer awareness and the absence of adequate structures to trigger essential investments in, and market uptake of, energy efficient buildings, products and services. The assessment of national energy efficiency action plans shows that there is a gap of 9-10 % between the Member States political commitment to energy efficiency and their actions. Member States need to implement more swiftly and effectively energy efficiency legislation. New instruments must be developed to further enhance energy efficiency. (Source: EU memorandum from 2008 and 2009)



In our analysis we have tried to estimate the segment of this gross potential that can be realistically achieved by 2020. The estimate is based on the assumption that:

- the marginal cost for end-use energy efficiency improvement measures is about the same as the marginal cost for energy conversion measures.
- end-use measures would be mostly simple measures with relatively low investment costs.

The NEP analysis shows that end-use measures in the building and industrial sectors make up approximately half of the measures in the energy efficiency improvement package that achieves the 20 %-target. Table 7.2 shows the segment of end-use measures in these sectors (electricity and heating/fuel measures). For further information see NEP reports on energy efficiency.

Table 7.2: Energy efficiency in the building sector and industry by 2020, relative to a business-as-usual level (TWh)

	Heating	Electricity	Sum	%
Residential and service	29	19	48	11%
Industry	15	8	24	7%
Total	**44**	**27**	**71**	**9-10%**

Calculation of the size of the efficiency potential for 2020

It is previously described how NEP has come up with an estimate of the share of the gross potential that can be realistically achieved by 2020. Below, it is illustrate how NEP arrived at this estimate. This is done by considering a specific example, namely that of energy efficiency in buildings in Sweden.

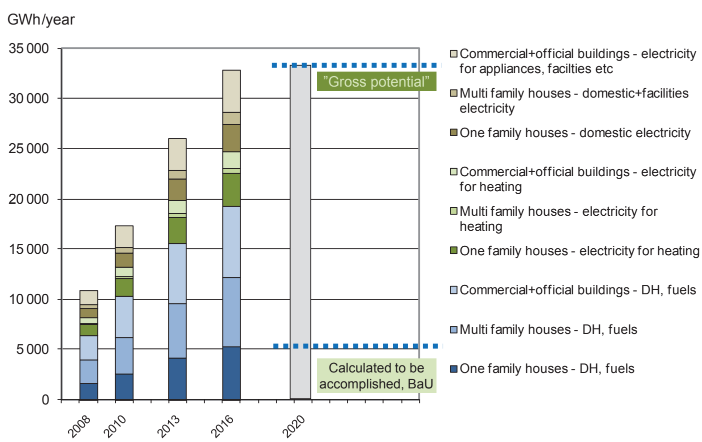


Figure 7.1: Calculation of potentials for efficiency improvement. Insulation, appliances etc in the Swedish building sector. Final energy (end use). From the Swedish NEEAP

NEP CHOICES AND ASSUMPTIONS

> ” 20% energy efficiency target”

It is not quite clear in the EU documents if the 20 % target, as the 9 % target, only deals with energy use in plants outside the EU emission trading scheme (EU ETS). NEP's choice is that in the analyses of the 20 % target, the energy use in all plants of the energy system will be included. This may lead to a situation where we analyse a somewhat larger energy efficiency ambition than the EU finally will decide, but we know that the both other 20 % targets, regarding reduced CO_2 emissions and increased use of renewable energy, also give incentives for reduced primary energy use. Our judgement is therefore that we will not deviate too much from the real development, even if the EU chooses to keep the plants within the EU ETS outside the 20 % energy efficiency target.

The ESD directive allows, the including of already decided policy instruments in the 9 %. Among those are for example energy tax, CO_2 tax and voluntary agreements. In the EU's document about the 20 % target it is clear that the member countries will not be allowed in the same manner to include measures that are results of existing policy instruments. It is however not easy to isolate these measures, at least not in the energy conversion stages. Thus, an exact judgement of which measures requires new policy instruments will be difficult to make. NEP has therefore chosen to compromise in its analyses, and exclude a majority of the measures in the final user stage, identified in the NEAAP:s, for which existing policies give incentives, but include a majority of the measures in the energy conversion stages for which existing policies give incentives.

Figure 7.1 above shows the gross potential of energy efficiency in Swedish buildings. In this case, the gross potential is about 34 TWh, or 22 %, of the total final energy use. The concept gross potential refers to what is private-economically profitable in a present-value calculation. The potential includes all types of measures, i.e. supplementary insulation, ventilation, change of electrical equipment, etc. Conversion of heating technology is not included. The implementation is distributed over time according to usual lifetimes for apparatuses, building parts etc.

How much of the gross potential is spontaneously implemented?

Only a part of the gross potential will be spontaneously implemented in reality. This has been established and described in a large number of contexts and inquiries. The Swedish EnEff inquiry estimates that only about 15 % of the efficiency measures, excluding conversions, will be implemented in a business-as-usual case. This corresponds to about 5 TWh in year 2016 in Figure 7.1.

Obstacles to implementation

There are many reasons why not everything is implemented. Examples of these are

- Deficient knowledge about the existence of improved efficiency possibilities
- Doubt of the suitability of certain measures
- Stricter profitability requirements or problems with financing
- Too narrowly or short-sighted calculations of profitability
- Doubt whether the business will last in its present form
- Lack of time to handle this type of issue or produces an inadequate basis
- Lack of sufficient competence in the organization or focus on other issues

How much of the gross potential should be easy to realize?

All of the measures in the gross potential are profitable in calculation terms, but naturally their profitability differs. A very large group of measures are actually quite simple to implement, and many of them cost nothing in investment. Examples of such simple measures are

- Adapting air flows and operation times for ventilation and illumination to the times when premises are used. This often requires only the right adjustments of existing clocks or the like.
- Electricity efficiency in households, buildings and businesses, in the form of change to the best on the market when changes are to be made anyway. Change to low-energy lamps.
- Insulation of attics.

These simple and cheap measures constitute more than half of the entire gross potential; see Figure 7.2. The potential of the simple measures is thus much greater than what is implemented spontaneously. And what is implemented spontaneously may not be the most profitable – experience from elsewhere indicates that real implementation is widely spread between the more and the less profitable.

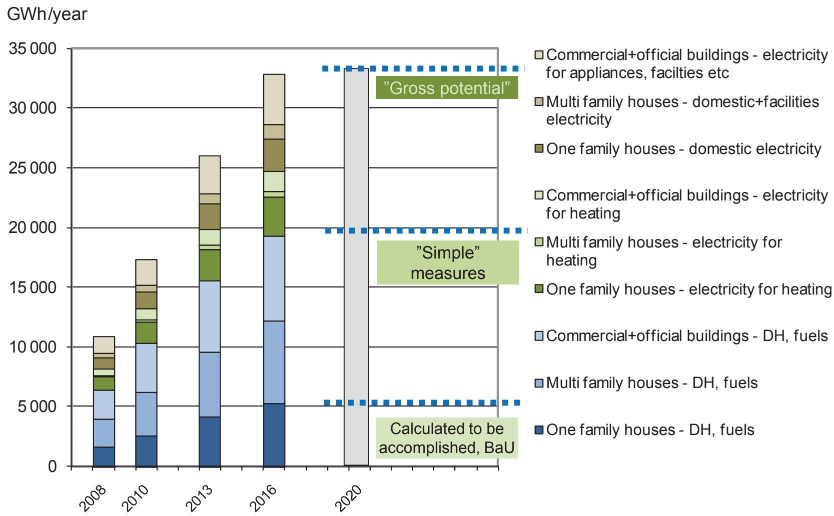


Figure 7.2: Calculation of potentials for efficiency improvement. Insulation, appliances etc in the Swedish building sector. Final energy (end use). From the Swedish NEEAP

The efficiency gap can be explained

Our conclusion is that there are certainly obstacles which lead to a great deal not being done, but that the house owner has many very profitable possibilities within reach when the obstacles have been passed. Policy instruments that help the decision-maker over the obstacles therefore seem to be well justified.

The energy-efficiency gap, which refers to the fact that apparently profitable measures are not carried out, and how its causes can be systematized, have been discussed in depth in NEP. There are also careful discussions of what should be defined as market failures or market barriers in general. Further, NEP has tried as far as possible, to find specific and concrete causes of the gap and to express them in figures where this is feasible.

For each measure, NEP has made a rough estimate of the time it takes for a building owner and his/her employees or family members to acquire information, purchase, follow up etc. With transaction costs included in this way, the potential decreases from 34 TWh of final energy to 28 TWh, or 82 % of the base case. This calculation is made with ample expenditure of time, and with a time valuation of: 10-12 SEK/hour for private persons' own free time. If we also add the influence of split incentives and the investor market, the potential decreases to 24 TWh of final energy, which is 72 % of the base case. We can now observe that this potential of 24 TWh has the same order of magnitude as the assessment of the potential for simple measures, which is about 20 TWh as shown above.

The above reasoning shows that there seems to be large possibilities for improved energy efficiency, and that this would justify the introduction of policy instruments. A set of various policy instruments and their impact on energy use was analyzed in the EnEff inquiry. Some of the policy instruments included was a ban on incandescent light bulbs, norms and regulations, voluntary agreements, and pricing feedback. The investigation justified the choice of these policy tools with their ability to bridge over several of the obstacles that were identified as most important to overcome for realizing large energy efficiency potential. In this case they are also made so that the influence between different policy tools is not counted twice. The analysis showed a potential of 20 TWh, including 5 TWh of measures that were carried out spontaneously.

A realistic efficiency target

The sections above illustrate a way of reasoning about how to set up a realistic efficiency potential" for buildings. In part, one proceeds from the gross potential, with the engineering entries, and makes reductions with regard to transaction costs and other obvious, calculable causes of the efficiency gap. This calculation gives a result which has the same order of magnitude as the assessment of the potential for simple measures. Secondly, we proceed from the spontaneous development and add the estimated impact of the proposed policy tools.

The conclusion is that both approaches have about the same outcome, in the range of 20-24 TWh of final energy for Swedish buildings.

Ongoing energy efficiency programmes and activities up to 2020 in two Nordic countries

Energy efficiency activities in Finland up to 2020

The first separate programme for energy efficiency was launched in 1992 and the programme has been renewed on a regular basis (1995, 2000 and 2002). The Action Plan for Energy Efficiency defined energy efficiency measures for the period 2003-2006, but the target year for energy efficiency improvements was 2010. In 2005, this Action Plan was incorporated into Finland´s new National Energy and Climate Strategy. The target defined in the strategy, was to achieve an additional 5 % energy savings by 2015 by intensifying existing measures and by introducing new measures connected to the implementation of EU directives.

In order to replace and update some of the energy saving agreements that expired in 2007 a third generation of voluntary energy efficiency agreements for the 2008-2016 was prepared:

Table 7.3: Energy efficiency activities in Finland

Target group	Savings
Energy-intensive industry	
All energy-intensive industrial companies in Finland	The target (presented no later than 2010) will reflect the energy efficiency improvement targets set by the companies on the one hand and on the other, the energy efficiency improvement targets of the national Energy and Climate Strategy set at the time
Energy production	
Companies with combined or separate generation of electricity and heat, 80% of energy production	*Total saving of 1,000 GWh in the use of primary energy and an improvement of 1,000 GWh in electricity generation calculated in electrical energy by the year 2016 when compared against the situation where these new measures are not taken.*
Medium-sized industry and private service sector	
Companies with no sites exceeding a maximum annual energy consumption of 100 GWh. A least 60% of the energy use of the medium-sized industry and private service sector.	The indicative target of energy conservation to be set for each branch will be 9%
Energy services	
Companies delivering district heat and district cooling to end users and those carrying on electricity transmission, distribution and retail sale. The target is to have 80% of the electricity transmitted to end customers (electricity distribution), the electricity sold to end customers (electricity sales) and the district heat sold to end customer.	Saving of 150 GWh of electricity in the transmission and distribution losses of electricity and in the electricity consumption of district heat production and transmission, and a saving of 150 GWh in the distribution losses of district heat and the consumption of fuel energy in separate production by the year 2016 when compared against the situation where no new measures are taken.

More than 30 companies of energy-intensive industries have signed the new agreement. By signing the agreement, a company undertakes to analyze its own energy consumption and to draw up an action plan on implementing cost-effective useful efficiency measures. Accordingly, municipalities adhering to the municipal sector agreement scheme are. The new agreements will promote the deployment of new technology and innovation activities more intensively, while including targets and measures for encouraging the use of renewable energy.

Table 7.4: Reported energy savings of Finnish energy-intensive industry in 2008 and future saving approximations (based on Motiva report on December 2009)

Action	Energy saving actions			Other actions		
	Saved energy total TWh/a	**Saved electricity TWh/a**	**Invest-ment M€**	**Saved energy total TWh/a**	**Saved electricity TWh/a**	**Invest-ment M€**
Deployed	0.7	0.2	16.9	0.1	0.02	5.1
Decided or considered	3.0	0.6	156.7	1.3	0.7	260.5

The voluntary energy saving agreement for residential buildings was signed in November 2002 for the 2002-2012 period. The targets were:

- 15 % decrease in heat and water consumption by 2012
- Turn electricity consumption to decrease by 2008
- Get 80 % of the communities that have signed the agreement to be analyzed and under consumption follow-up by the end of 2010.

Savings in Finland by 2020 according to Energy Efficiency Committee

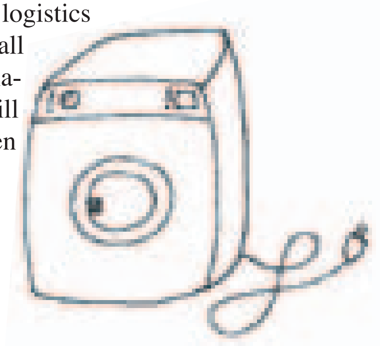
Energy Efficiency Committee established by the Ministry of Employment and the Economy proposed in June 2009 long term energy saving and energy efficiency measures that would impact approximated 37 TWh savings in final energy consumption by 2020. Note that transport is included here, but is excluded in the NEP analyses.

Electricity savings would be 6.4 TWh, see Table 7.5. The highest savings calculated would be achieved through new automotive technology (8.5 TWh), regulations for new building and renovation building (4.9 TWh), more challenging energy efficiency agreements (2.8 TWh), and energy performance requirements for appliances (2.1 TWh). Due to the proposed measures, final energy consumption will be approximately 11 % lower in 2020 than it would be without these measures.

Table 7.5: Approximated energy savings in Finland by 2020 according to Energy Efficiency Committee

Target group	Savings by 2020 approximately		
	Heat and fuels [GWh]	Electricity [GWh]	CO_2 [1000 tons]
Buildings	5 600	1 050	1 400
Traffic	12 600	130	3 600
Domestic	580	360	210
Agriculture	490	30	140
Industry and services	10 700	2 700	3 500
- energy intensive industry	(6 420)	(1 530)	(2 180)
Device energy eff.		2 100	430
Total	30 000	6 400	9 300

The approximated savings of energy-intensive industry are 1.5 TWh in electricity and 6.4 TWh in heat and fuels. The proposed measures cover a wide range of actions including e.g. emissions trading, training, education and innovations. The savings achieved by the actions of the energy efficiency agreements have a key role. In forest and metal industry, the main saving actions included process improvements, the use of more efficient equipments and systems like improved pumping, systems, inverters, turboblowers and efficient motors, and waste energy recovery. Energy efficiency improvements in logistics and in overall energy management will be also taken care of.



Energy efficiency in Norway up to 2020

The governmental enterprise Enova SF, which is the Norwegian authorities' most important policy instrument in the shift to a more environmentally friendly energy system, has for seven years offered different support arrangements that are to stimulate to energy efficiency. Enova makes yearly reports on the achieved energy savings and their costs. The support has to be the trigging factor for the initiative to be able to receive Enova support. Enovas reporting procedure, including the used methodology, is audited regularly. We therefore have confidence that this data material is of good quality.

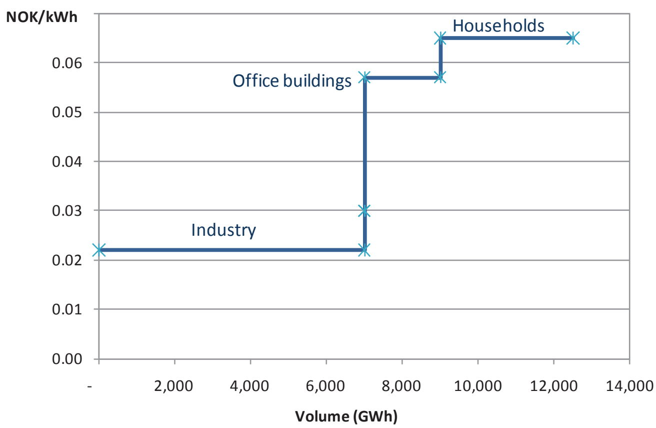


Figure 7.3: Enovas evaluation of the potential

Total potential for energy efficiency and costs

Looking at the three sectors industry, office buildings and households combined with a certain set of assumption, it is possible to realize a substantial potential (12-14 TWh) at a cost of less than 70 NOK/MWh or 10 €/MW).

Enova's evaluation of the potential for energy efficiency

Enova's goal is a sum of different initiatives within energy efficiency, shift from fossil fuels to renewable energy and establishing new production capacity for electricity and heat. Enova has a total of 18 TWh by 2016 and 40 TWh by 2020 regulated by contract. It is up to Enova to decide how this should be distributed among the different initiatives, but 3 TWh has to be wind power and 4 TWh has to be renewable heat.

Enova believes that about 15 TWh worth of energy efficiency can be realized almost without investment costs.

For further information:
Bo Rydén, Profu, Benedicte Langseth, Xrgia and Raili Alanen, VTT

8. The development of the Nordic electricity system – towards zero CO_2 emissions?

The future electricity system will be shaped by policies, market forces and expectations. The Nordic countries are endowed with significant renewable energy resources, but bringing down CO_2 emissions while sustaining competitive electricity prices is still a challenge. The NEP policy scenarios show to what extent CO_2 emissions from Nordic electricity generation are reduced with different combinations of renewables policies and the emission cap in the EU ETS. CO_2 emissions from Nordic electricity are likely to decline in all scenarios by 2020. The share of renewable generation is found to be the most important factor in reducing emissions, but reductions also depend on the degree to which surplus electricity generation can be exported to Continental markets. Although national renewable energy policies are likely to reduce emissions, the emission cap in the EU ETS and global climate policies are also crucial for CO_2 emissions from the Nordic electricity system. Model results indicate however, that net electricity exports are roughly in line with electricity generation based on fossil fuels in the scenarios with a high share of renewables generation. As such, Nordic electricity consumption can be said to be CO_2 free in the scenarios with a strict climate policy.

Energy markets are formed and transformed under the influence of market forces, policies and expectations about the future. Current policies and measures, as well as expectations of future policy targets and frameworks, and how the market is perceived to react to these conditions, determine investment behavior in the market today. And it is today's investments and decisions which will ultimately form tomorrow's electricity system.

Analyzing the development of the electricity system in the next two decades can therefore not be based exclusively on numerical simulations in market models. Equally important for the outcome are the analysis of basic policy drivers, the implementation of policies and how the stakeholders respond to these policies. Since the future balance between national policies, EU policies and global climate policy developments is currently undetermined, uncertainty abounds and expectations become decisive. Adequate predictions should hence be based on thorough scenario analyses as well as quantitative market simulations.

The NEP policy scenarios identify EU and global energy and climate change policies and the development in global markets as the crucial driving forces for the Nordic electricity market. The central elements are the cap on CO_2 emissions imposed by the EU Emissions Trading Scheme (EU ETS), the implementation of the renewable energy target in the Nordic area, fuel prices, and the export/import balance of the Nordic electricity market.

Scenarios

We have identified a reference case and two policy scenarios, each representing distinct development paths for Nordic electricity. The analysis naturally focuses on 2020, but also sees beyond the 2020 targets towards 2030.

The main scenario assumptions are discussed in more detail in the NEP final report "Coordinated use of energy-system models in energy and climate-policy analysis". Therefore, only a brief summary is given here.

Reference scenario

The reference scenario carries forward today's energy policy status. In terms of EU policy compliance, the EU ETS is carried forward with a 20 percent reduction in CO_2 emissions by 2020, but the EU renewable target is not fully met. The Nordic governments continue to support increased investments in renewable generation.

European policy scenario

In the European policy scenario, EU policies are enforced, but in the absence of a binding and ambitious international climate agreement. This means that the cap in the EU ETS is not reduced compared to the reference scenario. Investments in renewable generation increase, and the overall EU target of 20 percent renewables in the energy mix by 2020, is reached. In the Nordic market, this means that renewable generation increases by 29 and 35 TWh by 2020 and 2030, respectively.

In Figure 8.1, the development of the Nordic electricity-generation system is shown for the European policy scenario as estimated by the ECON-Classic model.

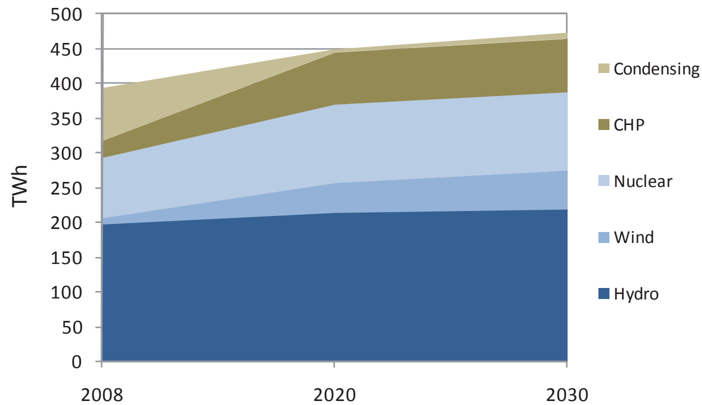


Figure 8.1: Nordic electricity generation in the European policy scenario (based on ECON-Classic model run).

Global policy scenario

In the Global policy scenario, climate negotiations result in a binding and ambitious climate policy agreement, which prompts the EU to reduce the EU ETS cap to a 30 percent emissions reduction. In this scenario the renewable target is also met. The same amount of renewable generation in the Nordic region is assumed in both the European and Global policy scenarios. The EU's 2020 targets include an ambition to increase energy efficiency by 20 percent compared to a baseline. We have not taken the energy efficiency target specifically into account in these scenarios (the impact of the efficiency target is discussed in e.g. Chapter 2). The main reason for this is that it is very uncertain how the efficiency target will affect electricity demand.

The policy scenarios are the basis against which we have analyzed the development of the Nordic electricity market and the resulting CO_2 emissions.

Results

The scenarios have been analyzed using a suit of different models with differing coverage and functionalities (see more in the NEP report "Insights from NEP policy scenario simulations" for more detail). In this section, we will concentrate on results from the electricity market models Econ-Classic, PoMo and VTT-EMM (for more information on the models, see NEP final report "Coordinated use of energy-system models in energy and climate-policy analysis").

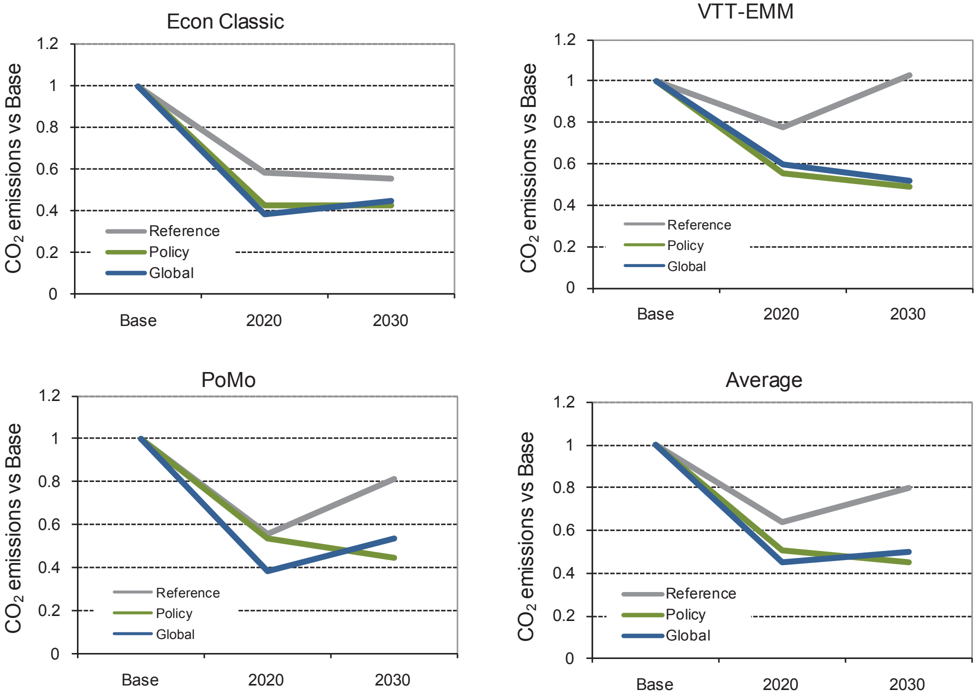


Figure 8.2: Development in CO_2 emissions from Nordic electricity based on resuts from Econ Classic, VTT-EMM and PoMo, and the average of all three electricity market models. Emissions relative to modelled Base year (2007).

Figure 8.2 shows the development in CO_2 emissions calculated by NEP's electricity market models. Although results vary somewhat, all models show that CO_2 emissions are reduced, even in the Reference scenario. In the Econ Classic and PoMo model runs, CO_2 emissions in 2020 are 40 percent lower in than in the Base year (2007/2008), whereas VTT-EMM shows a somewhat lower reduction. In the European and Global policy scenarios emissions are 40-60 percent lower than in the Base year.

In Econ Classic for example, CO_2 emissions are reduced by around 30 million tons in the Reference scenario and by around 40 million tons in the European and Global policy scenarios.

Why do we get these reductions?

The results show that the Nordic electricity market is likely to develop an increasing electricity surplus, due to an increase of investments in renewable generation combined with moderate demand growth. Even in the Reference case there is a significant increase in renewable generation, whereas reaching the EU target requires an additional 29 TWh by 2020 (European and Global policy scenarios), see Figure 8.3.

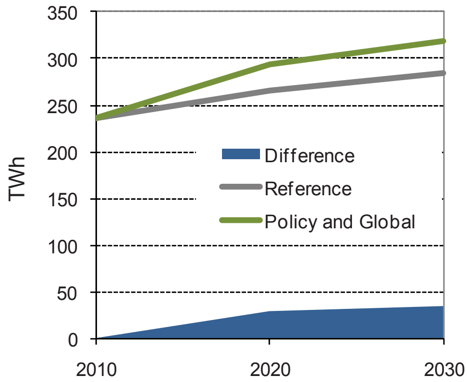


Figure 8.3: Increase in policy-induced new renewable electricity generation in the Nordic power sector in the scenarios, plus difference between Reference case and European and Global Policy scenarios.

The full cost for renewable generation capacity is high and investments are driven by government subsidies. However, once renewable capacity is brought online, marginal generation costs are low. Hydro and wind power are based on free resources, and electricity from CHP based on biomass is a side product of heat generation. Hence, the generation from this added capacity will replace conventional fossil fueled capacity with higher marginal costs, or be exported. Figure 8.4 illustrates this general effect. As generation from hydro, wind and biomass increases, generation in condensing plants based on fossil fuels goes down. The PoMo model yields some reduction in CHP generation as well. This can probably be attributed to restrictions in the export opportunities in the simulations. So as the overall effect is clear and consistent across the models, the results also show that different models capture different effects.

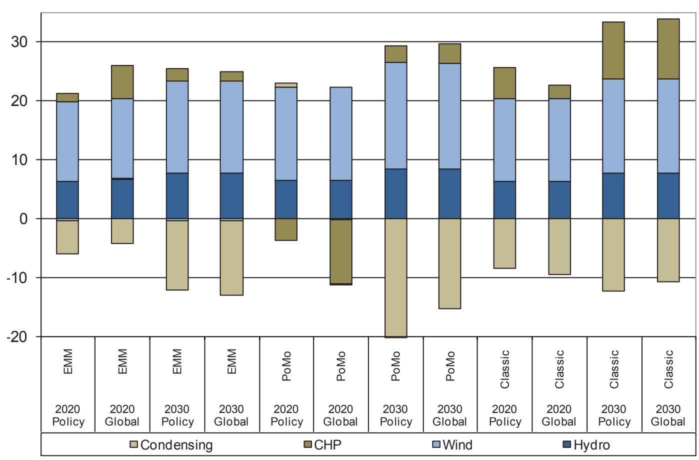


Figure 8.4: Changes in electricity generation from different energy carriers per scenario and electricity market model.

With the assumed increase in renewable generation and nuclear capacity, our model simulations show that it is not profitable to invest in new fossil-based capacity in the Nordic market before 2030. This also means that Nordic electricity prices will stay low, i.e. below the long-term marginal cost of new capacity and below Continental price levels. In the Continental markets new renewable generation replaces old fossil-fueled capacity which would have been phased out anyway, leaving room for new profitable investments in conventional capacity.

As indicated by the results shown above, assuming a certain level of electricity demand in the Nordic countries and a certain share of policy-induced investments in renewable capacity, the opportunity to export surplus electricity generation is crucial for the CO_2 emissions from Nordic electricity generation. We expect transmission capacity between the Nordic market and adjacent market areas to increase significantly, as shown in Figure 8.5. As the Nordic fossil fuel-based generation (coal and gas) – mainly located in Finland and Denmark – is very competitive compared with German and Polish fossil fuel generation, increased trading opportunities imply that fossil fuel-based generation in the Nordic region is exported, thereby effectively replacing less efficient generation capacity on the Continent. The increased exports imply that European CO_2 emissions are reduced, but Nordic CO_2 emissions are higher than they would be without this export opportunity (more on electricity trade between the Nordic countries and Continental Europe is found in Chapter 11).

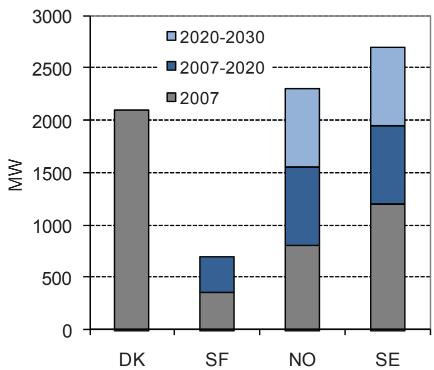


Figure 8.5: Development in interconnector capacity between the Nordic market and adjacent market areas, MW.

Using the Econ Classic results, we find that in 2020 only 1,4 TWh of the fossil generation is consumed in the Nordic region in the European policy scenario, whereas in the Global policy scenario Nordic exports are 0,3 TWh higher than fossil generation. Similarly, fossil fuel generation is higher than net exports in 2030 in the European policy scenario. In the Global policy scenario a larger share is consumed in the Nordic region in 2030, as lower prices result in increased demand. Hence, the results should be interpreted with caution as demand growth and price developments play a role.

The effect on Nordic CO_2 emissions is largely the same in the European policy scenario and the Global policy scenario. This indicates that it is the increase in renewable generation capacity that has the most significant impact on emissions from Nordic electricity generation. The level of renewable generation is the same in the European and Global policy scenarios, but represents a significant increase compared with the Reference scenario. CO_2 emissions in the Nordic countries are roughly at the same level in both scenarios, despite the fact that the assumed price of emission allowances in 2020 is much higher in the Global policy scenario than in the European policy scenario. The reason is that the increase in carbon costs affects all power generation in Europe, and the Nordic fossil fuel generation retains its competitiveness as the cost increase is general.

For further information:
Berit Tennbakk, Econ Pöyry and
Per Erik Springfeldt, Sweco

The challenge of making Nordic electricity CO_2 free

From a political perspective it would be positive to be able to claim that the Nordic power sector is CO_2 free. On the other hand this may not be a very rational goal since small quantities of fossil fuel generation can be very profitable to keep in the system as regulatory power, enabling more intermittent power like wind power to be introduced. Fossil fuel generation can bee seen as "lubrication" in an almost CO_2 free electricity system.

The model results from the NEP toolbox indicate that CO_2 emissions in the Nordic region are likely to be substantially reduced in coming decades. However, none of the models yield zero CO_2 emissions from Nordic electricity. This is also the case for the results from the models that include the heat market.

We also know from our work that there will be large unexploited resources of renewable energy in the Nordic area that would be profitable to develop compared to investments in renewable energy in central Europe. With the right economic support for example through common electricity support schemes, there is money to be saved.

A strict marginal perspective

A strict marginal perspective implies that we (the Nordic countries) are exporting our fossil generation and keeping the non fossil for our self?

Increase of renewable generation in combination with more nuclear and a weak demand growth result in large electricity exports from the Nordic countries to Continental markets. Since coal and gas-fueled capacity, which is the generation capacity that emits CO_2, is also the marginal capacity in the Nordic electricity system, it can be argued that it is coal and gas generation which is exported to the Continent: if export opportunities were curbed, Nordic coal and gas generation may be reduced.

However, the perspective on CO_2 emissions from the Nordic power sector should be somewhat broader than on emissions from Nordic power generation alone. If Nordic fossil generation is more competitive than generation on the Continent, even though CO_2 emission costs are the same, exports from the Nordic region replace higher cost and thus lower emission generation on the Continent. Within the framework of a common cap-and-trade system for emission allowances such as the EU ETS, the total CO_2 emissions are not reduced, but the cost of complying with the cap is reduced, contributing positively to the competitiveness of European economies in a carbon-constrained environment.

ELECTRICITY DISCLOSURE AND TRADE IN GUARANTEES OF ORIGIN (GO)

Large quantities of hydro power "attributes" are being exported from the Nordic market to countries in central Europe. This export is carried out through the exchange of certificates, so called guarantees of origin, not physical power. According to the EU legislation for electricity disclosure (2009/28/EC) member States shall ensure that the same unit of energy from renewable sources is taken into account only once (Art 15 §2). This means that disclosure regulation has to take GOs in the account and this regulation has to be coordinated with other countries.

Exports of renewable electricity through guarantees of origin have to be balanced by an equal amount of imports of "attributes". These imported attributes can refer to a specific generation resource, proven by GO (or some other accepted tracking device), or mirror the so called residual mix. If the present trends of exporting GO from the Nordic region will continue - the electricity consumed in the Nordic countries from an electricity disclosure perspective, can deviate a lot from the physical generation mix.

9. Can we expect electricity demand to grow?

The development of electricity demand will have a large impact on the Nordic electricity market in the coming years. Large volumes of new power are coming into the market both through market forces and public support schemes. Without a substantial increase in domestic demand, much of this power will most likely be exported out of the region.

The demand for electricity is flattening out

As long as there has been electricity, demand for it has grown. During long periods the demand for electricity in the Nordic region has even grown faster than the economy. This is illustrated in Figure 9.1. A change of economic policy in the 1990's can partly explain why demand for electricity has declined. The devaluations that were so common in the 70's and 80's and that provided an invaluable boost to industries with high exports and low imports – which is the case for the electricity intensive industry - were replaced with among other things, a low inflation policy. Consequently, many electricity intensive industries have faced tougher conditions that have resulted in smaller increases in production and electricity use.

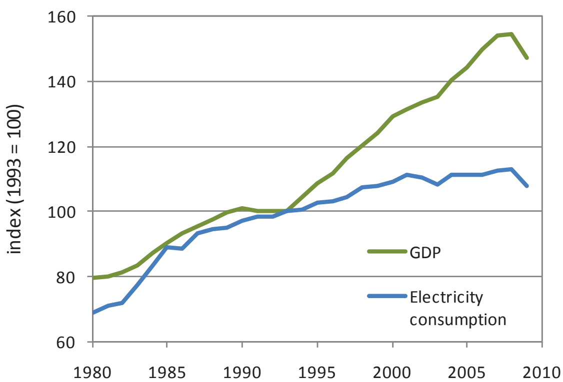


Figure 9.1: Total electricity demand and GDP in Demark, Finland, Norway and Sweden.

There are two sectors that are especially important in the Nordic electricity market for the total level of electricity demand: the electricity intensive industry and electricity heating including heat pumps. During the financial crisis that started in 2008 some electricity intensive industries made significant cuts in production. When it comes to the heating sector, new heat pump technology is not only making electric heating much more efficient but also more competitive. In some areas, electric heating is even taking market share from district heating. Whether this development increases or decreases demand for electricity remains to be seen.

Price sensitivity of demand in the industry depends on global climate policy

The price sensitivity of industrial electricity consumption in the Nordic region is proportional to the geographical scope of climate change policies. The more countries that implement climate change policies similar to those in the Nordic region, the less price sensitive Nordic electricity demand will be. Widespread adoption of stiff climate change policies will lead to overall higher worldwide product prices, lower competitive pressures on industrial firms in the Nordic region, and higher electricity demand from these companies. Conversely, if many developing countries refrain from implementing ambitious climate change policies, worldwide product prices will not rise as much, competitive pressure on firms in the Nordic region will increase, and electricity demand from these companies will fall. If only the EU implements climate change policies, the price sensitivity of electricity demand in the Nordic region can be expected to be quite high.

In the Global scenario we have assumed that OECD adopt ambitious climate change policies, which leads to higher prices for electricity and other forms of energy both inside and outside the EU. In this scenario industrial firms in the Nordic region have roughly the same conditions as competitors in the rest of the rich world, but they are still at a disadvantage compared to competitors from developing countries such as China. Here the leakage effect is reduced, but not eliminated. In the two scenarios, Reference and Policy, we assume that EU adopts a more ambitious climate policy than the rest of the world. The effect of this policy is that the electricity intensive industry in Europe loses more in the global competition.

The two curves shown in Figure 9.2 describing the relationship between the electricity price and demand for electricity from industry has been calculated from statistics from different industries, such as the aluminium and Ferro alloys industries. Yearly investment costs are included in the costs, implying an ability to pay for electricity in long run. From the curves we

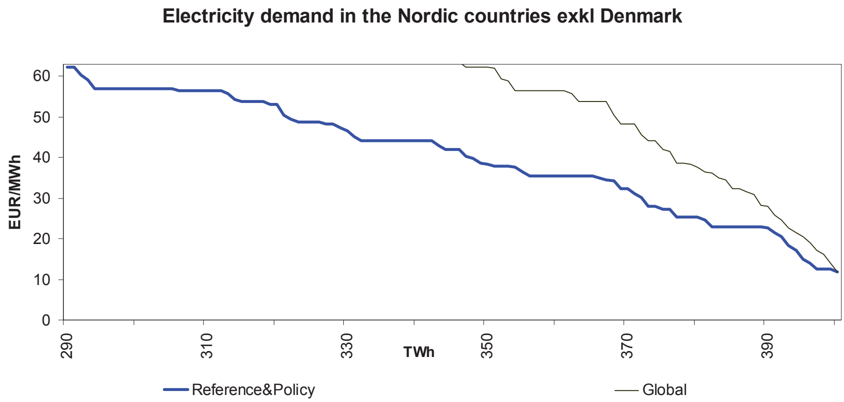


Figure 9.2: The price sensitivity of electricity demand in the Nordic region in the three NEP scenarios "Reference", Policy and "Global"

see that 25 % of the heavy industry or 100 TWh of electricity demand and electricity heating could be threatened if we get electricity prices in the range of 60 EUR/MWh. The ETS Directive does, however, offer an opportunity for national governments to compensate industries with a risk of "carbon leakage" – relocation resulting from an increase in costs due to carbon cost pass-through in electricity prices. Such compensation, if applied, could help strengthen the Nordic electricity intensive industry's competitiveness in world markets even if climate change policies in the EU are stricter than elsewhere.

Small changes in demand could have significant impact on the market

In Finland, Norway and Sweden electricity consumption decreased by 25 TWh, or 7%, from the top levels seen in July 2008 to November 2009, as rolling 12-month values. In the last quarter the rate of the reduction slowed down, but was still significant. Demand has decreased in the iron and steel, mines, Ferro alloys, aluminium, base chemistry and pulp & paper industries. The greatest reductions were seen in the iron and steel industry, in the mining industry, and in the pulp and paper industry in Finland.

We believe that the long-term effects of the crisis will be small, and that the situation will be normalized by 2020, even though IEA in their WEO 09 have slightly lowered projected energy demand by 2025 as a consequence of the crisis. The IEA believes that the situation will be fully normalized by 2030.

Even though the different models used in NEP calculate demand in different ways, they all predict slow demand growth at the market equilibrium price, see Figure 9.3. It is also interesting to note that even small variations in demand growth rates lead to significant changes in net exports, and therefore the need for grid investments. The horizontal line represents the present demand level.

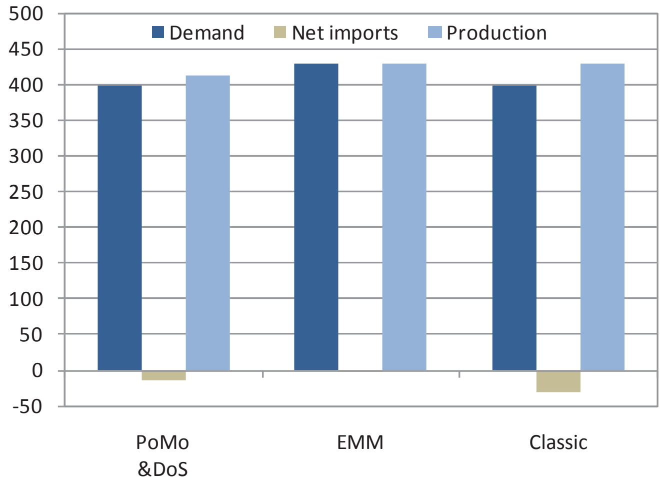


Figure 9.3: Different electricity demand forecasts in different NEP models, The model year is 2020

Energy efficiency policy may increase certain types of electricity use

More efficient energy use does not necessarily imply lower electricity demand for all types of use. The possibility of large amounts of plug-in hybrids by 2030 is one example. We have for example in the NEP-project assumed about 20 TWh of electricity demand, which replaces a much larger volume of petrol demand. Heating pumps is another example. This is also the outcome of the Global Times model runs presented in Chapter 20, even though these results are on a global scale.

For further information:
Peter Fritz and Per Erik Springfeldt, Sweco

Finding the balance between politics and markets

- a recurring theme in the Nordic Energy Perspectives project

The challenges related to coordination of policy incentives and targets, and at the same time providing sufficient room for the market to provide proper price signals, are formidable in the transformation of the energy system to a sustainable, low-carbon world. The balance between markets and politics has been a recurring theme in the Nordic Energy Perspectives project.

Climate policies profoundly changes the energy system

The climate policy focus promises to profoundly restructure the energy system. As we enter the second decade of the 21st century, energy investments are less driven by market signals than perhaps ever since the liberalization of energy markets started. The EU energy and climate policy package, particularly the implementation of the renewables directive, implies that energy investments are set to be determined by policy targets and measures, and not by market prices, in the foreseeable future.

The Nordic electricity market is increasingly policy-driven

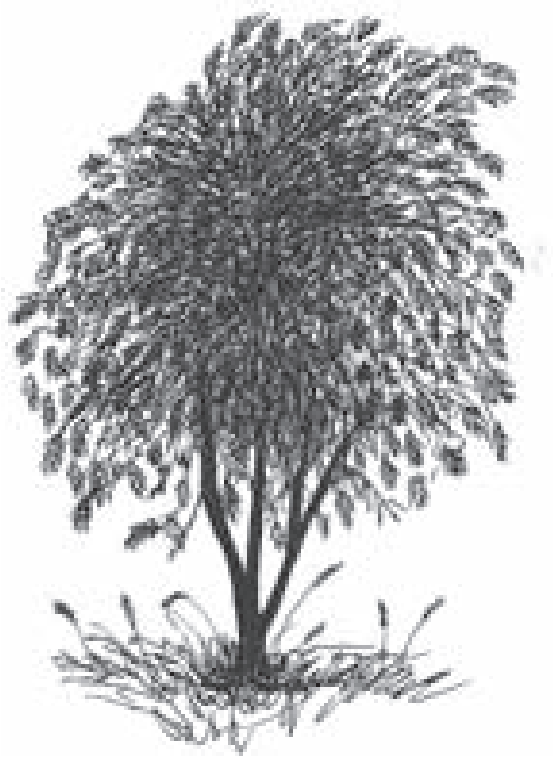
Although the policy measures implemented in the Nordic countries, procurement auctions for offshore wind as in Denmark, feed-in premiums as in Finland, investment subsidies as in Norway and green certificates as in Sweden, are linked to the development of power market prices, the overshadowing driver is the political renewables target. Against the background of weak demand growth, the prospect for the Nordic power market is a growing surplus situation with correspondingly declining market prices. The lower the prices, the higher are the needed auction price/investment subsidy/feed-in premium/green certificate price to realize the ambitious renewables targets. The market still plays a role, and aids policies by providing cost efficient solutions within the limits set by policy targets and measures. Nevertheless, the overall market development is policy driven.

New types of generation create new challenges for the grid, for existing generation and for consumers. More low cost, but intermittent generation capacity, incentivized by support schemes, creates new system challenges and requires new solutions. A pressing question is whether the market will be made able to deliver in a future system heavily influenced by a mosaic of regulations and policy targets. The strength of the market is to generate and utilize flexibility where it can be found. When policy intervention overrides market adjustments, the necessary flexibility may not be provided.

As markets may have failures in terms of failing to generate efficient solutions, so can policies. The (lack of) balance between different policy targets, e.g. emission abatement, renewable electricity vs. renewable heat or fuel, energy efficiency improvement in an energy surplus situation, are examples of such failures.

The deregulated Nordic electricity market has produced proper price signals

The Nordic electricity markets were deregulated and integrated during the 1990s. At the beginning of the first decade of the 21st century, the Nordic electricity market was commonly regarded as the most well-functioning international power market in the world.



The most prominent characteristic of a well-functioning market is to provide proper price signals. In the power market, market prices should yield proper incentives for demand flexibility and energy conservation, operation of generation capacity and investments in new generation capacity, grid investments, and substitution between electricity and other energy carriers.

During the last decade, market fundamentals have shifted. One implication is that the market is more frequently divided into several price areas, and in some areas there is talk of a looming power “crisis”. This development can be seen as a strength – given the cost of infrastructure investments and the variations in generation levels (hydro, but even nuclear) and generation structure (hydro vs thermal systems), and changes in demand (activity fluctuations in industry, cold winters) – prices should differ between market areas (at least from time to time) to provide proper price signals for investments in infrastructure and generation capacity. On the other hand, price differences can be seen as a sign that the market has not been able to generate the proper investments.

Successful deregulation requires adequate reregulation

To provide adequate price signals, most markets must be regulated to correct price formation for so-called market failure, i.e. external effects such as environmental damage from emissions, and natural monopoly, such as the electricity network and transmission lines. Moreover, regulations should ensure a market structure sufficiently decentralized to mitigate market power.

The electricity market is complex and all these concerns, and more, are relevant. Hence, successful deregulation of power market is to a large extent a question of successful reregulation of the markets. The regulations and market design of the power market has been constantly developed over the course of the last decade. At the same time the markets around us have developed, and the Nordic market has become increasingly linked to continental markets through investments in infrastructure and improved market coupling.

The market cannot always be blamed

Sometimes the market is blamed, when in fact it is regulations that should be blamed. When it comes to price differences and possible inadequate investments in infrastructure, these should primarily be blamed on regulations. A one-price policy for a larger area (country) with bottleneck problems will for example obscure price signals and expose the system to erroneous investment signals. In a future where we expect more distributed investments in new generation capacity, adequate locational price signals may prove to be crucial for the cost efficiency of accommodating the targeted volumes of renewable energy.

With a growing Nordic power surplus and increasing market coupling with neighboring market areas, there should be a significant basis for expansion of interconnector capacity. Investments in interconnector capacity are however not purely market based, nor should they be. Although parallel transmission lines may be profitable up to a point, publicly owned TSOs with the objective of maximizing social surplus are prone to make marginal investments that may render privately owned transmission lines unprofitable in the long run. Thus the market is not likely to provide such investments “on its own”. New interconnectors are large investments which take time and huge resources to realize. Such investments are moreover subject to regulations in more than one country. Hence, it would be optimistic to assume that interconnector investments can “keep up with” a rapidly changing market based on strong policy measures. On the other hand, infrastructure investments, including new interconnectors, should be taken with a view to the market implications, i.e. the price effects, of such investments. As we also pointed out in the NEP book ”Ten Perspectives on Nordic Energy”, a coordination between generation and grid development requires a “visible hand” in the market.

10. Millions of electric vehicles will have manageable impacts on the Nordic power system

Electric vehicles (EV) have been a hot topic in the past year. Several car manufacturers have announced their intentions of introducing plug-in and/or full electric vehicles to the market in the coming years. The Royal Academy of Engineering Sciences of Sweden visions 600,000 plug-in hybrids and electric vehicles by 2020 in Sweden. Scaled up to the Nordic level, this corresponds to 1.3 million plug-in hybrids and electric vehicles in the Nordic countries. This would help us in reaching our EU targets for renewables, including the 10 percent renewables share in transport fuels, the reduction of carbon dioxide emissions in the non-trading sector, and the energy efficiency target. Security of supply would also improve. All kinds of practical issues will, of course, have to be sorted out for this to happen. In NEP we have looked at the effect five million electric vehicles would have on annual electricity usage and on peak load. Five million vehicles amount to half of all personal vehicles in the Nordic countries. According to our estimates, the annual Nordic electricity consumption would grow less than 4 % while peak load would grow even less, just 1.5 %, assuming very basic smart charging of the vehicles.

NEP's analyses show that a large commitment to electric vehicles can make a significant contribution to the Nordic countries reaching the EU's climate and energy targets by 2020:

1. EVs can markedly reduce carbon dioxide emissions in the non-trading sector and can become a decisively important measure for fulfilling national obligations, which would otherwise be difficult to fulfil. Energy conversion is moved to the trading sector, where petrol and diesel consumption is exchanged for electricity production.
2. Renewable energy sources are well represented in the Nordic power system. Nordic EVs will therefore rely mainly on renewable electricity for power. Since the EU scales up renewable electricity for electric vehicles by a factor of 2.5, the contribution from electric vehicles becomes large.

3. Electric operation makes plug-in hybrids and electric vehicles very energy-efficient. An electric motor converts more than 90 percent of the electrical energy to mechanical energy. A petrol engine can convert only 20-30 percent of the petrol's energy content for propelling the vehicle.
4. Moving from fossil fuels to electricity in the transport sector increases security of supply in the Nordic countries both as a whole and as separate nations.

The large-scale introduction of EVs brings to light issues concerning the distribution of responsibility for reaching the EU targets between different sectors, in this case the energy conversion and transport sectors, and the possibilities of collaboration and synergies. The ambition in NEP has been to try and understand the big picture, to see what happens when we broaden the analysis from a sector responsibility view to a holistic approach.

Need for new electricity production due to electric vehicles

The electricity requirement for a million electric vehicles in the Nordic countries will depend on the distribution of different models of EVs being used and their consumption, but can be estimated at roughly 2.3 - 2.7 TWh per year. This corresponds to less than one percent of electricity consumption (year 2020) in the Nordic countries. NEP's analyses show that the Nordic electricity system can meet this greater need by reducing its export of electricity. The export of electricity is otherwise estimated to grow until 2020 hand in hand with an increased capacity for renewable power production resulting from the EU's Renewables Directive. Moreover, nuclear power capacity will also increase as a result of upgrades and the new Finnish fifth reactor, Olkiluoto 3. Thus, according to NEP, while the introduction of a million EVs in the Nordic countries does not require extra electricity production, electricity exports will not increase as strongly. However, the amount of electric vehicles can very well rise quite steeply from 2020 to 2030. 5-10 million electric vehicles will need roughly 12-27 TWh. At the

same time a lot of older capacity will be shut down, so the power balance would be much more strained without additional new capacity by 2030, renewables and otherwise.

Electric vehicles reduce CO_2 in the non-trading sector, but increase the price of EUA

A large investment in plug-in hybrids and electric vehicles would greatly reduce carbon dioxide emissions and help the Nordic countries meet national targets within the non-trading sector. If 1.3 million plug-in hybrids and electric vehicles are introduced in the Nordic countries by 2020 (of which 600,000 in Sweden and approximately 200,000 in each of the other countries), CO_2 emissions from private cars are reduced by approximately 20 percent. For the transport sector as a whole, carbon emissions decline by approximately 8-9 percent and for the non-trading sector (in CO_2 equivalents) as a whole, electric vehicles provide a decrease in emissions of around 4%. This corresponds to one quarter of the entire reduction commitment by 2020. CO_2 emissions are thus reduced in the transport sector. Moreover, the energy conversion is shifted to the trading sector as energy is needed for the electricity production instead of as petrol/diesel. Electricity production is covered by the EU Emission Trading System, and at a given emission ceiling of carbon dioxide for the trading sector the introduction of electric cars will result in higher carbon prices (EUAs). NEP calculations show that if electric cars are introduced in the entire EU at a similar market share as in the Nordic countries by 2020 carbon prices will increase by 5-10 euro/ton.

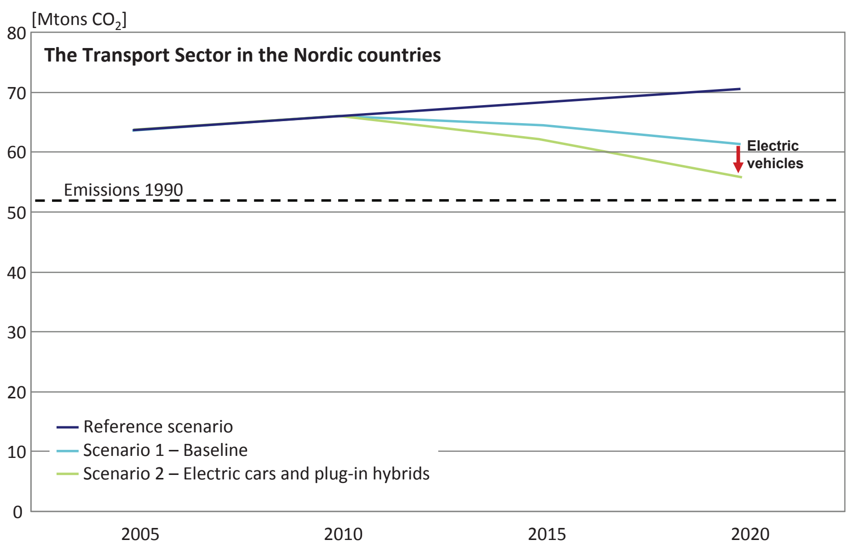
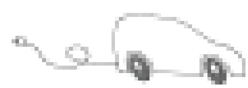


Figure 10.1: CO_2 emissions from the transport sector in the Nordic countries in two scenarios compared to 1990 emissions and emissions in the reference scenario. The emission reduction due to the introduction of 1.3 million plug-in hybrids and electric vehicles are highlighted.

Electric vehicles are an efficient way to achieve national renewable energy targets

In the EU's Directive on the promotion of the use of energy from renewable sources, which calculates the share of renewables according to the end use, electricity used in vehicles is part of the country's electricity mix and displaces fossil fuel use. By 2020, the Nordic countries will be able to count almost two thirds (about 65 percent according to NEP's analyses) of their electricity as coming from renewable energy sources and contributing towards fulfilling the Directive's targets. Furthermore, for the calculation of the electricity from renewable energy sources consumed by electric road vehicles, that consumption shall be considered to be 2.5 times the energy content of the input of electricity from renewable energy sources. This means that one kWh used in an electric vehicle is equivalent to 0.65*2.5 = 1.63 kWh renewable energy in the directive implementation calculations. Using electricity to power vehicles is therefore an efficient way of attaining national renewable targets.

If the introduction of electric cars also results in higher carbon prices, the profitability of wind power and biomass power in the Nordic countries could be further strengthened. Electricity production from coal and gas will become more expensive, especially in the rest of Europe. Since the Nordic countries have a great potential for renewable power production, the prospect of higher European electricity prices strengthens our motivation for increasing electricity production, and thus exports, from renewables. (NB: we have not analyzed within NEP whether the increase of electricity exports due to the rise of carbon prices would be larger or smaller than the decrease of electricity exports when electric cars are introduced in the Nordic countries.)



ENERGY EFFICIENCY GETS A BOOST

An electric motor converts more than 90 percent of electrical energy into mechanical energy. A petrol engine can convert only 20-30 percent of the petrol's energy content for propelling the vehicle. Electric vehicles are very energy efficient, even if we look at the chain from the grid to the road. Even if electric vehicles were powered by electricity only produced in coal condensing plants total efficiency would still be better than for petrol cars. The biggest gain would come from city traffic, which is very fuel guzzling, but suits electric vehicles just fine. The average energy used per unit transport (e.g. passenger-km) will decrease, helping to bring down the overall energy demand.

Security of supply is better off

Electricity for electric vehicles will be produced in the Nordic countries. NEP calculations show that less and less imported fossil fuel will be needed for electricity production. This has a huge impact on the security of supply of the Nordic countries as a whole and also as individual nations.

The electricity production mix is also more diverse, which makes it easier to adapt to changes in the operating environment. Domestic fuel resources like natural gas in Denmark, oil and gas in Norway and biomass and peat in Finland and Sweden need refineries, conversions etc. to become usable transportation fuels while they can be used more or less directly in existing power plants.

The Nordic power system would manage a massive introduction of EVs, but at a cost

The NEP study has assessed the impact on peak load of 5 million electric vehicles. One million vehicles were assumed to be battery powered electric vehicles (BEV) while 4 million were assumed to be plug-in hybrids (PHEV). According to our analysis peak load will rise with 6 percent.

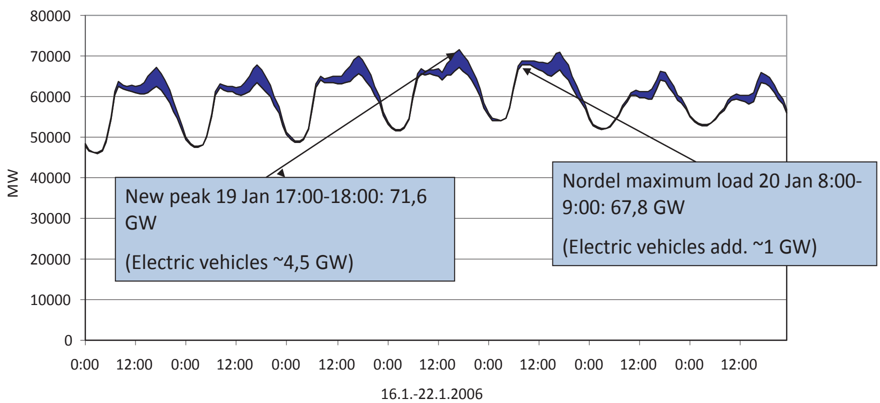


Figure 10.2: The effect of charging 5 million electric vehicles on the Nordic peak load, assuming uncontrolled charging. The Nordel peak load week from 2006 is used as basis. The peak load hour shifts from Friday morning to Thursday evening, and increases by 3 800 MW (6 percent)

The daily driving and charging of EVs was stochastically modelled 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 percent of the EVs had the possibility to charge at work, while two percent didn't ever charge at home. PHEVs differ from BEVs in that they have smaller batteries, enough for 20-100 km, after which the car's fuel-based motor is used. Smaller batteries mean shorter charging times. Cars were assumed to be charged without any controlling intelligence (smart charging), i.e. charging started as soon as the cars were plugged in. The changes in the peak load can be seen in the previous figure. The charging of the EVs will hopefully be affected by future policy recommendations otherwise the burden added to the peak load from unregulated charging would be somewhat heavy as new peak load capacity of 3800 MW is needed.

Smart charging of EVs will help make better use of the Nordic power system

Just a few simple rules or recommendations concerning smart charging would achieve a much nicer picture. For example, if 90 percent of all charging otherwise taking place between 16:00 and 23:00 local time is moved to the night hours (0:00 - 07:00), peak load increase is limited to 1 000 MW.

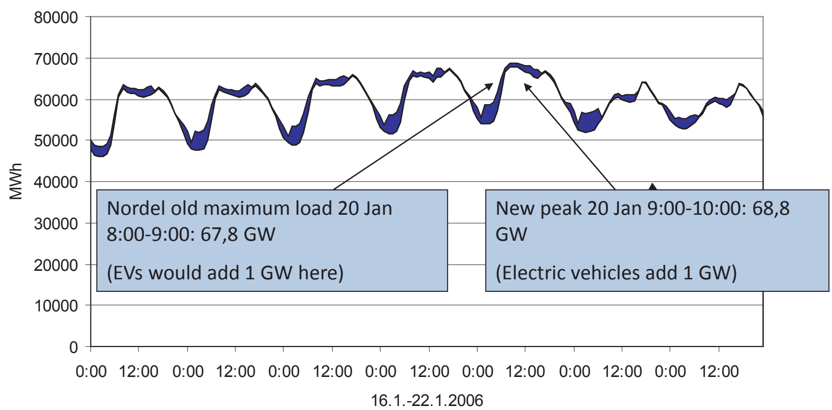


Figure 10.3: Smart charging. The peak load moves to the next hour compared to the case of no EVs, and increases by a measly 1 000 MW. The load also looks much nicer making a better use of the Nordic power production capacity

The gap between day-time and night-time consumption diminishes clearly.

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 can 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.

For further information:
Göran Koreneff, VTT and Bo Rydén, Profu

11. Huge opportunities for Nordic electricity export in a widened European electricity market

The EU Renewable Directive requires significant increases in renewable electricity generation in the Nordic countries. In terms of potentials and costs, the natural conditions for new renewable electricity generation are better in the Nordic countries than in many other North European countries. The expected increase in renewable generation in the Nordics is likely to lead to increased net exports to Continental Europe. According to model results around 30 TWh may be exported in 2020. This amount may grow even larger if a common European scheme for tradable green certificates (TGCs) is introduced, particularly if this is combined with increased interconnector capacity between the Nordic countries and Continental Europe. In a "high renewables-high interconnector" case, model results indicate that Nordic electricity export may approach 50 TWh per year around 2020. Such an expansion of renewable electricity will require massive investments in generation capacity and interconnections, and present a huge challenge to the electricity grid. On the other hand, potential benefits from electricity and certificate exports are substantial, and may contribute to an overall reduction in the cost of fulfilling the EU renewables target.

A common European TGC market and new interconnectors may significantly increase Nordic electricity exports

Results from the NEP models clearly demonstrate that ambitious targets for renewable energy profoundly affect market balances in the Nordics. Figures 11.1 and 11.2 show corresponding results from two different model approaches, the Econ Classic and the MARKAL-NORDIC model (see more on the NEP model toolbox in the NEP final report "Coordinated use of energy-system models in energy and climate-policy analysis"). Both models reveal the huge potentials for Nordic electricity export to Continental Europe. As can be seen in Figure 11.1 (results based on (European) Econ

Classic model runs and calculations in the Eureno model — a model for long term European renewable energy sources (RES) generation potentials and costs), 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 in all three RES 2020 scenarios analyzed here:
Base: RES generation is developed according to national policies and there is no certificate trade – the RES target is not fulfilled
No TGC Trade: The EU RES target is fulfilled without European certificate trade
TGC Trade: The EU RES target is fulfilled with full European certificate trade.

The results indicate that in a common TGC market, Nordic RES potentials and costs are competitive compared to potentials and costs in the rest of Europe, and hence the Nordics become net exporters of TGCs in a common market. Nordic net electricity exports to Continental Europe become significantly larger than today, around 35 TWh if unrestricted TGC trade is assumed. The common TGC price in the TGC Trade scenario is estimated by the model to around 65 EUR/MWh.

Calculations using the energy system model MARKAL-NORDIC, show similar results: The Nordic RES-E potential is highly competitive on a European level. Applying increasing TGC prices, the MARKAL-NORDIC model finds increasing electricity exports from the Nordic area, see figure 11.2. The figure shows the electricity balance between the Nordic countries as a whole and Germany/Poland for different TGC price levels in an assu-

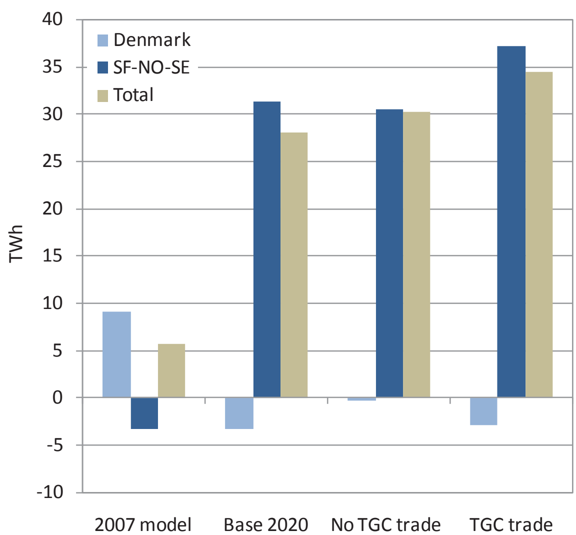


Figure 11.1: Results from the European Econ Classic model, showing net exports to Germany, Netherlands and Poland in 2020 for three different TGC-scenarios. Both existing and new interconnectors are utilized

med common European TGC market. Letting investments in new interconnector capacity being optional (i.e. investments are chosen endogenously by the model if they are profitable), the Nordic export may approach 50 TWh in 2020 given relatively high TGC prices*. The main explanation for the higher exports found by MARKAL-NORDIC compared to Econ Classic, is the assumed potentials and costs for RES-E generation and the export capacity from the Nordics. RES-E investments are based on the sum of the wholesale electricity price and the TGC price. With less export capacity, increased RES-E investments will yield lower wholesale electricity prices and, hence, less investments for a given European TGC price.

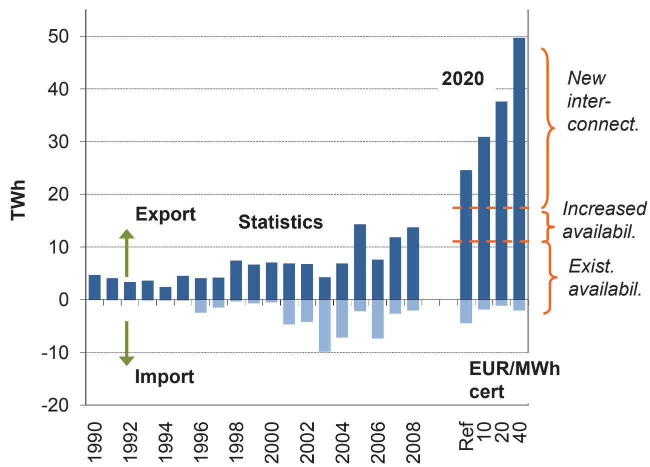


Figure 11.2: MARKAL-NORDIC model results showing total Nordic exports and imports to and from Germany and Poland for different TGC prices in an assumed common North European TGC market. Both existing and new interconnectors are utilized.

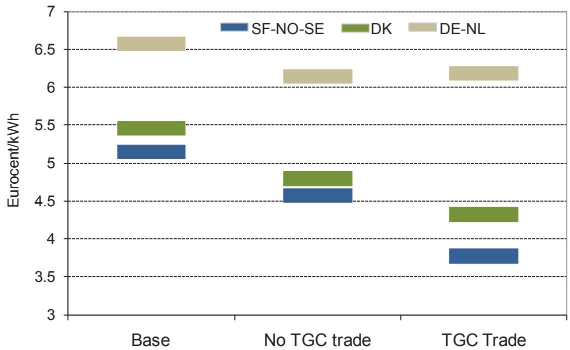
New interconnectors more profitable with TGC trade?

As the price differences and traded volumes increase, so does the income from trade. In the "TGC trade" scenario analyzed by the Econ Classic model the NorNed cable is fully utilized for exports from Norway to the Netherlands, i.e. prices are higher in the Netherlands than in Norway in all load blocks. The price differences indicate that an expansion of the transmission capacity may be profitable (see Figure 11.3a, next page). The results are however very sensitive to changes in the RES-E level, or more

*) The model does not consider an actual market price for TGCs but rather a marginal cost for generating TGCs (i.e. marginal cost for producing renewable electricity minus the wholesale electricity price). Therefore, the "TGC price" used in MARKAL-NORDIC should be considered as a "lower equivalence" to an actual market price which also includes other features such as market uncertainties etc. The TGC price used in MARKAL-NORDIC is also not fully comparable with the TGC price used in ECON-Classic since they are calculated somewhat differently

precisely to the power balances including demand responses and changes in conventional capacity, 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 varies significantly between seasons and years, and these aspects are not captured by the long-term scenario model used here (Econ Classic).

The impact on Nordic wholesale electricity prices of the assumptions on available interconnector capacity is shown in Figure 11.3b, based on the MARKAL-NORDIC model. Permitting the model to invest in new interconnector capacity between the Nordic countries and Continental Europe leads to higher wholesale electricity prices for any given price on the assumed European TGC market, than if only existing interconnector capacity is available. However, if the model is limited to using only existing interconnectors, this still leads to a significant net export from the Nordic countries, typically more than 20 TWh (see Figure 11.2). It is assumed that the availability on existing capacity can be increased somewhat compared to historical levels of utilization. Limitations in the availability of existing interconnector capacity may be due to maintenance, larger than anticipated safety margins for system stability, imperfect market coupling (e.g. explicit capacity auctioning), domestic grid limitations and interruptions. Such factors are not included in the model. Furthermore, reported NTC (Net Transfer Capacities) values for a given interconnector may change between years and seasons, which is why the observed NTC values over a certain period can differ significantly from the default values that have been used in the modelling. If such features were taken into account in the model simulations, net electricity exports from the Nordic area to Continental Europe would be even lower in the case with only existing interconnector capacity, and Nordic electricity prices correspondingly be lower (cf. the green line in Figure 11.3b).



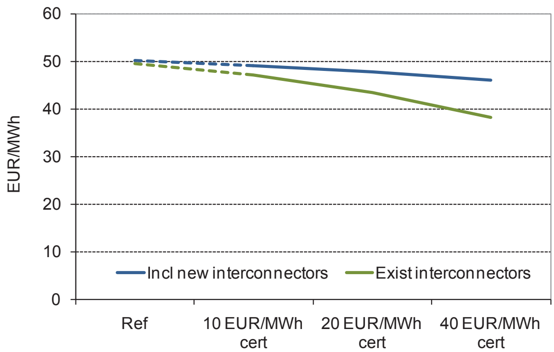


Figure 11.3a (above) and 11.3b (below): Two NEP models showing the decrease in Nordic wholesale electricity prices from increasing the incomes from renewable electricity production in the Nordic countries (Econ Classic model above and MARKAL-NORDIC model below).

Huge challenges for national grids

The reversal of trade patterns and the dramatic increase in net exports from the Nordic countries 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 on the supply side as the share of conventional power generation is reduced. The challenge for the electricity grid and for transmission system operators is amplified by the relatively large amounts of intermittent wind power that we can expect as a result of renewable policies, especially if trade in renewable certificates and increased interconnector capacity is made available, as shown by this analysis. Such a development will also affect existing thermal power plants with a likely increase in the number of annual starts and stops. Large volumes of wind power (and other intermittent production) will, therefore, also require a higher degree of flexibility on the demand side, e.g. from electric boilers, both at the end user side and in district heating, and electric vehicles and other means for temporarily storing electricity.

Increased investments in renewable electricity generation crowd out fossil-fuelled electricity generation

As the share of renewable electricity generation increases, the generation levels in conventional thermal power plants are reduced. The generation in existing coal and gas plants is reduced and investments in new conventional capacity are postponed. The Econ Classic results indicate that no new investments in conventional capacity are profitable before 2020 in the TGC trade scenario. Figure 11.4 (based on MARKAL-NORDIC model runs) show that with increasing TGC price on an assumed common European TGC market, renewable electricity generation in the Nordic countries increases. This involves both biomass and wind power (hydro power expansions are considered equally cost-efficient for all investigated TGC prices). At the same time the output from both gas and coal power generation is gradually reduced.

As fossil-fuelled generation is crowded out, CO_2 emissions are of course reduced. This is further discussed in Chapter 8.

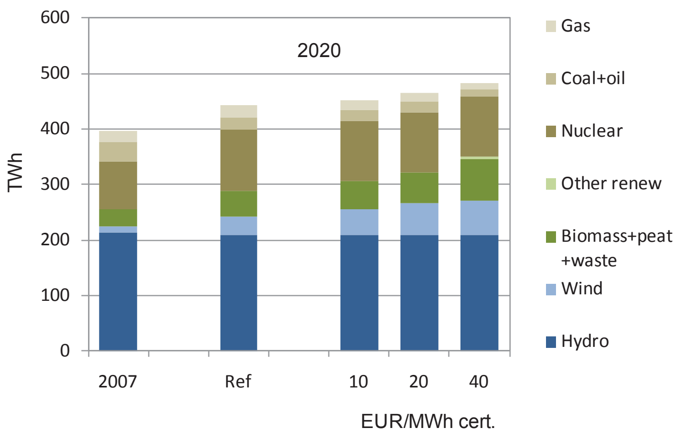


Figure 11.4: Nordic electricity generation today and in 2020 in a reference case (”Ref”; including only existing policy instruments) and a case with a common European TGC scheme with three different TGC prices

Differences between the Nordic countries and Continental Europe are likely to remain in a foreseeable future

The driving force for increased cross-border electricity trade between the Nordic countries and Continental Europe is, of course, differences in price structure due to differences in electricity supply and demand patterns. Although price differences prevail in a future with increased trade, trade is likely to impact Nordic prices as well. One such indicator for regional differences in electricity-price structure is found in Figures 11.5 and 11.6. Here the Econ BID model has been used to calculate wholesale electricity prices

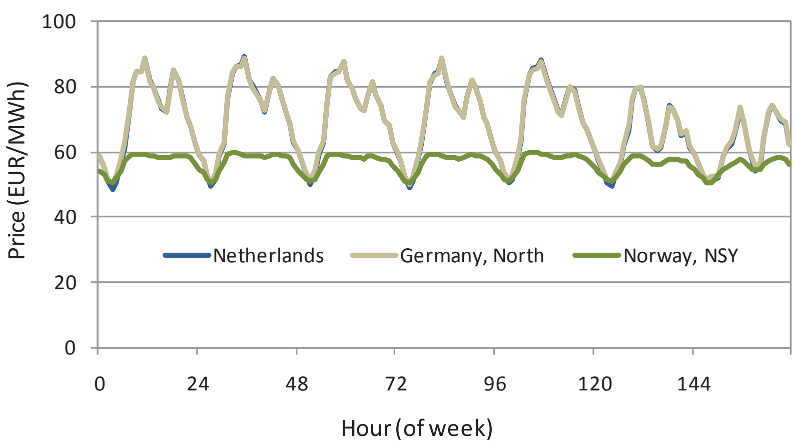


Figure 11.5: Average weekly price structure for South Norway, North Germany and Netherlands, European Policy scenario 2030.

by 2030 for different North European regions in the NEP main scenario "European policy" with a high level of renewable generation in the Nordic area (for a detailed description of the main scenarios see the introduction of this book and NEP final report "Coordinated use of energy-system models in energy and climate-policy analysis"). Nordic electricity prices are generally much flatter (and lower) than prices on the Continent, at least for some Nordic regions (Figure 11.5). For other Nordic regions situated geographically closer to Continental Europe, e.g. Southern Sweden, electricity-price patterns resemble much more of the ones on the Continent (Figure 11.6).

Although known expansions of the Nordic grid are taken into account, today's internal grid capacities are assumed. In the BID model Norway is divided into seven market areas and Sweden into four. Hence, the results indicate that the expansion of renewables in the Nordic countries increases internal bottlenecks. On the other hand, the results can be interpreted to show that a future increased integration with Continental Europe is also likely to affect domestic Nordic grid investment, or that the location of renewables investments may be crucial for the general profitability of such investments in the Nordic area.

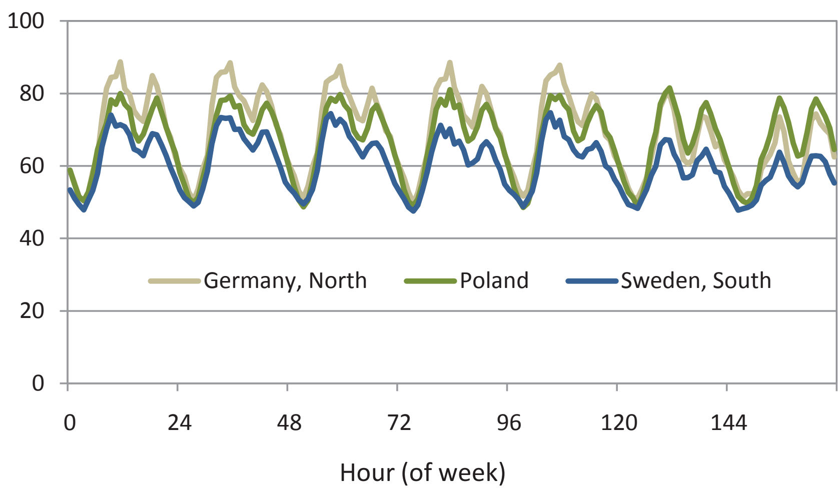


Figure 11.6: Average weekly price structure for South Sweden, North Germany and Poland, European Policy scenario 2030.

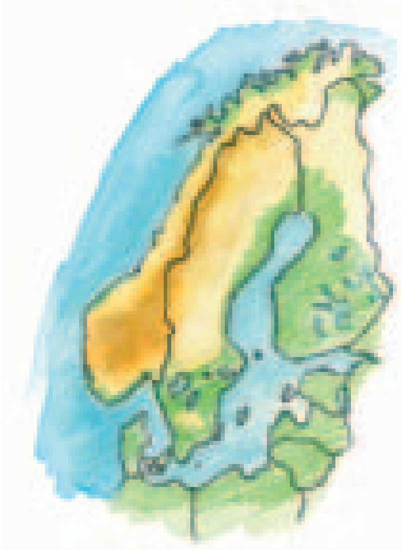
For further information:
Thomas Unger, Profu and Berit Tennbakk, Econ Pöyry

Important issues to consider in a further integration of the electricity markets in Northern Europe

The NEP project has in various aspects analyzed effects of, and preconditions for, a widening of the North European electricity market. Such a widening includes both increased electricity trade through new interconnectors and a joint effort to meet the renewable targets defined by the EU through e.g. green certificate trading.

Using renewable energy in the Nordic countries in a European context

It is likely that conditions for investing in new renewable electricity are superior in the Nordic counties due to abundant natural resources (the potentials for renewable energy in the Nordic countries are further discussed in Chapter 5). Therefore, a further integration and increased electricity trade with Continental Europe could increase the exploitation of these resources and provide substantial benefits from electricity (and green certificate) exports, and at the same time reducing the overall cost of fulfilling the EU renewable target. Thus, the exploitation of renewable resources in the Nordic countries is valuable also for other European countries where renewable resources are less abundant. Some of this has been taken into consideration in the burden-sharing of the renewable goal within the EU but there are reasons to believe that the Nordic region, in a European context, may supply a larger amount of renewables than is domestically required in the burden-sharing agreement. Hence, further integration of electricity provides for important opportunities in the Nordic region. However, such an integration of the North European electricity markets also presents a couple of challenges that must be considered.



Intermittency and public acceptance – two decisive issues

Integrating an increased share of intermittent electricity production is a challenge in itself. The Nordic countries are blessed with large amounts of hydro power which may be used for regulating purposes. Nevertheless, a significant expansion of wind power will have impact on the operation of thermal-based electricity generation, e.g. increasing the number of starts and stops.

Renewable electricity production is frequently associated with public resistance when it comes to choosing appropriate sites. This is especially relevant for wind power and hydro power. The question is: will citizens of the Nordic countries quietly accept a massive expansion of renewable electricity from which a large part may be assigned for export?

Significant investments in cross-border and domestic transmission grids

Model analyses of the NEP project have shown that meeting the EU energy and climate package in a cost-efficient way is likely to involve new interconnector capacity between the countries in Northern Europe. This would be further amplified if a common trade regime for e.g. green certificates were to be launched. Massive investments in renewable electricity generation and large investments in new interconnectors will change electricity flows within the Nordic region. More frequent and new internal bottleneck situations may be the result, and the electricity market may more frequently become divided into several price areas. Regions close to the interconnectors may experience prices more equal to the prices on the other side of the interconnector (border). This also indicates that significant investments in both cross-border and domestic transmission grids are likely to be needed (more on this is discussed in Chapter 11).

Increased exposure of differences in national policy measures

Further market integration is likely to further expose differences in national policy measures. For instance, investing in renewable electricity is not only a question of where natural conditions are favourable but also where national support schemes generate the highest incomes or profits. From an electricity-system operational point of view, there might even exist a third consideration: to balance the location of wind power over a larger region with respect to wind availability, thereby reducing the risk of having high or low wind situations simultaneously.

Market considerations

What happens with electricity demand in Northern Europe? The energy-efficiency target of the EU may actually lead into two, equally possible, but opposite directions. More efficient energy use may result in increased electricity use, e.g. in transportation (this is, among others, discussed in Chapter 2). However, a future decrease in electricity demand is also a possible outcome of a general increase in energy efficiency in e.g. industries (prospects for electricity demand are elaborated on in Chapter 9). If demand is reduced significantly during the coming years, Northern Europe may face a significant “oversupply” of generation capacity partly initiated by the renewable targets of the EU. Such a situation would imply relatively low wholesale electricity prices in the Nordic market if the export possibilities were limited due to bottlenecks in interconnector capacity.

Electricity-price volatility is likely to rise as the share of intermittent production is increased. However, a geographical widening of the electricity market may reduce the significance of such volatility.

Increasing electricity trade and creating an integrated North European market for renewable support, through e.g. green certificate trading, is likely to change the electricity balances significantly in some of the countries participating in such a market. Thus, depending on the country consumers and producers may face higher or lower electricity prices. Therefore, generators of the Nordic countries may increase their profits while consumers of the Nordic countries may face increased costs. Increasing interconnector capacities is likely to imply increasing wholesale electricity prices for the Nordic countries while a common European market for renewable electricity support is likely to imply also higher support costs, paid e.g. by the consumers, for the Nordic countries (this is further discussed in Chapter 12)

The role of non-renewable electricity generation

The significant electricity-export opportunities of the Nordic countries pointed out by the NEP project is not only enabled through an expansion in renewable electricity generation, but is also largely dependent on maintaining the existing non-renewable thermal electricity generation. In the case of nuclear power, the capacity is likely to increase during the coming decade due to the fifth nuclear power station in Finland and due to repowering of several nuclear power stations in Sweden. A more rapid phasing out any of the non-renewable electricity capacity due to economic or political reasons will, of course, reduce the electricity-export potentials of the Nordic countries that have been identified by the NEP project.

In Chapter 8 it is argued that increased interconnector capacity may imply somewhat higher CO_2 emission from Nordic electricity production than otherwise. This is due to the fact that fossil-based thermal electricity generation in the Nordic countries generally have higher efficiencies than their counterparts in Continental Europe. Thus, increasing the export capabilities of the Nordic countries may imply crowding-out of fossil-based electricity generation in Continental Europe rather than in the Nordic countries. In a European perspective this is, due to the EU ETS, equivalent in terms of reducing CO_2 emissions. But will this be in accordance with political ambitions in the Nordic countries?

12. Scenarios for the Baltic Sea Region

The countries in the Nordic and Baltic regions are diverse with respect to recent history and economic developments, as well as to energy supply technologies and energy resources. Thus, the energy intensity in the new democracies have over the past 20 years been cut to almost half, yet still being twice as large as in the old democracies, leaving room for energy savings.

The countries are united through physical infrastructure (electricity transmission lines) as well as trends toward developing a common electricity marked. Moreover, national environmental goals blend with EU targets and regulations, leaving room for co-operation options in their achievement.

The Nordic and Baltic regions together contain large renewable energy sources, including substantial amounts of unexploited hydro, wind and biomass, and hence ambitious targets for reducing CO_2 and increasing the share of renewable energy can be met with local resources. Shifting from national targets to a common regional target in relation to renewable energy will permit overall savings in achieving the target. Similarly, energy saving will have large impacts on such costs. However, the consequences and benefits will be unevenly distributed between countries and between actors in the markets.

The EU Policy scenario as an achieving future

Three scenarios for possible developments are presented in this analysis. Two of the scenarios are different versions of the NEP main scenario "EU Policy". The third scenario broadly corresponds to the NEP main scenario "Extended EU Policy" (more on the main-scenario definitions is reported in the introduction of this book). The first version of the "EU Policy" scenario analyzed here, the baseline scenario, is taken as a simulation showing a way forward to actually achieving the EU targets of reducing CO_2 emissions by 20 % in 2020 and increasing the share of renewable energy to 20 %. Moreover, a target of a 50 % reduction of CO_2 compared to 1990 is applied for 2030 (corresponding to a reduction of CO_2 emissions by 38 % compared to 2005). The means to achieve the policy targets in this scenario are to a large extent determined by the modeling tool based on a least cost analyses of supply side measures. Hence, CO_2 and renewable energy targets are formulated as constraints, while the associated prices/costs/subsidies are derived as the marginal costs of achieving these targets. Consequently, the CO_2 price is common to the region while in the Baseline scenario there are differing national renewable energy prices.

A further consequence is that the simulated electricity price internalizes the marginal CO_2 cost (driving the price upwards). Likewise the marginal cost (in form of subsidies) for renewable energy is reflected in the electricity price (driving it downwards).

Figure 12.1 shows the development of the simulated annual electricity prices from 2015 to 2030 for each country. The decline in prices between 2015 and 2020 is explained by the simultaneous mandatory introduction of renewable energy. Hence, to the consumer electricity prices as shown in the figure should be added the proportional costs of renewable energy subsidies (assuming that the expansion of the renewable energy is financed by the electricity consumers).

In these model runs, the CO_2-reduction target has been applied as a cap which implies that the CO_2-allowance price becomes a model result. In other model runs of the NEP project, the EU Policy scenario has exogenously assumed a CO_2-allowance price rather than a CO_2 cap. Therefore, CO_2 costs are not identical even though they are of similar. Also other differences are present, the origin of them are that the present analyses are derived from a parallel work, Sustainable Energy Scenarios, http://ea-energianalyse.dk/reports/Sustainable_Energy_Scenarios.pdf.

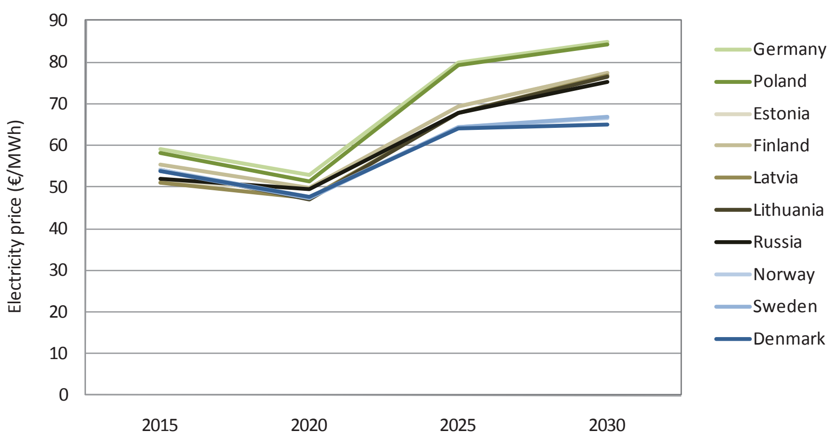


Figure 12.1: Wholesale electricity prices in the countries of the Baltic Sea region in the “baseline” scenario (Balmorel model runs).

The renewable energy prices differ between the countries. In 2020, Finland, Lithuania, Latvia and Germany have the highest marginal costs (approx. 30 €/MWh) of expanding renewable energy electricity generation, while Denmark, Estonia, Norway and Sweden have the lowest (approx. 10-20 €/MWh), with Poland in between. The difference in compliance costs reflects the costs of new renewable energy generation in each of the countries compared to the value of new renewable energy electricity in the electricity markets

Between 2020 and 2030 another goal becomes dominant: electricity market prices increase as the CO_2 target becomes an increasing constraint causing the CO_2 price to increase significantly.

Thus, the simulated marginal cost of abating CO_2 is approx. 7 € per ton in 2020 and approx. 50 € per ton in 2030. This is in turn reflected in the electricity price. On the other hand, in 2030 the renewable target is hardly binding, implying vanishing or low associated renewable energy prices.

Generation technology and energy sources

The region has a number of old power plants with low efficiency. In the short run, the model chooses to replace these old power plants with new coal-fired power plants or combined heat and power plants with high efficiency. This strategy could be reasonable to meet the CO_2 targets in the short run, but it may not be the most viable in the long run with more strict CO_2 targets.

Figure 12.2 (see next page) shows the electricity generation, grouped by fuel. The utilization of natural gas decreases initially as a result of the investments in wind power and new efficient coal power plants. The role of wind power is gradually increased over the period and by 2030 wind power is the largest source of electricity next to coal power and hydro power. Biomass and biogas only gain significance by the end of the period.

As shown, coal gains impetus initially (mainly in Germany), however, new biomass-fired power plants, biogas plants and coal fired power plants with CCS are close to being competitive with new conventional coal-fired power plants, but CCS only in Germany and Poland. Thus, these technologies could be part of the region's focus on new energy technologies with a strong global potential.

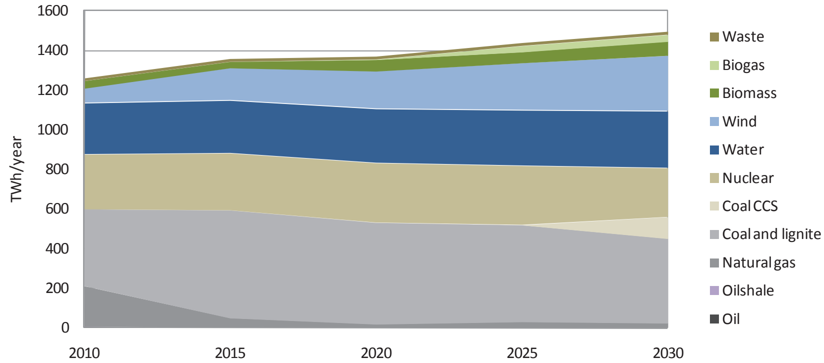


Figure 12.2: Total electricity generation of the Baltic Sea region in the "baseline" scenario (Balmorel model runs)

Sweden and Norway are net exporters of electricity in the beginning of the period and remain so until 2030, whereas Estonia, Finland and Germany are net-importers during the course of the period. Poland starts out as net exporter but eventually become importer. Latvia, Lithuania and Russia follow more mixed patterns.

In the end of the period a significant export of electricity, approximately 65 TWh, takes place from Denmark, Norway and Sweden toward the thermal based systems in Germany, Poland (where coal is still dominant) and Finland. In the Baseline scenario the national renewable energy targets imply national – and hence differing – prices and costs related to achieving the targets. Alternatively, the targets might be formulated as a common regional target, presumably with total lower costs in achieving the targets; this is analyzed in the second version of the "EU Policy" scenario, here defined as the Regional renewable energy targets scenario.

In this scenario the marginal cost of reducing CO_2 is 14 €/ton in 2020 compared to 7 €/ton in the Baseline scenario. The reason for this is that the renewable energy targets are met with less effort in the Regional renewable energy target scenario; hence the CO_2 target is a more binding constraint than in the Baseline scenario.

Regional co-operation on renewable energy: the renewable energy target scenario

As a result the electricity market prices are also slightly higher in 2020 in some countries than in the Baseline scenario (see Figure 12.3); this is particularly the case in German and Poland where the cost of CO_2 has a high impact on the short run marginal generation costs due to the high shares of coal power in the generation mix.

As in the previous section, to the consumer electricity prices should be added the costs of renewable energy subsidies assuming that the expansion with renewable energy is financed by the electricity consumers. The added cost to the consumer electricity price is the product of the price of a renewable energy certificate (now 19 €/MWh) and the share of renewable energy.

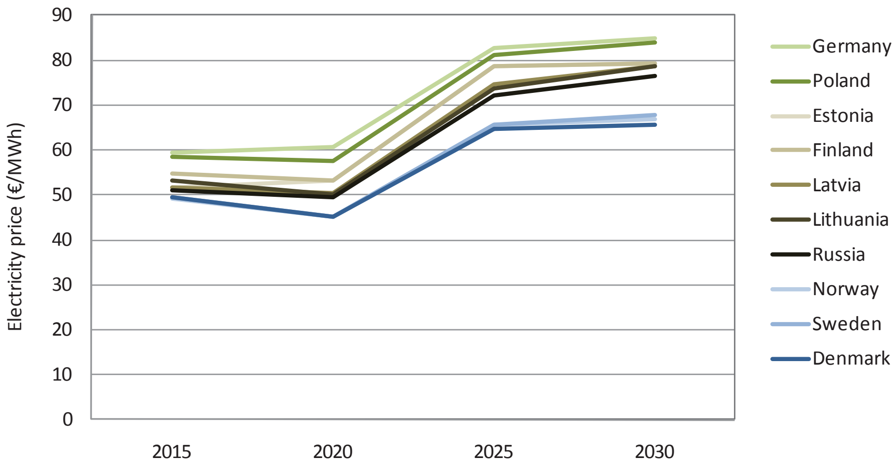


Figure 12.3: Wholesale electricity prices in the countries of the Baltic Sea region in the "renewable energy target" scenario (Balmorel model runs)

The economic consequences of the Regional renewable energy target scenario may be illustrated to comparing the socio-economic consequences between the Baseline and the present scenario. Moreover, the economic consequences are here distinguished as follows:

- Generators: Revenues from electricity and heat sales, minus fuel costs, CO_2, operations and maintenance, and capital costs related to new investments.
- Consumers: Expenses for electricity and heat.
- TSOs (transmission system operators):Income from bottlenecks on interconnectors.
- Public profit: Expenses for support of renewable energy.

The sum of these figures is taken as the total socio-economic benefit. It is here assumed that the public (the state) supports the development of renewable energy, while in many countries this commitment lies with the electricity consumers. Note that the figures shown in the table are calculated as differences between two scenario results, and thus for instance a negative generator profit does not imply that generators do not earn money, but only that they earn less money in the present scenario than in the Baseline scenario.

The simulations show that the benefit of this relocation of investments is approximately 5 billion € in net present value (2009, assuming a 6% discount rate), a figure which should be interpreted with caution due to significant uncertainty associated with specific estimates of renewable energy potentials and costs.

As always, there are winners and losers. From the table is seen that Germany is the greatest beneficiary from the Regional renewable energy target. The main benefit here stems from improved public profit due to lower subsidies for renewable energy.

Table 12.1: Calculated economic consequences of the regional renewable energy target *compared* to the baseline scenario

Mill. €, NPV	The Nordic countires	Estonia	Germany	Latvia	Lithuania	Poland	Russia	Total
Generator profits:	9082	219	12.609	-159	421	1.907	1.805	25.883
TSO profit:	1874	47	-331	29	1	91	337	2.048
Consumer surplus:	3755	-374	-14.659	-320	-298	-3.062	-1.417	-16.365
Public profit:	-18245	-134	15.531	854	98	-665	-3.641	-6.202
Socio economic benefit:	-3534	-232	13.150	404	222	-1.729	-2.916	5.364

In this scenario the international electricity exchanges are largely the same as in the previous scenario. The changes in socio-economic benefits therefore are mainly due to changes in electricity prices. The main changes are here observed for the years 2015 and 2020, and due to the discounting these first years dominate the overall picture. In a country where electricity prices are lower in the present scenario compared to the first one generator profits are, accordingly reduced. Meanwhile, consumer surplus in that country is increased for the same reason. The changes in TSO profits relate mainly to the changes in electricity-price differences between the countiries on each side of a specific interconnector.

Improved energy efficiency: potential gains for all countries

Some main consequences of a target of improved energy efficiency are next analyzed, assuming bluntly that the electricity consumption is reduced by 20 % relative to the baseline scenario. As mentioned before, this corresponds broadly to the NEP main scenario "Extended EU Policy". Whether such reduction is the result of energy policy action or e.g. reduced economic growth is left unspecified.

The lower demand for electricity, in combination with the targets for increasing the share of renewable energy, results in an overachievement of the CO_2 targets in the period 2015 - 2025. Only by 2030 the target on CO_2 becomes binding. At that time the marginal cost of reducing CO_2 emissions is 38 € per ton in the scenario compared to 52 € per ton in the Baseline scenario. This reflects that cheaper abatement measures are put into play at the supply side in this scenario. By combining demand and supply side measures it will be possible to achieve stronger CO_2 targets.

Denmark, Estonia and Norway overcomply with respect to the RE target, and hence there are no costs of renewable energy. For the remaining countries the costs of compliance are between 20 and 40 €/MWh. Denmark and Norway increase their net electricity export relative to the Baseline scenario, while Swedish net export decreases with approximately the same amount.

The general trends observed in the redistribution resulting from the electricity market are that consumers are the winners and producers are the losers, and the amounts redistributed this way are substantially larger than the values obtained between this scenario and the Baseline scenario. This is in contrast to the Regional renewable energy target scenario, where the generator side was shown to be the winner. Moreover, benefits resulting from the electricity market are seen in all countries.

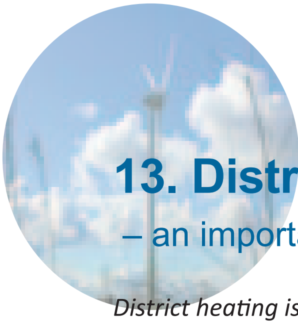
However, the net social welfare change in this scenario, relative to the Baseline scenario, cannot be assessed without knowing the costs of implementing the consumption reduction (and such assessment was not attempted here), nor can be distribution on the different actors without specifying the implementation costs and their distribution on the actors.

Ambitious targets, but with differentiated means and consequences

The Nordic and Baltic regions together contain large renewable energy sources, including substantial amounts of unexploited hydro, wind and biomass, and hence ambitious targets for reducing CO_2 and increasing the share of renewable energy can be met with local resources.

The consequences of approaching such targets will depend heavily on the relative weights on the different environmental goals, as well as on the details of their implementation. In particular, the goals with respect to CO_2 and renewable energy have adverse effects on the electricity price. Also the distribution of winners and losers among the countries and the actors within countries is heavily subject to policy goal and policy implementation.

For further information:
Hans Ravn, RAM-løse edb



13. District heating in the Nordic region

– an important part of a sustainable energy system

District heating is a valuable part of the Nordic energy system, with a total supply of 130 TWh/year. In the coming years, the district heating business will face challenges due to increased competition from other energy efficient technologies like heat pumps, combined with potentially increasing fuel costs. On the other hand, storing thermal energy is more feasible than storing electricity, thus district heating may provide valuable flexibility to the electricity system.

Diversified fuel mix also in future district heating systems

The choice of energy resources depends on local availability and energy infrastructure. Hence, the differences shown in Figure 13.1 are expected. Biomass and/or municipal waste are major renewable energy resources in all Nordic countries. According to our model results, the future fuel mix depends heavily on future energy policy. A primary focus on energy efficiency gives a high penetration of heat pumps, while a focus on renewable energy increases the utilization of biomass at the expense of fossil fuels and peat, as shown in our model results. However, irrespective of policy, the diversification of the fuel mix is also ensured in the long term.

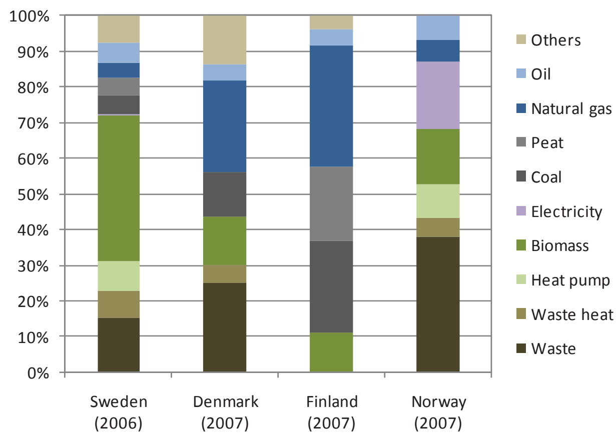
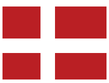


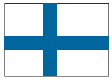
Figure 13.1: Energy carriers in district heat production

District heating policies in the Nordic countries

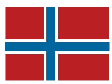
Sweden: A new district heating law came into force in 2008. The law aims at strengthening the district heating customer's situation, e.g., through increasing the transparency of the district heating business. There have been discussions about general third party access (TPA) to the district heating system. The idea was, however, rejected by a governmental investigation in 2005. During 2010 TPA will be studied in depth by a special investigator assigned by the Swedish government.



Denmark: Danish energy policy has a strong focus on energy efficiency and increased utilization of renewable energy resources. Through energy planning, the municipalities have assigned some areas to district heating and others to natural gas distribution. The municipalities may choose to make access to collective energy distribution systems (natural gas or district heating) mandatory. A major challenge now arising for the municipalities is drawing the line between district heating areas and areas for local heat production like heat pumps. Because of the strong focus on CO_2 emissions, natural gas areas may now be converted to district heating, thus further increasing district heating's market share.



Finland: District heating has a very stable pricing policy in Finland. Since 1999, the price of most fuels has risen more steeply than the price of district heating. Some reasons for this are the diversified use of fuels, the increased use of peat and waste wood and the widespread use of coal, although the price of coal has risen steeply since the summer of 2007. However, the main reason for the success of district heating in Finland is that 75 % of all heat is produced in combined heat and power (CHP) plants having high total efficiencies.



Norway: District heating is growing extensively in Norway, but from a small base. The official target of at least 4 TWh of new renewable heat before the end of 2010 has been met, and several market participants compete to establish new district heating systems. A concession for district heating is mandatory for plants with more than 10 MW maximum heat loads. Municipalities may decide on mandatory connection of new buildings to the district heating system, provided that there is a concession for the district heating system. According to the Energy Law, the price of district heating may not be above the cost of electric heating. The Ministry of Petroleum and Energy is now deliberating on the future regulation of the district heating business in Norway.

Energy efficiency and heat pumps reducing customer heat demand

Business development tends to follow an S-shaped curve. In a district heating context, the volume of energy sold is related to the penetration rate. When (if) a level where all customers have district heating is reached, the volume is bound to be at the same level or decline due to both energy efficiency and substitution to local solutions (e.g. heat pumps). On the other hand, as long as the building stock increases, new potential customers enter the market.

The European Union (EU) has ambitious targets for energy efficiency improvements by 2020, and this will probably affect the demand for heat. As building codes get stricter, with consumption level targets reaching those of low energy houses or even passive energy houses, the overall heat demand in new houses and areas will be significantly lower. Customers are hardly likely to choose a heating solution that has a high fixed yearly cost and a lower energy cost when they need less energy. If the fixed prices are low and the energy price higher, some of the customers will probably want to install a heat pump as a complementary technology to district heating, and use the heat pump as base load and district heat as peak load. This is not a good situation for the district heating companies, as they would have to keep the installed capacity high while selling less heat. This indicates the importance of balancing the district heating price models in relation to climate policies.

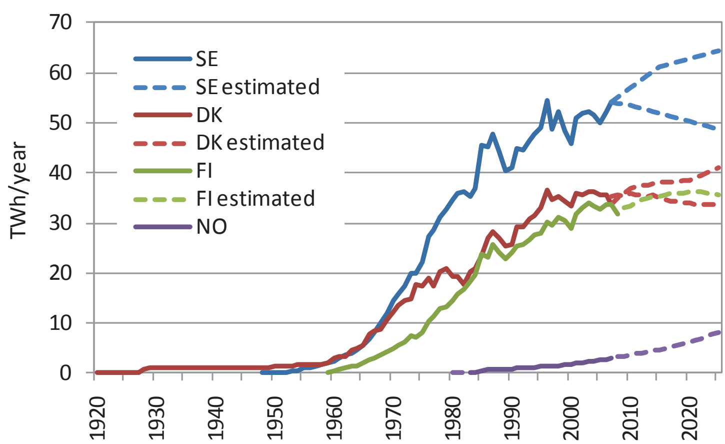


Figure 13.2: Actual development of district heating in the Nordic Countries, and future scenarios

Policy affects primarily the fuel mix, to a lesser degree volume

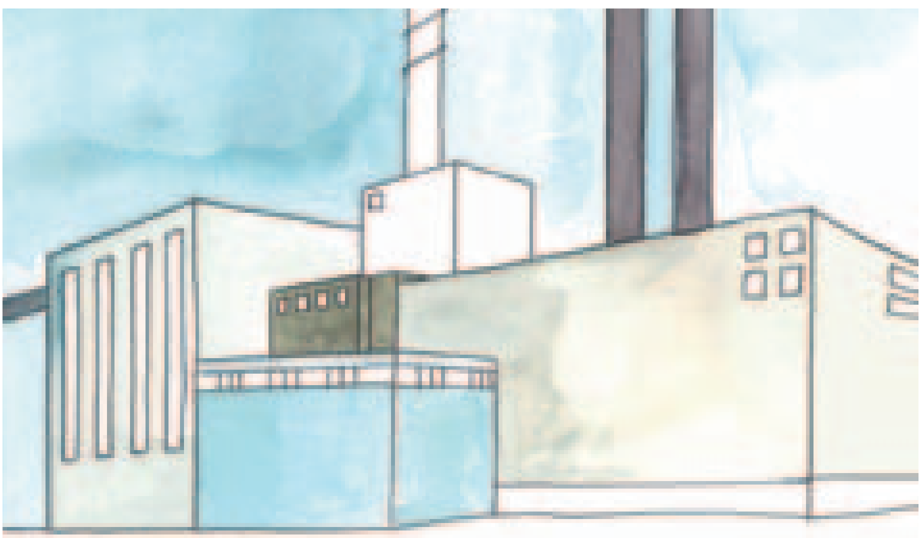
The EU 20/20/20 goals have a profound impact on the development of the use and production of district heating in the Nordic countries. This has been analysed within the NEP project through model calculations for each of the four countries. Three scenarios have been calculated:

1. Today's policy instruments – the reference case
2. Adding the EU's target for increased use of renewable energy
3. Adding the EU's target for improved energy efficiency as well

The district heating results have been derived from the more comprehensive scenario calculations presented in Chapter 4 — "The EU's renewable target alone will reduce the Nordic emissions of CO_2 by 20 %".

Present policy instruments used in the Nordic countries, including a price of CO_2 emission allowances of 25 €/t, lead to a development of district heating production according to Figure 13.3. The total use of district heating increases marginally. The use of coal decreases, while waste incineration and the use of natural gas increases. Biofuels maintain a dominating role in the district heating production for another 25 years. The use of peat increases in Finland.

In the EU renewable energy directive, there are quantified goals for the share of renewable energy in each country. A condition that imposes this total amount of renewable energy on the common Nordic energy system has been inserted in the model. This influences the development of the Nordic



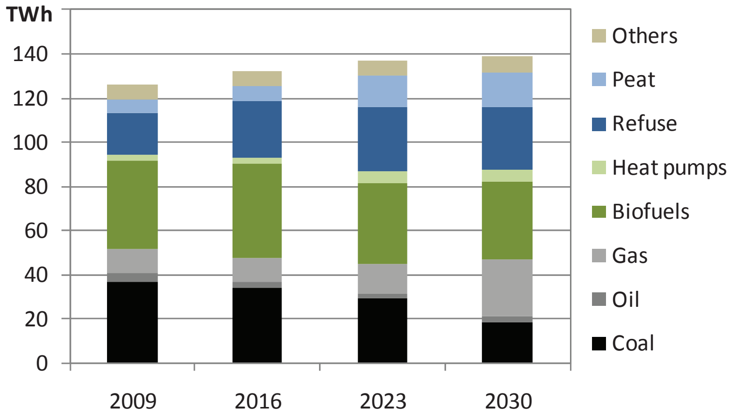


Figure 13.3: Nordic district heating production with no new goals from the EU

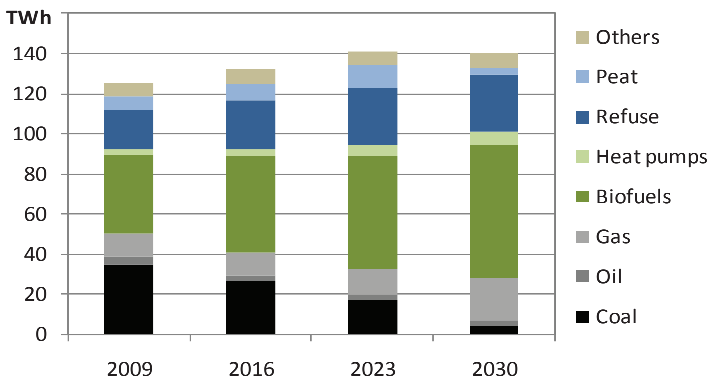


Figure 13.4: Nordic district heating production with EU renewable energy goal applied

energy systems, e.g. the district heating production, see Figure 13.4. The EU target leads to a marginally larger district heating production than in the case with today's policy instruments. The most obvious difference is the large increase in the use of biofuels, at the expense of coal and peat.

When we — on top of today's policy instruments and the EU's 20 % goal for increased use of renewable energy — also add the EU's energy efficiency goal, the use of district heating remains almost constant. This is a significantly lower level of district heat production than in the two previous scenarios. One exception is Norway where the efficiency target increases the use of district heating slightly. Biofuels retain their dominating role. Natural gas expands less than in the other scenarios. The energy efficiency target also acts as a promoter of heat pumps, which results in a larger district heating production by heat pumps, especially in Sweden and Norway.

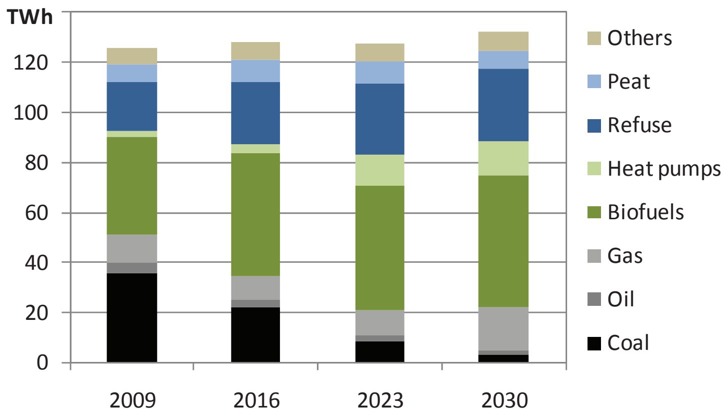


Figure 13.5: Nordic district heating production with EU renewable goal + EU energy efficiency goal

District heating provides valuable flexibility to renewable electricity

Increased investment in stochastic renewable energy production like wind power and small-scale run-of-river hydro power plants, also increases the demand for a system that is able to balance a fluctuating and unpredictable power production. Large scale hydropower plants with a reservoir offer such balancing power. In parts of the Nordic system, like Denmark, other measures have been used to cope with the increased volatility in the power system. One of these measures is to use excess electricity in district heating systems.

In periods with very high power production, and/or very low demand, the prices could be zero or even negative. Such situations already occur in the Nordic electricity market. Utilization of low price electricity, even in short periods, could be of interest both in district heating systems and for process heat. Conditions for very low prices typically occur when the wind power plants produce at maximum load during low demand periods.

Electric energy is very expensive to store, while thermal energy is both cheaper to store and relies on mature technology. Some district heating systems have accumulators installed already, as they offer the possibility to store excess heat from base load production and use it during peak load periods. This load shifting strategy could be further utilized with electric boilers converting cheap electricity to thermal energy, storing it in accumulators and replacing expensive use of fossil fuel as peak load.

In addition to electric boilers, heat pumps can also be used when available. If electricity has a low price often enough, even investments in electric boilers, accumulators and/or heat pumps might become viable.

For further information:
Monica Havskjold, Xrgia, Göran Koreneff, VTT and Hans Ravn, RAM-løse edb

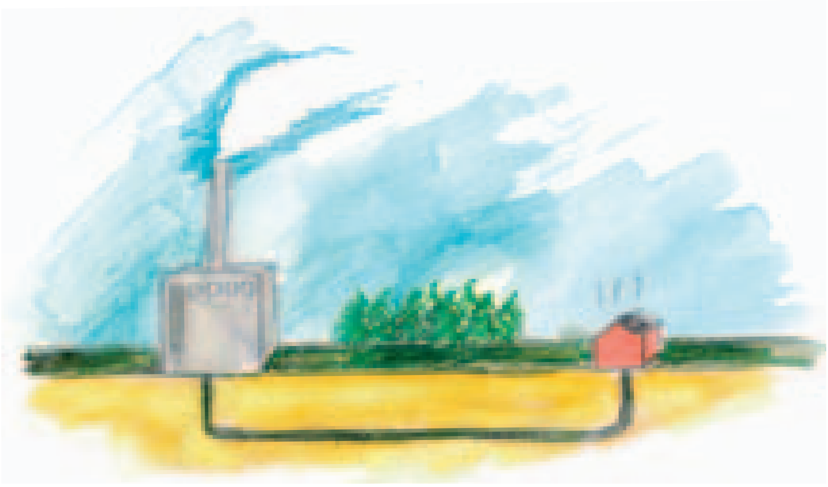
The district heating challenge

– how to remain competitive and contribute to a sustainable development if/when energy demand starts to decline

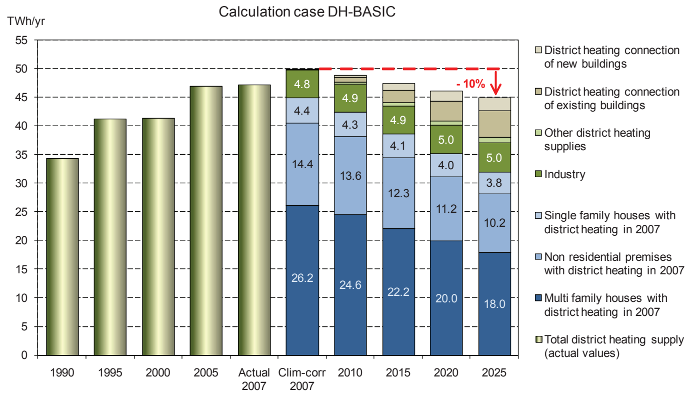
District heating is an energy carrier that has been growing steadily for decades in the Nordic countries. The use of district heating is still increasing, but there are signs that this is happening at a slower pace. Eventually this could lead to the stagnation or even the reduction of district heating use.

A number of factors will influence the use of district heating in the future, including:

- Increased energy efficiency in buildings (decreases demand)
- Conversion to other heating alternatives (decreases demand)
- Warmer climate due to increased greenhouse effect (decreases demand)
- District heating to new customers, both through conversion of existing buildings and for new buildings (increases demand)
- Heating demand due to more efficient household appliances (increases demand)
- New markets for district heating (increases demand)



Increased efforts towards a more efficient use of energy in buildings tends to reduce heating demand

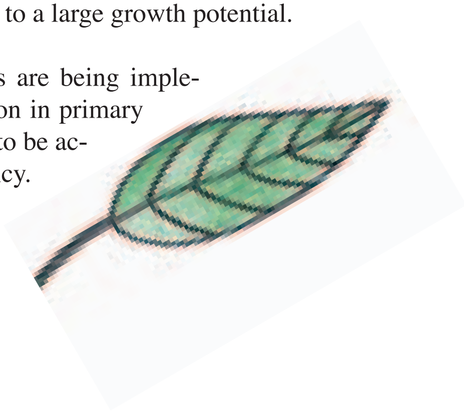


The situation for district heating imposes a number of challenges. We touch upon some of these in this text.

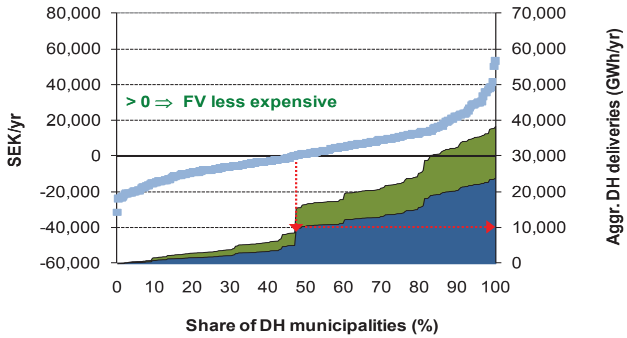
Some analyses indicate that the heating demand in the Swedish housing and service sectors may decrease considerably as a consequence of increased energy efficiency efforts by existing district heating customers. Energy savings is not a new phenomenon. While heating demand has gradually decreased, new customers have enabled the district heating sector to continue growing. From the figure it is clear that district heating deliveries to new customers moderate the decline of district heating, which would be even more drastic without this effect.

However, other analyses are less pessimistic and foresee continued growth. It may be wise though to be prepared for a situation with declining demand. Norway may be an exception in this respect due to a large growth potential.

At present, more ambitious energy policies are being implemented, like the EU target for 20% reduction in primary energy use compared with projected levels, to be achieved by 2020 by improving energy efficiency. Together with national policies in the Nordic countries this is expected to intensify energy savings efforts.

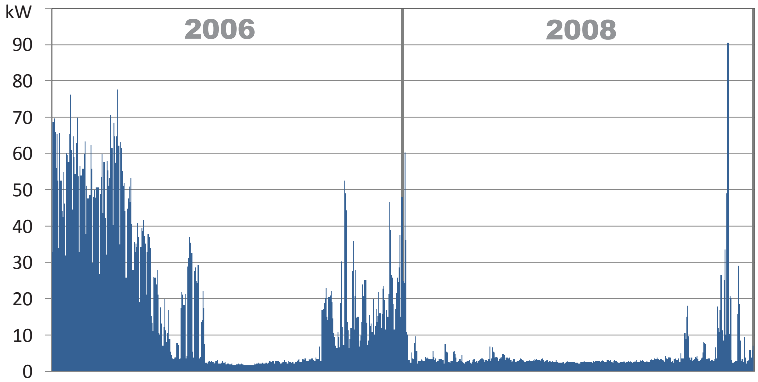


Increased competition from increasingly efficient heat pumps may also decrease total district heating demand in the Nordic countries



It is very unusual for existing district heating customers to convert from district heating to other heating alternatives. This is partly due to regulation issues, but it may also indicate that customers are either satisfied with district heating or that there is a lack of competitive alternatives.
However, competition from ever more efficient heat pumps has become more and more intense. For example, there is a growing trend for Swedish customers to switch part of their heating consumption from district heating to heat pumps. There are also examples of this in Finland. These customers often remain as district heating customers, but consume considerably less. At present this happens on a very limited scale, but the underlying economic incentives are obvious. Based on data from the Swedish Energy Markets Inspectorate we have calculated that a new heat pump is economically favourable compared to existing district heating in almost half of the Swedish municipalities where district heating is available. Competition is obviously most critical in municipalities in which the price of district heating is the highest. It is reasonable to expect that competition from heat pumps will reduce demand for district heating in the Nordic countries.

As a consequence of the partial conversion from district heating to heat pumps, the remaining demand for district heating often shows an unfavourable load curve. The figure on the next page shows daily district heating demand for one customer before (2006) and after (2008) a partial conversion to heat pumps. Small energy demand in combination with unchanged capacity demand often leads to a situation in which a district heating company's income decreases more than its costs do. This is a consequence of the typical structure of the district heating tariff. The advantages of a district heating tariff that reflects true cost structure is discussed further below.



District heating delivery for a specific customer without (2006), and with (2008), a partial heat pump switch

Warmer climate due to increased greenhouse effect

Future heating demand was estimated with the help of climate scenarios in an analysis of the consequences for Swedish society of increased greenhouse gas effects (”Sverige inför klimatförändringarna - hot och möjligheter”, SOU 2007:60). The results vary between different parts of the country, but on average, heating demand could be expected to decrease by approximately 0.3 % per year. Since Sweden is situated in the middle of the Nordic region, it is reasonable to assume that all Nordic countries could be facing a similar development.

District heating can grow through expansion to new customers, but the potential is limited

District heating can be seen as a mature business in three of the Nordic countries - Denmark, Finland and Sweden. This means that its growth potential is limited. Most buildings in energy dense areas are already connected to district heating. Conversion of existing buildings to district heating provides only limited potential for expansion. In Norway, market penetration of district heating is much lower as Norway has traditionally relied on electrical heating. This means that the potential for conversion to district heating is large. Nevertheless, there are obstacles to overcome, like the fact that many buildings lack the internal heat distribution system necessary to make district heating feasible.

District heating is also a competitive alternative for new buildings. However, volumes are limited in the short term, both due to the rate of construction of new buildings and to the often very small specific heating demand in new buildings. Passive houses, energy neutral buildings and low energy buildings are concepts that are often discussed, and increasingly put into practice.

New markets for district heating provide opportunities but expectations are limited

As the growth of district heating in its traditional markets starts slowing down it is natural to intensify the efforts to identify and exploit new markets. Some examples are:

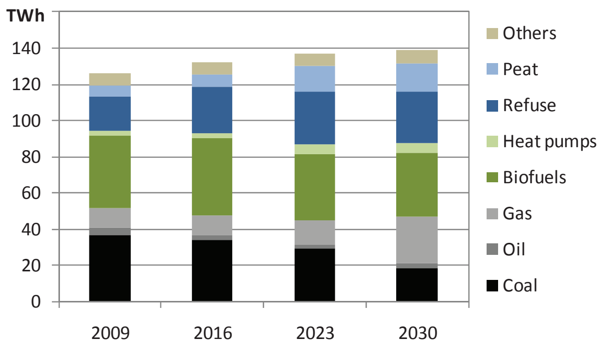
- Heating of ground (e.g. streets and sidewalks)
- Absorption cooling
- Appliances in households (e.g. washing machine and dish washer)
- Laundries in multi family houses (e.g. washing machine and drying)
- Greenhouse heating
- Refining of fuels (e.g. drying)
- Combined processes (e.g. transportation fuel, electricity and industrial waste heat)

Discussions with Swedish district heating representatives indicate that although these new markets are viewed as interesting and it is important to try to develop them, expectations for future district heating demand from these markets are low. It is reasonable to assume that the situation is similar in the other Nordic countries.

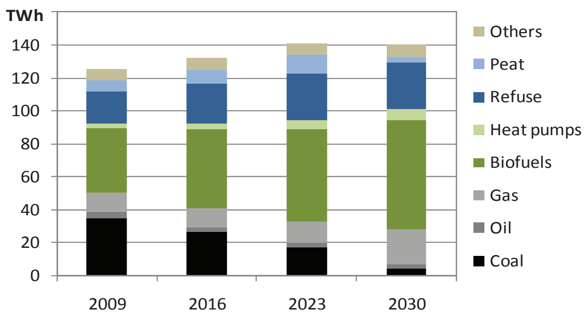
Climate and energy policies influence district heating demand and production, both positive and negative

The EU 20/20/20 goals will have a profound impact on the development of Nordic district heating business. This has been analysed within the NEP project through model calculations for each of the four countries. Three scenarios have been calculated:

- Today's policy instruments – the reference case
- Adding the EU target for increased use of renewable energy (the first figure below)
- Adding the EU target for improved energy efficiency to all of the above (the second figure below)



Nordic district heating production with no new goals from the EU



Nordic district heating production with EU renewable energy goal applied

Current policy instruments in use in the Nordic countries, including an EU-ETS price of €25/t CO_2, lead to a marginal increase in the total use of district heating in the coming years. The use of coal decreases, while waste incineration and the use of natural gas increases. Bio fuels maintain a dominant role in district heating production for another 25 years. The use of peat increases in Finland.

The addition of the increased use of renewable energy target leads to a marginally larger district heating production than in the previous case. This indicates that district heating is an effective way to utilize renewable energy. The most obvious difference regarding the production mix is a large increase in the use of biofuels at the expense of coal and peat.

When we on top of current policy instruments and the EU 20 % target for increased use of renewable energy also add the EU's energy efficiency target (-20 % energy use), the use of district heating remains almost constant, i.e. clearly lower than in the two previous scenarios. Biofuels retain their dominant role, but at a smaller volume. The use of natural gas grows less than in the other two scenarios.

These calculations highlight the possibility that increased energy efficiency may result in stagnating - or even decreasing - total deliveries of district heating. This will also affect the basis for future combined heat and power (CHP) production, since the possibility of utilizing the related heat is lower. This becomes even more obvious if more industrial waste heat and heat from waste incineration (with a more limited electricity to heat ratio) are introduced.

How to utilize five strategic heat source advantages

In order to be competitive in the heating market, district heating must rely on inexpensive energy sources. This is important since district heating includes a heat distribution system whose costs must be justified by the low cost of heat production. Fortunately the district heating concept provides opportunities for such low cost energy production. Five strategic advantages can be identified from an energy production point of view:

- Combined heat and power (CHP) production is a powerful measure for improving energy efficiency in energy conversion. By not using separate plants for electricity and heat production, considerable efficiency improvements can be achieved. Economies of scale are an important issue for CHP and district heating is in line with this.

- Waste incineration is a competitive measure from a waste management perspective if efforts are made to minimize landfill. Energy recovery is, in addition to volume reduction, an important part of waste incineration. Electricity production efficiency is limited due to boiler material restriction related to the nature of the fuel. This means that heat production, and the necessary heat demand, is a prerequisite for effective energy recovery.

- Industrial waste heat is often available as a by-product in connection with energy intensive industry. Industrial waste heat is typically low temperature and therefore lacks useful applications. District heating however, makes it possible to utilize this otherwise wasted heat for heating purposes.

- Geothermal energy is a very large energy source in a global perspective. It is often available at relatively low temperatures, which means that district heating is often a prerequisite for the utilization of this heat source.

- ”Difficult fuels” could be seen as a label for fuels that require large efforts for handling, combustion, flue gas cleaning, etc. Examples could be wood residues, peat, coal and heavy fuel oil. The advantage of such fuels is, of course, the low cost. However, given the high fixed costs associated with combustion, the energy conversion plant must have a certain scale, which district heating can facilitate.

Combining two or more strategic advantages is obviously better. For example, a combined plant that uses what could be labelled as difficult fuels in a process for production of transportation biofuels, and where waste process heat is recovered and electricity is produced through CHP, combines three of the strategic advantages mentioned above.

A production mix in which these strategic advantages are utilized as much as possible creates a strong foundation for a competitive district heating concept.

Both total price and the design of the district heating tariff is important for competitiveness

Nordic district heating tariffs typically include a large variable component, the energy fee. The energy fee is related to energy use and typically makes up 70 to 90 % of the total district heating price. In all four countries large differences could be observed between different companies, with the share of the energy fee ranging from 50 % to 100 %.

Marginal costs are often used as a basis for price-setting, as they give information on what the cost is for producing what customers are about to use or not use. Marginal costs vary from hour to hour and these variations can be large due to different heat production costs for different alternatives. For practical reasons, hourly resolution cannot be applied in the district heating tariff. Average marginal costs over, for example, three seasons may be a reasonable compromise.

Marginal costs for district heating production can vary widely in different district heating systems due to differences in the production mix. However, this study shows that on average, marginal costs in Sweden are 20 % lower than the energy fee (including energy related capacity fees). This means that the district heating tariff generally does not completely follow the cost structure in this respect. From this point of view, it would be an improvement if the price of capacity was a larger share of the tariff and had a more direct relationship to actual capacity demand.

Analyses of Swedish district heating production show that there are also *l*arge differences in average marginal costs between seasons. Since typical district heating tariffs do not reflect seasonal variations through differentiated energy fees, a recommendation would be to increase seasonal differentiation in order to achieve a tariff that better reflects the cost structure.

At this point it is important to be aware of the typical differences in the structure of district heating production in the Nordic countries. Finland and Denmark have a large share of CHP (mainly based on coal, natural gas, biomass or peat) while in Sweden district heating is primarily based on waste incineration, a relatively small share of CHP (based on wood fuels), heat pumps and heating plants (based on wood fuels). These different structures typically lead to different variations in average seasonal marginal costs for district heating production. Variations are smaller in Finland and in Denmark than in Sweden.

We have, in this study, discussed the district heating tariff from a cost reflecting point of view. The district heating tariff is, however, constructed with more goals than to be "cost-correct". A further goal is that the tariff is simple to understand. Customers often also prefer that a large share of the district heating tariff is variable and reflective of how much energy they consume, as they want to be able to influence costs through their behaviour. Further, a general political ambition to stimulate energy savings is often present, which tends to favour a large variable share. At the same time, district heating companies prefer a price that does not vary too much between years, is easy to predict and relates to the cost structure of competing heating alternatives. Therefore, we realize that there may be quite rational reasons for choosing a pricing structure that may not entirely reflect the cost structure. Nevertheless, we have chosen to discuss this issue as we feel that it is important to bring attention to this matter in order to make an informed decision on the design of the district heating tariff structure.

What could then be the consequences of applying a district heating tariff that does not correctly reflect true variable costs? Below we discuss a case in which the energy fee makes up a significantly larger share of the total price than the variable costs' (average marginal cost) share justifies. This leads to - or risks leading to - a number of phenomena. Below we list some of these:

- Energy savings risk reducing the volume of district heating deliveries, so the energy fee will have to be gradually raised in order to cover also part of the fixed costs that remains intact.
- Partial conversion to heat pumps to reduce the use of district heating could appear to be more competitive than it really is. (This reduces district heating energy deliveries, while the demand for delivery capacity remains.)
- Greater energy saving than what would be economically optimal.

This, of course, goes both ways. If the energy related part of the district heating price is too low from a "cost-correctiveness" point of view the opposite phenomena would occur. That would be equally negative.

District heating provides additional value for the customers

The competitiveness of district heating is not only determined by the comparison between the price of district heating and the price of alternative heating options. District heating can present other advantages, such as:

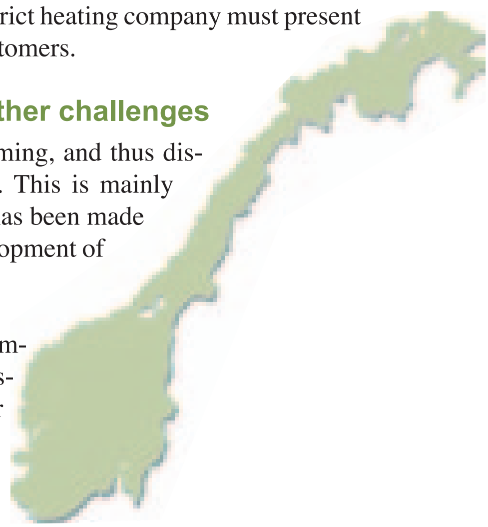
- Often favourable from an environmental and climate change perspective
- Inherent flexibility regarding production mix
- Carefree for the user
- Creates additional space

These aspects are of course important to take into consideration when district heating is compared with its alternatives.

A recurring argument against district heating is that customers are locked to one company and that it is more or less impossible to switch to other forms of heating. This is often used as an argument for the regulation of district heating.

However, it can be argued that real alternatives are in fact available. Conversion from district heating to heat pumps is one such alternative. Furthermore, the customer-company relationship can be viewed as being a mutual dependence. It is not only the customer that is dependent on one supplier; the district heating company is also dependent on its customers. Since the district heating system is fundamentally coupled to one location the district heating company must present a competitive offer in order not to lose its customers.

District heating in Norway facing other challenges



The district heating sector in Norway is booming, and thus distincts itself from the other Nordic countries. This is mainly due to public policy, as funding from Enova has been made available for both green-field plants and development of existing plants.

During the last 1-2 years, companies have competed to get hold of the most valuable concessions. NVE (the Norwegian Energy and Water Directorate) has granted a lot of new concessions in areas not yet supplied with district heating. A concession is a necessity to get the financial support from Enova, and also for the municipality to make connection to district heating mandatory for new buildings.

However booming, even in Norway two important challenges have arisen for the district heating companies. First, heat pumps represent a commercially highly attractive alternative to district heating, especially if the customer also has a cooling demand.

Second, the export boom of municipal and industrial waste to Sweden imposes a demand surplus for low value energy sources.

To cope with the first challenge, some district heating companies are offering district cooling, installing heat pumps themselves for combined production of district heating and cooling. Also existing district heating customers consider installing their own heat pumps. All this resulting in the same problems as described for Sweden where district heating may end up as peak load supply.

Competition for fuel is a common situation for the district heating companies. Nevertheless, the current situation with “aggressive pricing” of municipal and industrial waste for incineration, challenges the very existence of some companies. A lot of new incineration capacity is being built both in Norway and Sweden in recent years. At the same time the financial melt-down in 2008-2009 tightened the supply of waste for incineration. While Swedish incineration plants are able to sell 100 % of their heat production, the Norwegian incineration plants face small district heating systems still under development. Thus, the more competitive Swedish incineration plants can reduce their gate fee for waste, leaving Norwegian plants with too little low cost fuel for their heat production commitments.

An important lesson from this situation is to increase the focus on the fuel supply. It should be stressed that momentary prices in a continuously developing common waste market should not be taken for granted. Other technologies that exploit resources that either are easily transported or may have different areas of application, could face similar problems in the future. Hence, more resources should be invested in risk management as further investments in biomass based plants may face an increased risk. A strategy for diversification may be to invest in heat-pumps, where 2/3 of the heat is produced from temperature differences in ambient air or other forms of “free” energy.

As the Norwegian district heating systems are still under extensive development, they may apply investment strategies to design plants more adaptable to future challenges than the case is for the fully developed district heating systems in the other Nordic countries.

Regulation of district heating – present situation and trends

Two countries, Denmark and Norway, have regulation in place that makes it possible to force customers to connect to district heating. Customers must in that case pay for the forced connection but they are not forced to buy heat. If they choose to buy heat after being forcefully connected, regulated tariffs apply. Regulated tariffs do not apply for customers that voluntarily request to be connected to the district heating system.

In Finland and in Sweden, customers are free to choose between the different heating alternatives and there is no formal price regulation. Finnish district heating tariffs must, however, be based on costs.

In three of these countries district heating is widely diffused and is the dominant heating alternative. Among these countries there are examples of both

- forced connection together with price regulation and
- free choice of heating alternative.

As a result, the Nordic countries do not provide a clear indication as to how different regulating regimes influence the penetration of district heating.

In Sweden, there is an increased focus on regulation resulting from the general perception that district heating prices have risen rapidly and that potential waste heat suppliers feel shut out from the heating market. The Swedish Competition Authority claims that introducing price regulation to district heating is an important step in order to improve competition and create better functioning markets. They also recommend that third party access (TPA) to the district heating distribution system should be considered. TPA is also favoured by a number of industries and energy companies that feel that they are not given the opportunity to supply heat to existing district heating systems. During 2010, TPA will be studied in depth by a special investigator assigned by the Swedish government. At this stage it is uncertain how TPA would influence the future competitiveness of district heating. It is however fair to assume that mandatory TPA would have a profound impact on the district heating business.

14. District heating price model

– important for future competitiveness

District heating tariffs in the Nordic countries typically include a variable component that is linked to energy consumption and often makes up 75 to 90 % of the total price. The corresponding average marginal cost for the district heating production is typically lower than the variable income, in Sweden typically 20 % lower. This means that the district heating tariff generally does not completely reflect cost structure. Furthermore, average marginal costs typically vary significantly depending on season. If the ambition is to have a tariff that reflects the cost structure in this respect, larger price differences between seasons are desirable. If the district heating tariff lacks in "cost-correctness" there is a risk that the customers are encouraged to behave in a way that leads to sub-optimizations.

In this section we discuss the tariff structure of district heating in relation to the cost structure, and the possible implications of this relationship in an energy supply perspective. One example could be that the energy related (variable) portion of the total price is disproportionately large compared to the cost of producing and distributing the heat, which includes large fixed or capacity related costs. This may result in incorrect price signals to customers, who could therefore make suboptimal choices, e.g. regarding energy savings or partial conversion to heat pumps.

Already at this stage it is important to stress the fact that a switch from district heating to e.g. heat pumps could in certain cases be a correct and optimal choice. In this study we have, however, chosen to focus on the risk for suboptimal choices due to an inappropriately designed district heating tariff.

District heating tariff – a very large part related to energy use, only a small part related to capacity

Swedish district heating tariffs typically include a large variable component, the energy fee. A study of the district heating tariff for 15 Swedish district heating companies shows that on average, the energy fee corresponds to 66 % of the total price. However, the capacity part of the tariff is often directly coupled to energy use and not to demanded capacity. The capacity part of the tariff could therefore be seen as a variable income related to energy, and the real energy-related fee is thus probably closer to 90 %. (nb: the survey refers to the situation in 2006. In the past few years some district heating companies have changed to "genuine" capacity fees.)

The tariff structure is similar in the other Nordic countries. In Finland, the energy fee makes up approximately 85 % of the total district heating price, while in Denmark it typically amounts to around 70 %. In Norway the energy fee is typically in the range of 75 %. In all countries, large differences can be observed between different companies, with an energy fee ranging from 50 % to 100 % of the total price.

District heating marginal production costs – often large variations between seasons

The average variable production costs are considerably lower than the energy fee, typically less than half. (When we discuss cost they include policy instruments, e.g. taxes.) However, for the purpose of designing cost-correct tariffs, the short term marginal cost is a more relevant valuation of variable costs than the average variable cost. Marginal costs are often used as a basis for price-setting as they give information on what the cost is for producing what customers are about to use or not use. Marginal costs are considerably higher than average costs as they reflect the cost for the most expensive production alternative that is used to satisfy the demand.

The marginal costs of district heating vary from hour to hour. These variations can be large due to different heat production costs for different alternatives. For practical reasons, hourly resolution cannot be applied in the district heating tariff. A reasonable compromise could be average marginal costs over for example three seasons.

The marginal costs of district heating production vary significantly in different district heating systems due to differences in the production mix. However, this study shows that on average, marginal costs in Sweden are 20 % lower than the energy fee (including energy related capacity fees). This means that the district heating tariff generally does not completely follow the cost structure in this respect. From this point of view it would be an improvement if the price of capacity was a larger share of the tariff and with a more direct relationship to actual capacity demand.

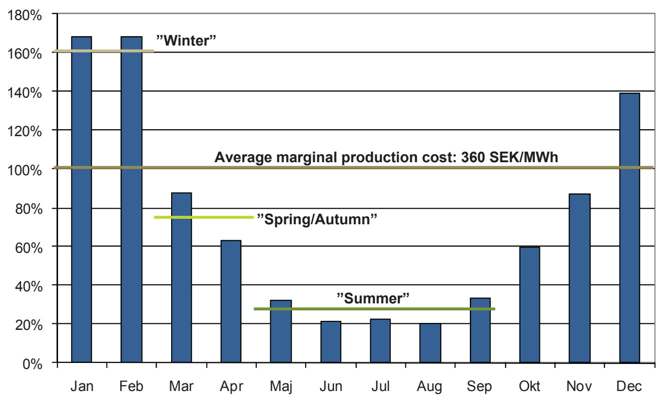


Figure 14.1: Cost (incl. taxes) of the Swedish average marginal district heating production month by month for the year 2006

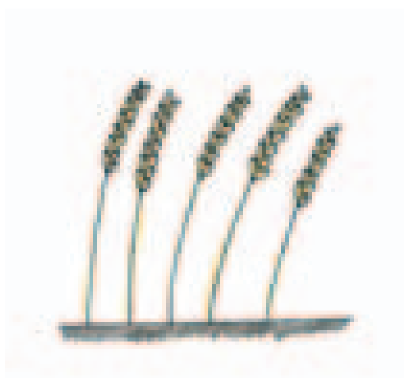
The large variations in both variable price (energy fee) and variable cost (marginal cost of production) between different district heating systems indicate that, although overall the tariff appears to be fairly close to “cost-correct”, there are many systems with tariffs that do not reflect the true cost structure. This may go both ways, i.e. there may be systems in which the variable fee makes up too large a share of the total price as well as systems in which the share is too small. There is no such thing as a uniform national district heating production. The national picture is a consequence of a large number of local district heating systems, each with its own characteristics.

At this point it is important to bring to light some typical differences in the structure of district heating production in the Nordic countries. Finland and Denmark have a large share of CHP (mainly based on coal, natural gas, biomass or peat) while district heating in Sweden is primarily based on waste incineration, a relatively small share of CHP (based on wood fuels), heat pumps and heating plants (based on wood fuels). These different structures typically lead to different variations in average seasonal marginal costs for district heating production. Variations are smaller in Finland and in Denmark than in Sweden. Note, however, that further aspects particularly related to the interplay between the electricity and heat supply aspects are not treated in this text.

Risks if the tariff does not match the cost structure

We have, in this study, discussed the district heating tariff from a cost reflecting point of view. The district heating tariff is, however, constructed with more goals than just to be “cost-correct”. A further goal is that the tariff should be simple to understand. Customers often also prefer a large part of the tariff to be variable and reflective of how much energy they consume, as they want to be able to influence costs through their behaviour. Further, a general political ambition to stimulate energy savings is often present, which tends to favour a large variable share. At the same time, district heating companies prefer a price that does not vary too much between years, is easy to predict and relates to the cost structure of competing heating alternatives. Therefore, we realize that there may be quite rational reasons for choosing a pricing structure that may not entirely reflect the cost structure. Nevertheless, we have chosen to discuss this issue as we feel that it is important to bring attention to this matter in order to make an informed decision on the design of the district heating tariff structure.

The study thus indicates that on a national average, the size of the energy fee is higher than the corresponding average marginal costs and, as shown in Figure 14.1, that average marginal costs typically vary significantly between seasons. The average marginal cost for district heating production could be five times higher during winter than during the summer. Nevertheless, many Swedish district heating companies apply the same price throughout the year and companies that do apply different pricing during the different seasons have only small price differences. If the ambition is to have a tariff that reflects the true cost structure of district heating production, larger price differences between seasons should be encouraged. As discussed above, seasonal differences could typically be smaller in the other Nordic countries, but the principle is similar.



What could then be the consequences of applying a district heating tariff that does not correctly reflect true variable costs? Below we discuss a case in which the energy fee makes up a significantly larger share of the total price than the variable costs' (average marginal cost) share justifies. This leads to - or risks leading to - a number of phenomena. Below we list some of these:

- Energy savings risk reducing the volume of district heating deliveries, so the energy fee will have to be gradually raised in order to cover costs.
- Partial conversion to heat pumps to reduce the use of district heating could appear to be more competitive than it really is. (Reduces district heating energy deliveries, while capacity demand remains.)
- Greater energy saving than what would be economically optimal.

This, of course, goes both ways. If the energy related part of the district heating price is too low from a "cost-correctness" point of view the opposite phenomena would occur. That would be equally negative.

Future competitiveness of district heating – a principle discussion for Sweden as an example

The competitiveness of district heating can be explained by a number of factors, for example cogeneration providing a high total efficiency, the possibility to utilize cheap but complex fuels with low variable costs, and a flexible production that facilitates rapid adaptation to changing fuel costs.

Although district heating is regarded as an environmentally friendly heating source, other solutions are competing for the same market. In all the Nordic countries, the main entrants seem to be heat pumps and local biomass-fired production (i.e. pellet stoves and boilers). Solar heating is also attracting more interest. Energy efficiency is high on the political agenda. Long-term, this may lead to a reduced demand for heat which may hurt the district heating business. In many respects district heating is still a competitive heating alternative, but competition from other alternatives is toughening. At least in Sweden, heat pumps and to some extent pellets boilers are the most competitive alternatives.

District heating legislation in the different Nordic countries is not consistent. For example, in Norway and Denmark connection to the district heating system is mandatory in certain specified areas, whereas customers in Finland and Sweden are always free to remain unconnected. There are also other differences in legislation. In the discussion below we concentrate on Sweden, which means that the competition between different energy carriers and energy conversion alternatives is mainly decided by market forces and there is no regulation of the heating market in this field.

We have analyzed competition to district heating from other heating alternatives in Sweden. We have identified four main scenarios for a specific building, seen from a district heating perspective:

1. Existing district heating; conversion of the total heating demand to another energy carrier and another energy conversion alternative
2. Existing district heating; conversion of a fraction of the heating demand to another energy carrier and another energy conversion alternative
3. Presently heated by another energy carrier and another energy conversion alternative; conversion to district heating
4. New building; all alternatives starting from scratch, district heating is one of the options.

In scenarios 1, 3 and 4, competition between district heating and other heating alternatives is mainly decided by the total cost for heating, current and future. Although it is unusual to convert from district heating to other alternatives, there are examples in Sweden of district heating customers that, disappointed with the cost of district heating, have taken the drastic step of switching to alternative heating sources like ground heat pumps. Surveys have also shown that heat pumps could successfully compete with district heating from an economic point of view in several Swedish municipalities. If heat pumps are competitive, there is of course in principle no objection against choosing them at the expense of district heating.

On the other hand, district heating is still a competitive alternative to convert to, especially from oil-fired boilers or electric boilers, so district heating may continue to gain market share. However, the most attractive areas (= the most energy dense areas) are typically already connected to district heating. The areas considered for district heating are therefore increasingly less energy dense, which means that potential additional markets get smaller all the time.

It is important that tariffs match the cost structure – conversion of a fraction of district heating to heat pump as an example

Partial conversion from district heating to heat pumps, scenario 2 above, is becoming increasingly common in Sweden. There are indications that this may lead to an annual drop in demand of more than 0.3 %. Further, these customers may exhibit a very unfavourable profile from the district heating company's point of view. An example of this is shown in the following figure.

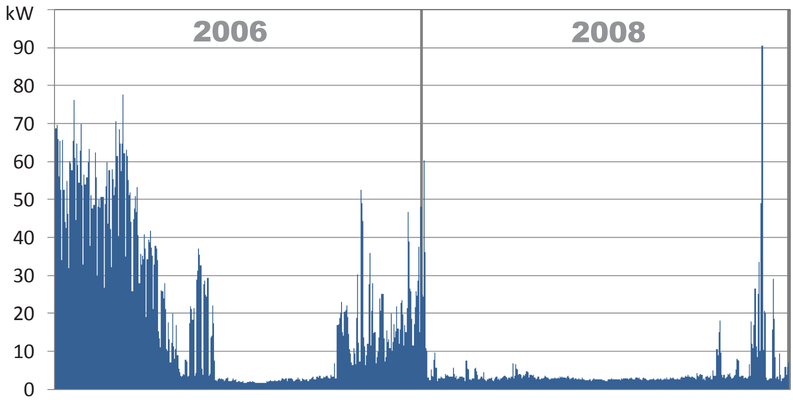


Figure 14.2: District heating delivery for a specific customer without, and with, a partial heat pump switch

The profitability of making a partial conversion to heat pumps is influenced not only by the total overall price of district heating, but also by the tariff structure. The larger the energy fee, the more favourable the heat pump alternative will become. The reason is that a considerable share of the district heating company's costs are fixed or related to capacity. If the remaining district heating deliveries largely consist of short-lasting heating peaks, the costs of the district heating company will remain high while the income will be relatively small.

A district heating tariff that reflects the true cost structure therefore provides two important advantages:

1. It will be less attractive to convert parts of the heating to e.g. exhaust air heat pumps or solar heating (for other types of heat pumps the consequences are more ambiguous, at least in relation to the seasonal differentiation of the energy fee).
2. If the partial conversion to heat pumps still happens, the company's costs and income will decrease proportionally. Otherwise there is a risk that the income decreases more rapidly than the costs.

However, if the heat pump proves to be competitive also in the presence of a district heating tariff that reflects the true cost structure of district heating production, the partial conversion to heat pumps is a correct and logical choice.

For further information:
Håkan Sköldberg, Profu, Monica Havskjold, Xrgia and Göran Koreneff, VTT

15. Proactive strategies for environmental sustainability of municipal companies

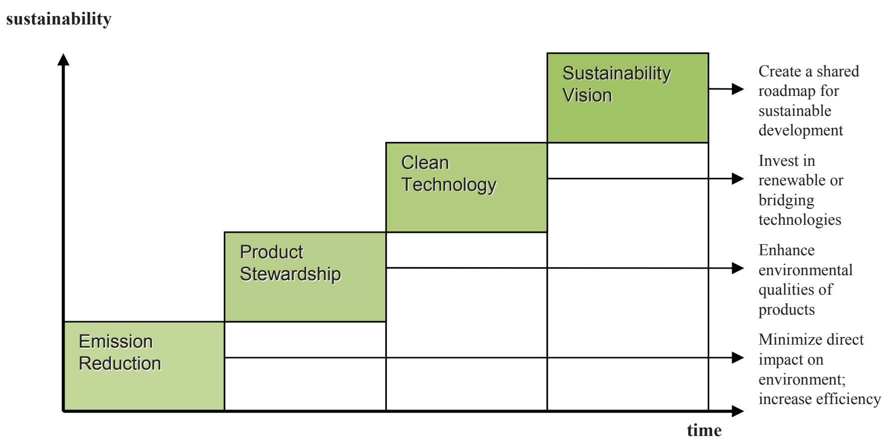
- pathways of sustainable development in the stationary energy system

There is a need for companies in the stationary energy system to take a strategic approach to sustainable development and intensify their efforts to integrate sustainable practices into their business. This chapter sets out how municipal energy companies mitigate their impact on the environment by working systematically with the sustainability challenge in several dimensions. Companies with a proactive strategy for environmental sustainability follow a sustainable vision for their business that includes reducing their carbon emissions, improving the environmental qualities of their products and investing in clean technologies. Besides mapping what such proactive strategies for environmental sustainability involve by conducting case studies of municipal energy companies with a strong environmental focus, key mechanism facilitating such strategies have been investigated to show pathways for sustainable development for companies in the stationary energy system. The study illustrates that, by applying a strategic perspective to the environment, municipal energy companies can develop new business opportunities and contribute greatly to sustainable development within their sphere of activitiess.

How come some companies work strongly focused on mitigating their environmental impact while others don't go further than meeting compliance requirements? All companies face a similar institutional environment, are subject to the same regulations and operate on a common market. Hence, the driving forces for such strategic proactivity have to be searched for within the company. The first part of this chapter presents a framework consisting of different strategic areas that energy companies should engage in to work in a proactive and comprehensive way with the environmental challenge. Subsequently, the empirical findings of the study are presented using the framework to mirror selected activities of the case companies that lead to better sustainability of their business. Furthermore, key mechanisms that enable the studied companies to effectively embed sustainable practices in the companies' management and energy system are highlighted. Finally, conclusions are drawn.

Four strategic areas ensure a coherent strategy for environmental sustainability

Strategy can generally be viewed as "a pattern of important decisions that guides the organization in its relationships with its environment, affects the internal structure and processes of the organization, and centrally affects the organization's performance" (Hambrick, 1980:567). To be able to study what a proactive strategy for environmental sustainability involves, it has been broken up into four dimensions that represent important areas for companies to focus on in order to mitigate their impact on the environment. **Emission Reduction** draws attention to minimizing the emissions resulting from different corporate activities and opts at increasing the efficiency of operations. Under the **Product Stewardship** strategy, the company searches for opportunities to enhance the environmental qualities of its existing products or develop new sustainable products in line with customers' needs. **Clean Technology** sheds light on the investments in renewable or bridging technologies that companies engage in to bring about more radical changes to their production system. Lastly, a **sustainability vision** brings attention to how companies create a shared roadmap for sustainability within the firm and with its stakeholders that reconciles value creation for the company with wider goals for a sustainable society.



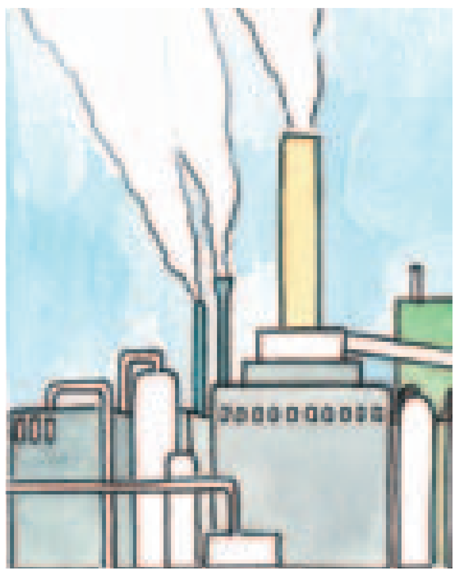
Source: Adapted from Hart (1995) and Hart and Milstein (2003)

Figure 15.1: Strategic areas of proactive strategies for environmental sustainablility

Highlights of case study findings illustrating proactive strategies for environmental sustainability:

Technical and organizational integration lead to emission reductions

The companies studied distinguished themselves by a strong capability to integrate sustainable business practices into their energy systems and management processes. On the technical side, fuel switching opportunities have been used extensively, for instance by replacing fossil fuel oils with bio-oil. The cooperation with other actors has also contributed to improving the environmental sustainability of the production mix and reducing emissions. An interesting example is the outsourcing of district heat production to local farms that can utilize their waste products in a beneficial way while contributing to greener production. The utilization of waste heat as well as connecting to neighboring district heating systems are other measures that ensure efficient resource use. When it comes to management systems, the integration of environmental concerns into the organizations was made sure by including environmental performance measures in the performance management tool Balanced Scorecard on which the incentive system is based. One company has taken the challenge further and made a commitment to become climate-neutral, setting a clear signal to its stakeholders in which direction the company will be developing. Central to the capability to reduce the impact on the environment is a well-established and competent environmental organization. Moreover, a timely adoption of the ISO 14001 norms for environmental management appears to be a decisive factor for achieving a high environmental standard. Efficient environmental management is a socially complex process under which competence gradually accumulates leading to the continuous improvement of routines and incremental emission reductions.



Innovations in product stewardship aim at enhancing environmental qualities of existing products or expanding into new business lines

Innovations at a strategic and operational level are crucial to secure the company's ability to stay competitive. It is also important 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. A continuous dialogue with customers is essential to keep the product portfolio tuned with opportunities opening up for energy companies. Examples are new products within energy services and the development of climate-neutral district heating. One company preempted competitors by offering environmentally certified district heat, a result from the close cooperation with an environmental organization. Naturally, such achievements are motivating for employees and good publicity. To conclude, strengthening energy services, which usually is a young line of business, gives companies a new platform for expansion, whereas improving the environmental quality of district heating reinforces the viability of this traditionally important business area. Moreover, with the introduction of remote meter reading, new possibilities arise to work with demand-side-management in the consumer market, raising customers' awareness on their energy consumption and creating incentives to save energy. Companies with a strong local embeddedness also have better possibilities to market new products in their niche. An innovative approach observed was to offer 'locally produced renewable electricity' from a newly built combined heat and power plant to the local community. Finally, biogas ventures create numerous opportunities for sustainable fuel use and constitute a rapidly expanding new line of business at one of the case companies.

Clean technology implementation through strategic cooperation

Clean technology investments are crucial to reposition the firm and develop the sustainable competencies needed to prosper in a carbon-restrained economy. At the case companies, cooperation proved to be an important means for business expansion and the dissemination of clean technologies. Strategic cooperation can extend the available competences and production resources of energy companies, leading to better economies of scale and financing possibilities for clean technology investments. Energy companies can also be valuable cooperation partners in smaller ventures, for example for biogas or rapeseed oil production where they can bring in their experience and resources. Furthermore, finding new forms of cooperation can give positive results. For example, wind farm expansion was favored by an innovative business model that builds on the co-operation with land owners and nearby residents. This seems to lessen the NIMBY effect that often stops up renewable investments. Close ties with the owners also favor the possibilities for investing in clean technologies. If the municipality is willing to stand as a guarantor for loans, the disadvantages of scale that smaller energy companies face when planning for new production capacity can be weighed up. Communication seems to be essential to a smooth implementation of new investments projects, be it with owners, the local community or other affected parties. Emphasizing the significance of such clean technology investments and creating a dialogue with stakeholders can build acceptance for the project and speed up the implementation process.

Sustainability vision creates a shared roadmap for the future development of the company

Communicating a vision for company development along sustainable lines to employees and stakeholders of the company is a central aspect of creating acceptance and commitment for the corporate strategy for environmental sustainability. Internally, such commitment facilitates implementing environmental goals. Supported by environmental training, employees feel empowered to take responsibility for the environment in their work tasks, which often results in bottom-up initiatives for environmental improvements. Communicating a sustainability vision to customers and financiers can strengthen the relationship which in turn increases the opportunities to further develop the organization in a sustainable direction. At a corporate governance level, a shared understanding by both managers and owners as to where the company is heading is essential. At the studied companies there is clearly a consensus between owners and the board of directors that environmental sustainability is important for business success. Furthermore, the owners focus on long-term sustainable returns and see the company as a means to produce social welfare at a local level. Clearly, the municipal energy company is the municipality's strongest tool to improve the local environment. This shows for examples in common goals such as the expansion of district heating and the promotion of fuel gas and biogas in transportation. A sustainability vision that is shared between the company and its owners can foster rapid changes.

Five key mechanisms foster the transition to environmental sustainability

From the empirical study five key mechanisms have been identified that facilitate the implementation of a proactive strategy for environmental sustainability in the case companies. **Organizational integration** relates to structures and processes that promote the integration of sustainability principles into both the technical and management systems of the companies. **Communication and learning** lead to a better understanding of the challenges ahead. By keeping a dialogue with stakeholders and engaging in a continuous learning process the companies can foster the required changes. Furthermore, **innovations** were vital to enhance the sustainability of products and processes. Emission reductions allow for incremental changes while adopting or developing clean technologies facilitate radical changes towards sustainable production systems. An important means for the realization of sustainable solutions was also the **co-operation** with actors that control resources of interest to energy companies engaging in a proactive strategy for environmental sustainability. Lastly, **local embeddedness** reflects that municipal energy companies can concentrate value creation from the energy system at the local level by embedding their activities in the local context.

Figure 15.2: Key mechanisms fostering a proactive strategy for environmental sustainability

Conclusions – pathways for sustainable business and environmental development

Embracing the above mechanisms, proactive municipal energy companies are well-positioned to develop energy solutions that facilitate the transition to a sustainable society. By taking a strategic approach to sustainability the companies can build important resources and competencies allowing them to exploit new business opportunities. At the same time, their embeddedness in the local context allows the companies to contribute to a sound development of the local economy and environment.

For further information:
Gabriela Schaad and Anders Sandoff,
School of Business, Gothenburg University

16. Leading indicators in successful facilitation schemes for Clean Tech companies

– the case of increasing growth and export volumes in the biomass combustion manufacturing industry

In the Nordic countries of Sweden, Denmark and Finland the extensive use of biomass for heat- and power production is one of the main explanations for the relatively low emissions of GHG in the Nordic region. The availability of biomass in parallel with stiff tax regimes on CO_2 emissions has made this one of the main technologies within the combustion industry e.g. district heating and industrial heating industries. Local manufacturers have answered to this demand and developed equipment to handle the special needs of renewable solid fuel combustion. There is now a great interest in turning so called "Clean Tech" industries within the biomass field into a growth sector with increased export revenues and employment as a much sought-after consequence. A lot of resources are committed by ***government****,* ***industries*** *and* ***investors*** *to fulfil this ambition. This chapter takes an actor perspective in analysing the conditions for growth and export orientation and outline important success factors for the design of actor oriented facilitation schemes. The analysis shows that in order to increase growth and export volumes in small Clean Tech companies characterized by an extensive operating history, facilitation schemes must be able to foster the following three core capabilities:*

- *creating competitive advantage based on customer value,*
- *developing foreign sales capabilities and*
- *increasing value from stakeholder collaboration.*

Introduction

In essence, combustion is the main source of green house gas emissions and eighty percent of all emissions within the EU emanates from production of power and heat. An increase in the use of biomass has potential to significantly reduce CO_2 emissions within the EU. EEA estimates that nearly half of the target of 20 percent of renewable energy could be met by biomass in the year 2020 (EEA, 2008). In terms of power and heat production, biomass has the potential to meet 18 percent of the European demand for heat and 12 percent of electricity demand in 2030 as compared to 3 percent and 6 percent respectively in 2008.

The increased demand for energy produced from biomass in the Nordic region is also illustrated by analyses made within the NEP project. As shown in the figure below, the present Nordic use of biomass for energy purposes is large and it can be expected to grow considerably during the coming 10 years.

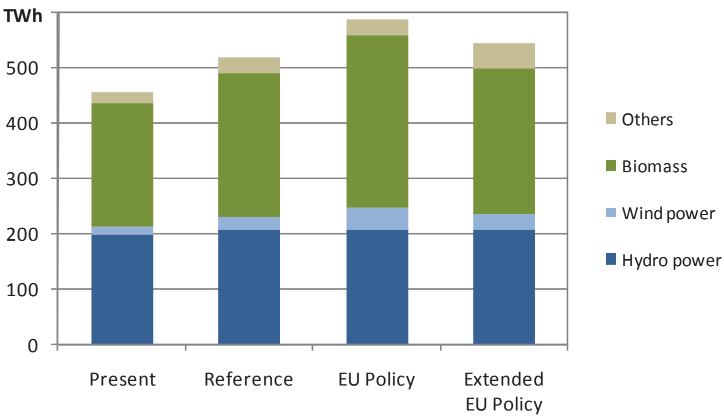


Figure 16.1: The calculated use of renewable energy in the Nordic countries by the year 2023 in three different NEP scenarios, compared to the present use

Several studies indicate that the biomass combustion sector can become a booming international market for the next 20 years (Berndes, Hoogwijk and van den Broek, 2003). The biomass combustion sector is one of the sectors in the Swedish Clean Tech industry[1] that has been identified as especially promising by Swedish authorities and is also receiving international recognition.[2] A plethora of facilitation activities, consisting of different measures such as economic endorsement, development programs, cluster formations, triple helix co-operations and explicit export initiatives are undertaken in order to realise this potential. However there have been growing concerns that progress is not heading in the right direction and actions are now called for improving existing facilitation schemes in order to break this development path[3].

1 Although Clean Tech segment have a rather wide scope it generally includes producers of "clean technology" facilitating input substitution increasing the use of renewable materials and energy sources that reduce the use of natural resources, and cut or eliminate emissions and wastes." (p 2. In Makower and Pernick, 2001).
2 See "A compilation of bioenergy in Sweden — Medium size plants and biofuel markets", 2009, Swentec for an overview and IEA Bioenerg
3 See for example the Swedish government decision Dir. 2008:31 to establish a Swedish Environmental Technology Council responsible for preparing an action plan for government work in facilitating Swedish Clean Tech companies. The action plan was finalized in Dec. 2009 containing 82 suggestions on how to improve this facilitation (Swentec, 2009).

In this chapter we take the position of the corporation at interest and investigate impediments for growth and export orientation and how these impact the design of actor oriented facilitation schemes. This is done by analysing the results of a study investigating **innovation**, **export** and **stakeholder collaboration** activities among Swedish manufacturers of biomass combustion plants. The empirical data has been collected during 2008 and 2009 by means of 'site visits' (Young och Selto, 1991) where personal interviews have been conducted with leading representatives in the companies and related organizations.

The Industry and its relation to growth and export facilitation schemes

The Swedish biomass combustion manufacturing industry has several important attributes that makes it particularly suitable for attaining knowledge about the prerequisites for growth in the clean tech sector. Besides the fact that the industry offers a significant global CO_2 emission reduction potential and an established home market, which makes it relevant in absolute terms, it also has interesting industry characteristics.

It contains six manufacturers of so called turnkey solutions for dry and moist biomass in the range of 10 to 50 MW_t.[4] All of these manufacturers are able to engage in business deals as a main contractor. They also share a long business history and extensive experience of product development, export activities and stakeholder collaboration. These companies have similar product portfolios, size (between 16 and 60 employees and turnover between 66 and 300 MSEK in 2008) and growth-patterns. The customers are mainly from the energy sector, pulp and paper, sawmills, service sector and industry. In essence these organizations are small, well established technology-driven clean tech companies that represent a broad set of experiences relevant for an important set of small and medium sized enterprises (SME:s).[5] It is significant to emphasize that this is a business context that stands apart from the typical clean tech company commonly referred to in media reporting; very small, innovation-driven start-up companies with difficulties finding venture capital. On the other hand, an extensive operating history associated with considerable institutional stickiness due to local embeddedness (Granovetter, 1985) will have a decisive impact on how growth and export activities can be induced in an effective way. When trying to facilitate growth and export in the clean tech sector by designing support initiatives and public policies it is important to acknow-

4 The companies included in the study are: Hotab AB, Järnforsen Energi System AB, KMW Energi AB, Petrokraft AB, Saxlund International AB, och TPS Termiska Processer AB

5 See EU Commission recommendation 2003/361/EC regarding the definition of micro, small and medium-sized enterprises.

ledge these differences. With insights from the analysis of the biomass combustion industry the suitability of existing growth and export facilitation schemes can be evaluated. In order to better understand the unique characteristics of this industry the next sections will give brief accounts on *innovation and product development*, *export activities* and *stakeholder collaboration*.

Impediments for growth and increased export orientation

There are some characteristics of these companies that seem to be especially important to understand in order to be able to design coping strategies to reduce or overcome these impediments.

First, demanding customers shift the focus in the company towards technological solutions and away from customer value; product development and innovation is to large parts characterized by incremental technical refinement rather than developing standardized business concepts addressing core customer needs. Small companies in rather mature industries have difficulties changing established power relations, defining the sale process and content of negotiation. Although this is mostly true for the Nordic markets with a high penetration rate and where the production technique is well known and established, the dependence of these markets make it hard to implement a more radical reframing of the business proposal, more suitable for high volume sales.

Second, the relatively complex product requires the companies to have high standards regarding abilities to manage intricate procurement processes, capabilities for onsite construction management and subsequent operating training. In markets where the concept of biomass combustion is new or unknown, there is also a great demand for educating the customers and helping to establish necessary supply chains. These high qualifications is a significant impediment for growth since an important condition for growth is the ability to recruit new employees. Given the size of these companies, the complexity of the products and the technological orientation of the corporate culture, it is a challenge to find new employees that can induce new ideas and ways of working and at the same time blend in with the existing corporate culture. Morevoer, an increase in export volumes for these relatively small companies will need local representation of some sort (e.g. partner/subsidies or agents/retailers with long term exclusive agreements). The difficulties involved establishing these international sales organizations are considerable in these companies.

Third, the option to facilitate business development and growth by stakeholder collaboration is framed by prior experiences from such activities. In many instances these experiences have been negative from the company's point of view. Small organizations have limited capacity to engage in these long range and time consuming activities with rather uncertain and sometimes vaguely defined value to the company. In too many cases these collaborative activities have not resulted in tangible positive effects such as increased sales or export capacity. There is even a considerable reluctance to engage in these activities in the future.

Leading indicators for successful growth and export facilitation schemes for small companies with an extensive operating history

The results from the Swedish biomass combustion manufacturers support the belief that existing clean tech facilitation schemes do not trigger a satisfactory increase in growth and export volumes in companies with a long operating history. Although these results are in line with more general concerns regarding the efficiency of existing facilitation schemes, the results in the above presentation indicate that these impediments are of fundamentally different nature, and needs to be addressed extensively in order to facilitate desired development. The large complexity of these areas; i.e. proper actions are contingent on industry-, company- and product/customer segment-specific circumstances, indicate that they need to be treated as specific and separate capability areas rather than bundles of more general problem area. The different nature and sheer complexity of these impediments implies that successful coping strategies must be able to develop these capabilities in the facilitated companies. So it is necessary that in order to increase growth and export volumes in small Clean Tech companies characterized by an extensive operating history, facilitation schemes must be able to foster the following three core capabilities in these companies:

- creating competitive advantage based on customer value,
- developing foreign sales capabilities and
- increasing value from stakeholder collaboration.

In the design of the facilitation schemes, the questions of in what form these capabilities should be exercised and by whom are of course delicate. Even more so is the question of what mechanisms should be in place to guide the build up and continuous development of competences to foster the development of firm specific capabilities. Suffice to say that it seems appropriate to divide responsibilities and concentrate facilitator competences into three different specialised competence areas. Below we give a brief account of tentative corner stones of these competence areas. The first one would be responsible for stimulating change by having special competence regarding business model development, management reorientation and corporate change processes. The second one, being responsible for building export capabilities, should have more hands on capabilities being instrumental in helping companies increase their export volumes. Important competences include knowledge of export activities, and biomass industry characteristics of different markets. Finally the third of these specialised competence areas should have the main responsibility for facilitating companies in stakeholder collaborations, develop their skills in increasing value from these activities and also evaluating the appropriateness of different initiatives/programs and schemes. Together, these competences manifest leading indicators proceeding growth and export volume increases.

A necessary prerequisite for the success of these responsibility areas is to have dedicated funds at their disposal. However, even with sufficient funds and adequate competence at hand, top-managers in these companies can't be assumed to generally be willing to change drastically. Building competence and capabilities are long term commitments that can't rest on the traditional good-willing intention of just being helpful. Instead it must be guided by carrot and stick mechanisms encouraging companies to devote considerable resources of their own and deepen their commitment to change.

The need for a conceptual framework for designing facilitation schemes

In the limited scope of this chapter it is of course not possible to cover all relevant aspects of actor oriented Clean Tech facilitation schemes. Here we have focused on small well established Clean Tech companies with extensive business experience. The suggested division in three distinct responsibility areas must also be analysed in relation to the needs and situations of the typical Clean Tech start-up companies. Clearly more research is needed in order to better understand these differences.

In this chapter we suggest a conceptual framework for a better understanding of the task at hand. The value of such an understanding becomes even more evident when we consider the enormous challenge of making Clean Tech a sector that significantly drives economic development. It is safe to conclude that successful facilitation schemes addressing organizational change will most certainly need co-ordinated actions of an extraordinary magnitude stretched out over long periods of time, binding substantial amounts of economic resources. In addition to this there are a great number of facilitators, all with vested special interests which needs to be "dissolved" in order reduce the institutional stickiness that characterize the current situation. A conceptual framework for addressing these issues will most certainly be a necessary starting point for a structured discussion about the design of future facilitation schemes and provide a firmer base for future action.

References, chapter 16:

Berndes, G., Hoogwijk, M. and van den Broek, R.,2003, The contribution of biomass in the future global energy supply: a review of 17 studies, *Biomass and Bioenergy,* 25, pp. 1 – 28.

Dir 2008:31, *Sveriges miljöteknikråd — en delegation för miljöteknik*

EEA (European Environment Agency), 2008, *Maximising the environmental benefits of Europe´s bioenergy potential*, Technical report no 10/2008, Copenhagen, Denmark

EU, 2003, Commission recommendation 2003/361/EC

Granovetter, M. 1985, Economic Action and Social Structure: The Problem of Embeddedness, *The American Journal of Sociolog*y, Vol. 91, No. 3 (Nov., 1985), pp. 481-510

IEA Bioenergy, 2009, *Bioenergy – Sustainable and Reliable Energy Source Main report*, ExCo:2009:06

Makower, P. & Pernick, R., 2001, *Clean Tech: Profits and Potential,* CleanEdge

Swentec, 2009, *Handlingsplan för svensk miljöteknik*

Young, M. S., Selto F. H., (1991). ”New Manufacturing Practices and Cost Management: A Review of the Litterature and Directions for Research.” *Journal of Accounting Litterature* : 265-298.

For further information:
Anders Sandoff, School of Business, Gothenburg University

17. International climate policy participation critical for Nordic industry competitiveness

The impact of emissions reduction policies varies by country and by industry. In Sweden, the total impact of climate policies on industries is quite modest, as the services sector is not greatly affected by the decline in output of other sectors. A much clearer impact is seen in Finland, where a larger share of the services sector is composed of industries that use significant amounts of fossil fuels (namely transports and construction). Norway is characterised by a large share of oil and gas production; energy commodities, which are also closely linked to services. Many industries important to Nordic countries face increasing costs under all the scenarios in the period 2004-2020, 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, provide less profitable use of available production factors compared to other domestic industries. However, such a development is largely offset by an overall growth in industrial output, which stays around 3% per annum in all scenarios

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 Sweden these sectors account for 25% of the total electricity consumption, and in Finland and Norway up to more than 35%. 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 manufacturing sectors.

The perspectives for the competitiveness of these industries – market environment, production costs, revenues, and differences between sectors and countries – are discussed against the background provided by GTAP model simulation results for the reference and global scenarios. The “Reference scenario” includes present 20% reduction target and ETS I and II. The “Global policy” scenario imposes an additional 10% reduction for EU, and a commitment of other Annex I countries to limit their emissions with comparable speed. The scenario simulations assume full emissions trading within sectors using fossil fuels and between participating countries. More detailed descriptions and assumptions for the scenarios are presented in Chapter 19.

Challenges from changing market environment, opportunities from cleaner energy

The loss of comparative advantage of energy-intensive industries in Nordic countries is a long-term trend present in all scenario simulations, and confirmed by real life observations such as the recent closures of production plants. Though the economic recession undoubtedly has accelerated the decline, there are more fundamental, long-term changes in the global competitive environment and local Nordic primary factor markets that are affecting energy-intensive industries.

On the other hand, facing the tightening regimes for green house gas emissions reduction, the Nordic countries have an advantage in the potential for clean energy production, which may imply lower energy price increases due to climate policies than in the rest of the world. The geographic and natural conditions in the Nordic countries give opportunities for energy production using land, coasts, forests and hydro power, and there is also unused potential for further wind and solar power. This potential is not fully incorporated in the global economy simulations, but it is explored further in Chapter 20 "Climate challenge – a stimulant for a new Nordic business."

Climate policies make final user energy prices rise and producer prices decline

In the GTAP model simulations, a considerable increase in the global energy consumption is observed. There is a generally increasing trend in oil and gas prices, whereas coal price is decreasing. As expected, the pre-tax world market price is highest when there are no climate policies, because the CO_2 price increases the final price paid by industries and consumers, hence lowers the demand, which in turn causes the supply prices to also decrease.

The world prices for all energy commodities decline significantly with stricter emissions policies. The higher the reduction targets, the lower are primary energy prices before taxes. When moving from European policy commitments in the Reference scenario to a Global policy with ambitious targets for EU, the relative impact on oil price is more severe than on other energy commodity prices. World average electricity prices develop the opposite way, as the CO_2 price is included in the primary energy prices paid by electricity producers.

Nordic energy-intensive industries face increasing costs but stagnant revenue

At the local Nordic markets, the prices of energy-intensive industry products increase significantly under all the scenarios over the simulation period 2004-2020 and beyond. At the same time, the world market price of these commodities remains virtually unchanged, except for refined coal and petroleum products that experience a world-wide price rise as discussed above. Not only are new competitors from Asia and South America benefitting from being closer to the fastest growing demand in the developing world and lower costs for the most important production factors, but the prices for labour in the Nordic countries are also growing faster than in the traditional industrialised competitor countries.

In the period from 2004 to 2020, the price of labour is simulated to grow 15% more in Finland, 10% more in Sweden and 7% more in Norway and Denmark compared to rest of the Western Europe and Northern America. The higher increase in labour prices is supply-driven, as the labour force growth relative to population growth is low in Nordic countries. This, in turn, is mainly due to less profuse immigration compared to other Western countries. This is clearly demonstrated in Figure 17.1, showing the development of local price, reflecting production costs, for paper and pulp sector in Finland and Sweden relative to world market price. The reasons for different European and global prices for Finland and Sweden are discussed below.

Thus, for the energy intensive industry, the production becomes more expensive in the Nordic countries, whilst the income earned at

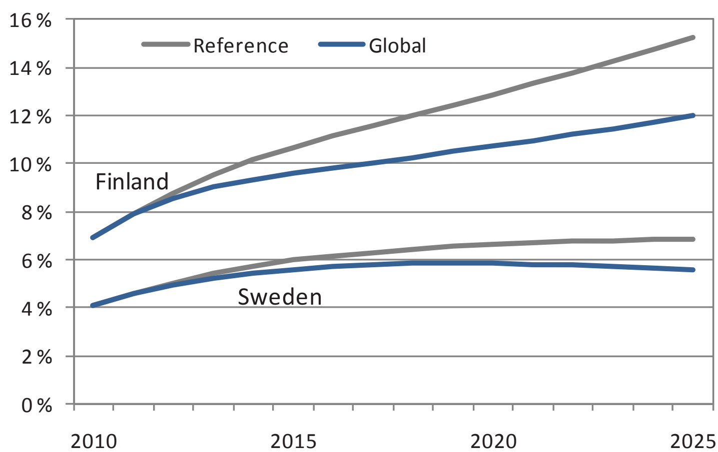


Figure 17.1: Prices for pulp and paper. Development of local prices in Finland as Sweden relative to world market price under "Reference" and "Global policy" scenarios.

world market does not increase in the same proportion. As the energy-intensive industries are typically export-oriented, they are becoming less advantaged compared to the foreign competitors. Both the demand and production of these sectors is moving towards the growing economies in Asia, where the primary factor prices remain, despite rapid growth, at relatively modest levels compared to Western countries in general. In addition, compared to those domestic industries that are able to produce higher value added, the use of available production factors becomes less profitable in the energy-intensive industries.

In absolute terms, however, the energy-intensive industries remain at current levels or grow modestly, since the loss in relative competiveness is offset by overall growth of industrial output, which stays around 3% per annum in all scenarios. Moreover, the observed decline in output levels is also to an extent compensated by higher prices: the value of the output is not decreasing as fast as the quantity, implying that the production within sectors is also moving towards products that have better sales prices.

Losers and winners of different climate policy scenarios

In Sweden, the overall results are similar in both simulations. The EU emissions reduction policies trigger only minor decrease in overall industry output growth in comparison to an experimental scenario with no emissions reduction policies at all, whereas the inclusion of other Annex 1 countries in climate policies results in a considerable increase in Swedish total manufacturing industries output. 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. A closer look at industry-specific results indicates that the main difference between simulations comes from the paper and pulp sector, where the supply price grows with climate polices clearly more than in Sweden for example, as was shown in Figure 17.1 above. The similar pattern is also visible in the rest of the heavy industry.

A large part of the climate policy impacts on industries comes through the electricity price, which is discussed in Chapter 9. The GTAP model simulations give an analogous picture with the other NEP models that focus on electricity demand and price development in Nordic countries: the electricity price in the "Global policy" scenario is lower than in the "Reference case" scenario, and subsequently the aggregate Nordic energy demand in 2020 is 5% higher. The model calculation deals with national electricity prices. In reality there is more or less a common Nordic electricity price. This may lead to slightly exaggerated differences in industry development in the different Nordic countries in the model results.

Figure 17.2 presents the average annual output growths under different scenarios in Finland and Sweden for four manufacturing industry groups. Comparing these results to the real life observations, it should be noted that the model does not provide for currency exchange rate regimes. Though the long-term impact from the inclusion of such policy is likely to be small, it might make the difference even more favourable to Sweden on the short run.

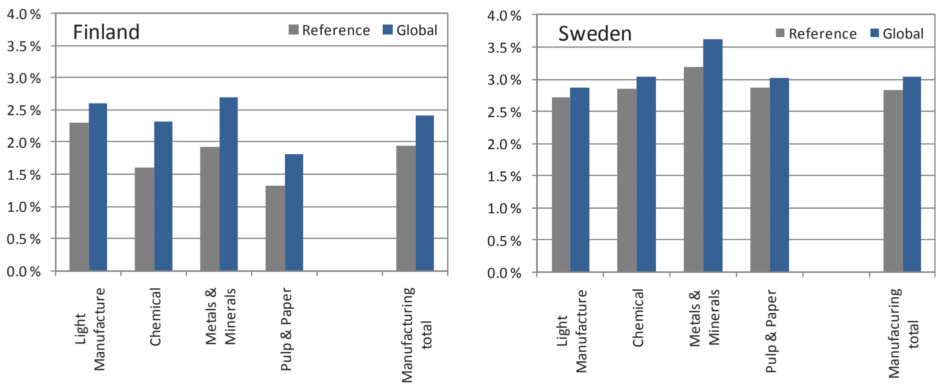


Figure 17.2: Output growth in manufacturing industries, Finland and Sweden. The bars show the average annual growth rates between 2004 and 2020 for manufacturing industries in Reference and Global policy simulations.

Differences explained by characteristics of industries

The impact of climate policies appears severe to the paper and pulp sector in Finland, but does not occur in the same way in Sweden, as illustrated in Figure 17.3. The Finnish paper and pulp industry is hit hard when the burden of emissions reduction is in EU alone, and in contrast has the biggest relative gain from a global policy, as there is a similar climate policy costs for the non-European competitors. There are two prominent explanations to this: the different composition of the aggregated sector ”paper and pulp”, and the price of wood.

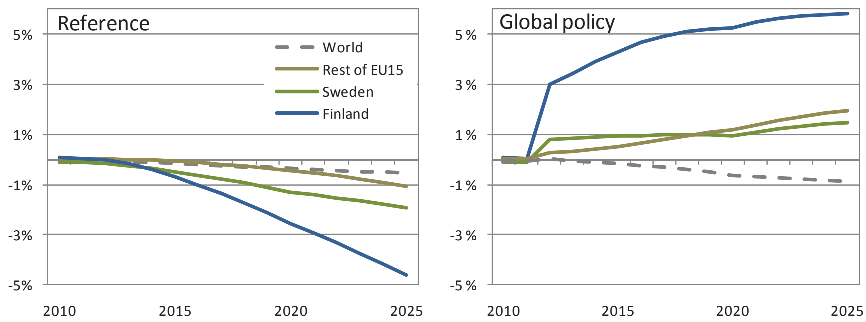


Figure 17.3: Paper and pulp production. Development of supply at the world market and in Finland, Sweden and rest of the EU15 under "Reference" and "Global policy" scenarios.

Within the pulp and paper sector, the share of pulp, out of the total production, is much higher in Finland than in Sweden. Further, paper production in Finland uses relatively more mechanical pulp than the industry in Sweden. Whilst higher share of mechanical pulp implies lower wood consumption, it also increases energy consumption. This is reflected as a larger share of energy in the pulp sector's cost structure in Finland than in Sweden. Energy price is, obviously, one of the factors most affected by emissions reduction policies.

The Finnish industries also face greater increases in wood price than their Swedish counterparts. The reason for this is a high degree of dependence on imports for supply of wood in Finland, which means that the wood price is affected by increased transport costs due to carbon taxes. This can be seen clearly in the high share of transports in the total cost structure of the Finnish paper and pulp sector.

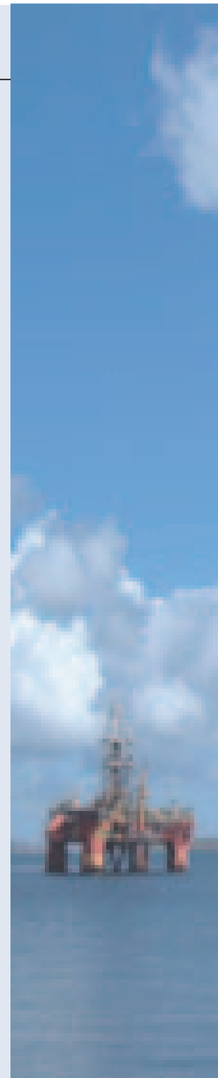
On a global scale, we can see the general trend where the production shifts away from traditional paper producing countries, and most importantly from Europe. Whilst the total output is increasing in all regions, the share of Nordic and also German production of total world trade is clearly decreasing. Related to this, Chapter 18 addresses in more detail several structural changes in Nordic and world forest industries, including the paper and pulp sector in China, Indonesia and Brazil, and differences between types of final products and raw materials used. As the Europe's loss of market share is biggest in the policy scenarios without participation of other countries in the climate policy, the industry development is likely to be accompanied with carbon leakage. This issue is discussed in more detail in Chapter 19.

Metal and minerals industries show quantitatively similar results as the paper and pulp sector. In 2020, the Swedish and Danish metal and mine-

OIL MAKES NORWAY DIFFERENT

Unlike other Nordic countries, Norway is not only characterised by energy-intensive industries but is also a large producer of fossil fuels. This makes a big difference to the simulation results, and complexity is added from the fact that Norway's own power production is not fossil fuel based. If there were no climate policies at all, the strong increase in global energy demand would make the simulation results show high growth figures for the Norwegian petroleum sector and decline of other industries, as the policy measures to restrict such development are not incorporated in the model. The oil price changes in different scenarios, greatly influencing the prices of production factors in Norway, and thus costs in all energy-intensive industries. Therefore the differences between different policy simulations are particularly noticeable in comparison to the other Nordic countries.

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. Hence, despite the fast increasing primary factor prices mentioned earlier, as the pre-tax oil price growth is slower with tightened climate policies, it becomes more profitable to use the production factors to other sectors than petroleum. Industries that compete for the same resources with the primary energy producing sectors will benefit from increased supply and lower prices. The Norwegian energy-intensive industry has a double advantage of having relatively clean energy available, and increased production factor supply (and lower prices) with climate policies. At sector level, the mineral industries behave quite similar to the other Nordic countries, but the impacts on metal industries are clearly more sensitive to the policy regimes



rals sector output in the Global Policy scenario is 7% higher than in the European Policy scenario, and in Finland the difference is 12%. Within the aggregated sector, iron and steel industry in all countries is clearly more sensitive to climate policy regime than other industries, and between the countries, Finnish industries are more sensitive than their Swedish and Danish counterparts.

Overall welfare losses are small but clearly influenced by policy

As discussed in Chapter 19, the emission reduction policies affect macroeconomic performance in developed countries relatively little even with high reductions in CO_2 emissions. However, how the distribution of welfare losses are divided between countries is greatly influenced by how much of the industrialised world is covered by the climate policy regime. The gross domestic product in 2020 in Nordic countries would be about 3% higher with the Global policy than in the reference case.

Figure 17.4 shows the difference in real GDP levels compared to the Reference scenario in the Nordic countries. It shows that, in accordance with the results for energy-intensive industries, Finland is the most sensitive to the policy regime whereas the influences on Swedish economy are smaller. Further, in the long run, the impacts of the Global policy are less straight forward due to the permanent changes in global demand for different industrial products.

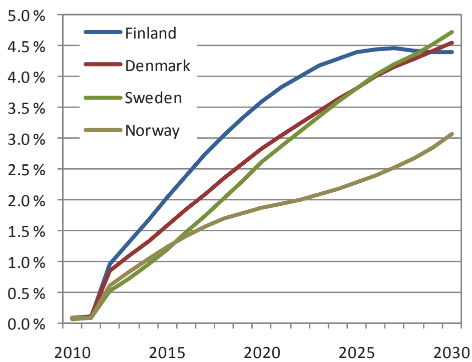
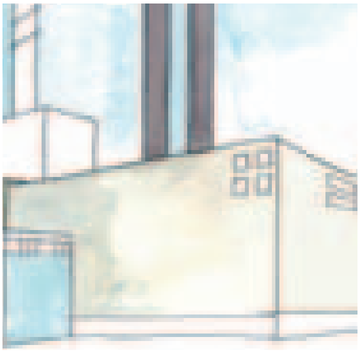


Figure 17.4: GDP in Nordic countries. The figures show the difference in real GDP levels in the ”Global Policy” scenario compared to the ”Reference” scenario.

For further information:
Janne Niemi and Juha Honkatukia, VATT

Industrial development and future export for Nordic industry – opportunities and challenges

International interest for Nordic environmental technology has been growing immensely over the past few years. Sub-segments such as water treatment, waste management, renewable energy and energy efficiency are on top of the international agenda. The demand for e.g. bio-energy solutions for the production of heat, electricity and transport fuels is growing all over the world. Driving forces are environmental concerns, climate focus and urbanization.



In the NEP project we have investigated the possibilities for the Nordic countries to meet these global challenges. There is a chance that Nordic industry could get a boost from climate and energy policies. The picture is, however, mixed and there will be both winner and losers. Global climate policies would be considerably more favourable for Nordic industry than regional EU policies.

Macro economic changes

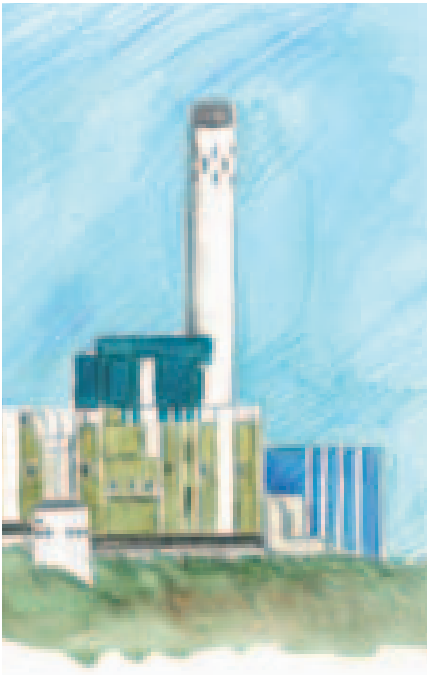
The growth in world population and economy drives the demand of scarce commodities that are difficult to substitute, such as primary energy, as well as generally all primary production factors. This growth drives international energy prices and shift traditional industries to regions with lower price for labour and resources. In the Western world in general, and in the Nordic countries in particular, the share of manufacturing industries decreases in favour of services and industries with high degree of processing. Attempts to limit the green house gas emissions with climate policy regimes can be compromised by carbon leakage if the participation in the regime is not global. Further, the cost of the reductions can be decreased if more countries are included in emissions trading.

Can energy also in the future support the global competitiveness of Nordic industry?

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 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 manufacturing sectors.

The loss of comparative advantage of energy-intensive industries in Nordic countries is a long-term trend. Though the economic recession has undoubtedly accelerated the decline, there are more fundamental, long-term changes in the global competitive environment and local Nordic primary factor markets affecting energy-intensive industries. This is discussed further in Chapter 18.

On the other hand, facing the tightening regimes for green house gas emissions reduction, the Nordic countries have an advantage in clean energy production, which may imply lower energy price increases due to climate policies than in the rest of the world. The geographic and natural conditions in the Nordic countries give opportunities for energy production using land, coasts, forests and hydro power, and there is also unused potential for further wind and solar power. Another example is the forest industry. Climate policies stimulate the forest industry to develop new high-value products such as new biomaterials, liquid bio-fuels, and electricity from renewables. This could balance reduced competitiveness for pulp and paper.



Case study: Time consuming physical presence in local markets is often necessary

Given the right conditions, the biomass combustion sector is an example of a branch that can become a booming market for the coming 20 years. The biomass combustion sector is one of the sectors in the Swedish Clean Tech industry that has been identified as especially promising by Swedish authorities and is also receiving international recognition. The results have so far not lived up to expectations something that support the belief that existing Clean Tech facilitation schemes do not trigger a satisfactory increase in growth and export volumes in companies with a long operating history. This is a business context that stands apart from the typical Clean Tech companies commonly referred to in media reporting; very small, innovation-driven start-up companies with difficulties finding venture capital.

The results from our work indicate that in order to increase low to moderate growth and export volumes in small Clean Tech companies characterized by an extensive operating history, these companies must increase their physical presence in these markets.

The relatively complex product demands high standards regarding abilities to manage intricate procurement processes, capabilities for onsite construction management and subsequent operating training. In markets where the concept of biomass combustion is new or unknown there is also a great demand for educating the customers and offering help to establish a business model for the customers regarding necessary supply chains. The difficulties involved establishing these international sales organizations are prominent in these companies.

The need to get involved in these markets through stakeholder collaboration is framed by prior experiences. In many instances these experiences have been negative from the company's point of view. Small organizations have limited capacity to engage in these long ranging and time consuming activities with rather uncertain and sometimes also vague value to the company.

18. The Nordic forest industry

- a temporary dip or the beginning of a structurally driven decline?

The paper and pulp industry has been the backbone of the Nordic industry for a long time. However, in recent years the industry has faced economic difficulties and is no longer growing. The industry has a large impact on the Nordic energy markets both as a large consumer of electricity and as a producer of electricity and heat. The forest industry is of course also a huge consumer of wood and a producer of leftover materials that can be used as biofuels. Understanding the factors that will influence the future development of this industry is paramount in understanding the future for the Nordic energy markets. This perspective is mainly based on the NEP report "Wood markets and the situation of the forest industry in the Nordic countries".

A production decline

Preliminary statistics show a rather dramatic decline for the Nordic paper and pulp industry in 2009. The Finnish industry has been particularly hit. The Swedish industry has done better, being able to benefit from a weak currency.

BASIC FACTS ABOUT THE NORDIC FOREST INDUSTRY

Turnover: 50 billion EUR (2007)
Net exports: approximately 35 billion EUR
Electricity consumption: 60 TWh (2007)
Electricity generation: 18 TWh (2007)

Structural threats observed long before the financial crisis

The Nordic forest industry has historically profited from a relative closeness to both customers and raw materials. Other advantages include relatively low electricity prices and a high proportion of raw materials 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 growing at a high rate of about 10 % per year. Nevertheless, this increase in demand has been met by an even larger growth in the production capacity of pulp from fast growing eucalyptus and rainforest wood. China imports fibre, but its paper production has increased significantly and China is now a net exporter of paper.

- Demand for newsprint has already fallen in the United States, and is now falling in Europe as well.
- A continuing modification of eucalyptus trees towards longer wood fibres will result in a larger supply of newspaper quality fibre and therefore increased competitive pressures on the Nordic forestry industry. Even Russia is expected to increase production of newsprint-quality pulp.

Price increases and the ability to pay for electricity and wood

Parallel to the structural changes affecting the Forest industry, we have seen a rapid increase in both electricity prices and prices for wood in the Nordic region. One reason for the rise in electricity prices is the introduction of a price on carbon in Europe, something not affecting non-European competitors. The increase in wood prices can partly be explained by the rapid increase in demand for biofuels, partly driven by strong support schemes in Sweden. This is one of the reasons the Forest industry in Finland was against joining the Swedish electricity certificate system even though the industry would have received certificates for the electricity produced from leftover products from their production processes. Export tariffs on wood from Russia are also driving up the price of wood, especially in Finland.

In an attempt to illustrate how the profitability of the industry depends on the price of raw materials and on the price of electricity, we have looked at historical profit margins in the industry and at the production technology used. We then calculated the electricity price and the wood price at the point in which the various parts of the industry reach break-even. These breakeven points were then plotted in a diagram. We call the resulting curve “the ability to pay curve” (ATP). In figure one this is calculated for the Swedish forest industry for wood and for the Nordic forest industry for electricity.

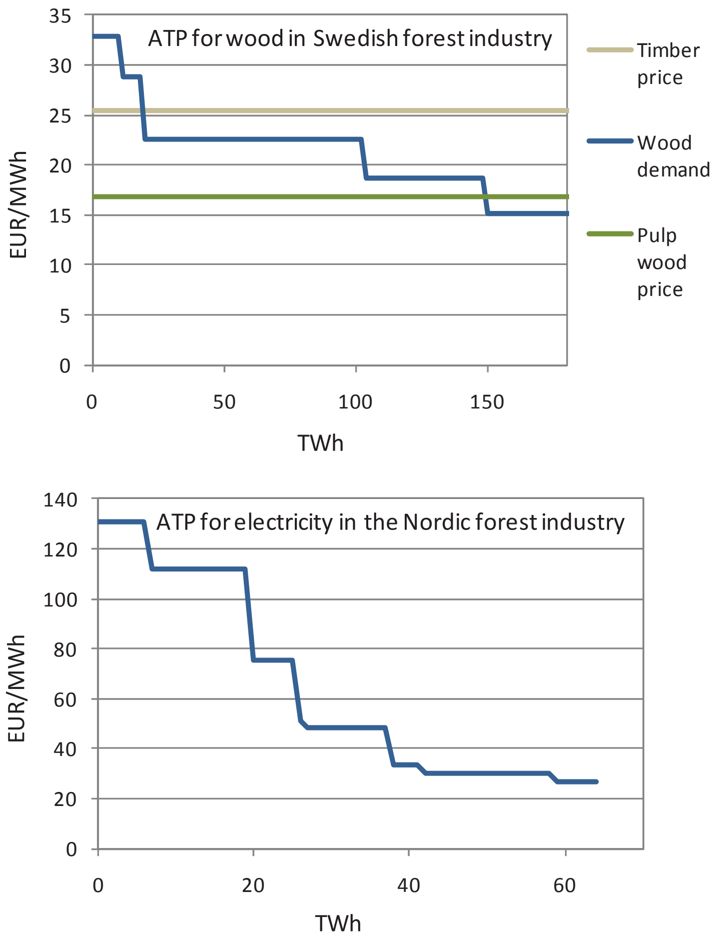


Figure 18.1: Ability to pay (ATP) for wood in the Swedish forest industry and the ability to pay for electricity in the Nordic forest industry.

Looking at the ATP for wood from right to left we see "pulp", "other paper", "saw mills", "newsprint", and at the top "other print paper". We have included two lines in the figure that illustrate the present price level in central Sweden for pulpwood and timber. Looking at the ATP for electricity we see from right to left "newsprint Norway" "newsprint Sweden and Finland", "mechanical pulp", "corrugated card board", "chemical pulp", "other paper" and "other print paper".

In our scenarios, electricity prices range from 40 to 50 EUR/MWh, but one should be careful to draw too strong conclusions based on the exact levels.

Newsprint has a low ATP for electricity, but a high ATP for wood. This is natural since this production uses a lot of electricity but much less wood than paper based on chemical pulp. The situation is similar for mechanical pulp. "Other print paper" has a high ATP for both wood and electricity. The ATP for wood is low for pulp, especially chemical pulp. The ATP for electricity is also rather low for chemical pulp, not because high electricity use but on an overall low profitability for this part of the industry.

To corroborate our results we have conducted interviews with representatives from the forest industry, and these interviews confirm the rough picture painted here.

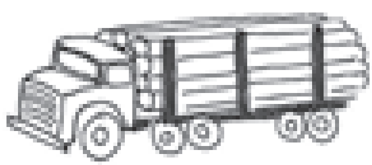
Does this mean that significant parts of the Nordic forest industry will be forced to close down, and that large amounts of wood will be diverted to other areas such as energy? We know that the industry is currently facing problems. This is quite obvious from company statements and the closure of plants. However, important adjustment measures from the industry are to be expected.

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 that 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. In that case, low wood prices will give the Nordic forest industry a comparative advantage over competitors in importing countries.

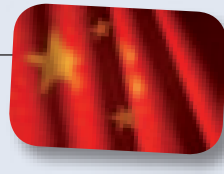
World market for biomass, competition from the energy sector and the role of China

The interaction between the forest industry and the energy sector has increased because of the strong drive for carbon-free, domestic energy. The forest industry competes with the energy sector for raw materials, but is also the major supplier of biofuels. To understand how the competitiveness of the Nordic forest industry will develop in the future, one must also consider the following facts:

- One advantage for the Nordic forest industry is that production of pulp and paper is usually integrated, which allows for more energy-efficient production. Nordic pulp and paper facilities are also relatively new and efficient.
- Developing new eucalyptus plantations and production facilities that use eucalyptus wood usually takes a very long time. In addition to the actual production plants, new infrastructure such as roads and harbours will be needed.
- International climate policies may also reduce the supply of wood from rainforests. This could drive up the price of wood in developing countries and reduce their competitive edge in the market for forest products. Restrictions on new eucalyptus plantations, due to water problems for example, could also result in higher wood prices in developing countries.
- The possibility of a "China-effect" in the future cannot be ruled out if Chinese demand for fibre cannot be met by supply. This might also lead to higher paper prices, but these price increases would be limited as long as China is a net exporter of paper.
- The electricity price in the Nordic region is important for the competitiveness of the Nordic pulp and paper industry. Results from the NEP model group indicate that electricity prices in the Nord Pool region may be rather low in the next few decades. Had the models considered the structural problems faced by the forest industry, the electricity prices would have been even lower (see Chapter 8 and 9).
- The forest industry is developing new high-value products such as new biomaterials, liquid biofuels, and so on. Successful development of these products could lead to a renaissance for the Nordic forest industry.



CHINA's SUPPLY OF FIBRE THREATENED?



Today China imports almost half of the fibre it uses. One quarter is waste paper imports that come mainly from the US. Reduced demand for newsprint in the US could reduce the amount of waste paper that China can import from the US. This shortfall would then have to be replaced by other source of fibre.

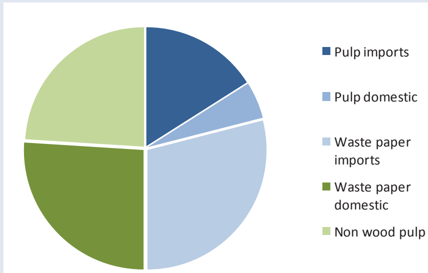


Figure 18.2: The fibre sources for paper production in China 2004. Source: China Paper Almanac 2004

Indonesia is the main exporter of pulp to China. Brazil is also a big exporter, in spite of long transport distances. A big share of the Indonesian pulp production comes from rainforests. Deforestation in rainforests in Indonesia and Brazil account for 25% of the world's total greenhouse gas emissions. If pulp exports from Indonesia to China are reduced as a consequence of climate change policies, China may again find it difficult to satisfy its demand for fibre.

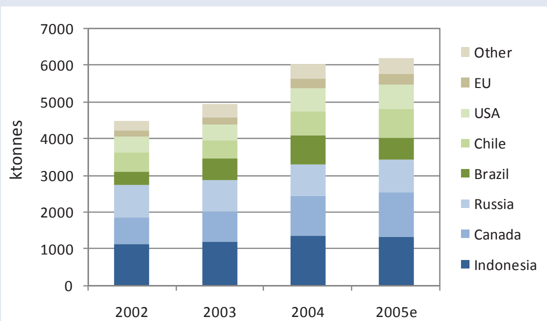


Figure 18.3: China's import of chemical pulp from 2002-2004 and an estimate for 2005.
Source: Global trade atlas, China import data

These are two examples of supply-side problems that could generate a "China effect" on pulp. A strong increase in Chinese consumption of pulp and paper would have a similar effect.

For further information:
Peter Fritz and Per Erik Springfeldt, Sweco

19. Broader participation required for successful emissions reduction as global energy demand increases

The growth in world population and economy drives the demand of scarce commodities that are difficult to substitute, such as primary energy, as well as generally all primary production factors. This leads to increased world market oil price and shifting of traditional industries to regions with lower price for labour and resources. In the Western world in general, and in the Nordic countries in particular, the share of manufacturing industries decreases in favour of services and industries with high degree of processing. Emissions reduction policies tend to accelerate this development. Growing economies also trigger an increase in energy use and green house gas emissions. An attempt to limit these emissions with climate policy regimes can be compromised by carbon leakage if the participation in the regime is not global. Further, the cost of the reductions can be decreased if more countries are included in emissions trading.

Reference and policy scenarios

The results from simulation with the Global Trade Analysis Project (GTAP) model focus on the period until year 2020. However, long-term projections for the macro variables have been obtained up to 2050 to enable the integration with the Nordic Times model, which by nature requires a very long time horizon.

Two of the GTAP model scenarios presented here correspond to the NEP modelling group policy scenarios presented in the Chapter 8, with minor differences. The "Reference" scenario incorporates EU's present 20% reduction target and ETS I and II, and the "Global policy" scenario simulation features an additional 10% reduction for EU and a commitment of other Kyoto Protocol Annex I countries to limit their emissions with comparable speed. The "2°C policy" scenario relates to the results presented in Chapter 20, and includes the emissions reduction requirements generated by the Nordic Times model to meet the 2°C target. The model simulations assume full emissions trading within sectors using fossil fuels and between participating countries. This produces an economically optimal shadow price for CO_2 emissions. In reality, the industry coverage of the trading is more limited, and only parts of the allocated caps are subject to trading. In other NEP model group simulations, different assumptions about the emissions reduction regimes are used, as discussed further below.

Implications for the Nordic industries in the "Reference" and "Global policy" scenarios are discussed in detail in Chapter 17.

Macroeconomic development

Assumptions about the growth of various macroeconomic driver variables are a starting point for the scenario work and given as an exogenous input to the simulations. The long-term projections on labour, population, and productivity or real GDP growth are incorporated in the scenarios, and the same figures are also used for scenarios presented in Chapter 20.

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. 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 9-10% in countries like China and India. By the year 2050, the extreme growth figures are projected to come closer to those in developed economies. It is important to be aware of these assumptions, since the have a significant impact on the final results.

Table 19.1 summarises the population, labour force and real GDP growth rates used in the baseline simulations for Nordic countries and other country groups. These are "normal", average rates in a equilibrium growth path, and for example the impact of the present economic recession are not included in the baseline projections.

Table 19.1: Macro drivers. Average annual growth rate assumptions 2004-2020 used in the simulations

	Population	Labour force	Real GDP
Denmark	0.4%	0.1%	2.7%
Finland	0.4%	0.1%	3.0%
Norway	0.9%	1.1%	3.2%
Sweden	0.7%	0.7%	3.3%
Western Europe	0.6%	0.7%	2.7%
Eastern Europe (incl. former SU)	-0.2% … -0.1%	-0.3% … 0.1%	5.1% … 5.6%
Other developed countries	0.0% … 1.3%	-0.3% … 1.3%	3.3% … 4.0%
China	0.7%	0.6%	9.5%
Other developing countries	1.5% … 2.8%	2.2% … 3.4%	5.0% … 8.8%

Global development characterised by 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, above all in China, energy takes an increasing share of total industry output value until 2020. 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.

ASIAN ECONOMIES INFLUENCE THE GLOBAL DEVELOPMENT INCREASINGLY

The weight of Asia in the global economy is increasing, and the development in Asia has a significant impact on the whole world. In addition to the overall growth, one striking characteristic is the growth of skilled labour especially in China, which has triggered an economic growth reaching 10% annually. A similar, though less dramatic pattern, applies to the developing South-East Asia. In the long run, relatively small differences in assumptions will cumulatively result in significantly different outcomes. To study these implications, we look at the results of an alternative scenario where the GDP growth rate in all developing Asia is cut by one percentage point, which corresponds to about 13% lower GDP growth for this region. All other assumptions are as in the "Reference" scenario.

Globally, each 10% reduction in developing Asia GDP growth results in a growth decrease of 2% for world GDP, 3% for investments, 3% for international trade and 5% for the price of primary factors. The CO_2 emissions grow 6% less than in the "Reference" scenario.

The differences in Asian growth assumptions have varying impact on global industry output results, but it is generally higher for the manufacturing sectors than impact on GDP. The output differences are particularly large in iron and steel sector (–4%), whereas paper and pulp industry impact is in the same range with the GDP, other heavy industries falling in between. In the Nordic countries, the falling global demand for industry products is offset by the lower supply form Asian countries: Nordic industries are in fact able to increase their global market shares, and the impact of Asian lower growth remains small.

World economies grow, emissions grow and leak

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 relative to GDP growth is high. This is shown in the policy scenarios comparing the countries that participate in the climate policy to those that are outside the regimes. Figure 19.1 shows how much the CO_2 emissions in different scenarios and regions grow as a percentage of the GDP growth. In developing countries, the emissions growth rates are more than 70% of the GDP growth rates in scenarios where they have no climate policy commitments. In non-participating developed countries the ratio is even higher. Instead, the emissions growth is only a bit over 50 percent of the GDP growth in all regions participating in climate policy under any regime. As the GDP growth differences between different scenarios are very small whilst the ratio of emissions to GDP growth drops significantly when emissions reductions are imposed, the impact of climate policy on the overall economic performance is small.

The simulations also show evidence on *carbon leakage*. In the developing

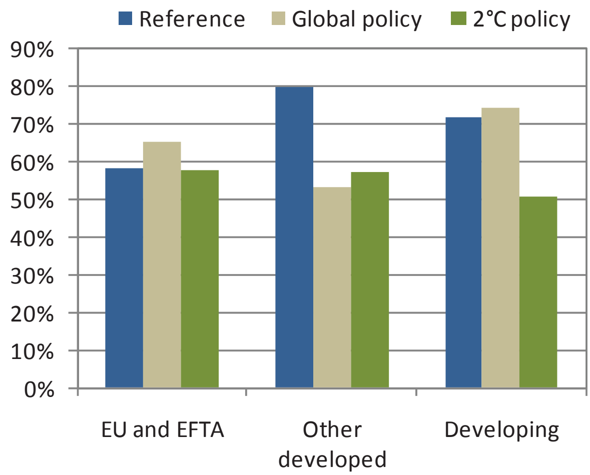


Figure 19.1: Ratio of CO_2 emissions to GDP growth 2004-2020

countries, fast economic growth is accompanied with increased emissions, as discussed above. In the reference scenario, developing countries account for 77% of total world CO_2 emissions growth in the period 2004-2020. However, emissions are growing fast not only in the developing countries but also in those Annex I countries not committed to international climate policy. Figure 19.2 shows regional and world emissions in "Reference" and "Global policy" scenarios compared to a hypothetical scenario with no climate policies at all. In the "Reference" scenario, 70% of the reductions in the EU are offset by emissions growth in other regions. One fourth of this leakage is attributable to other rich countries, about 60% to the develo-

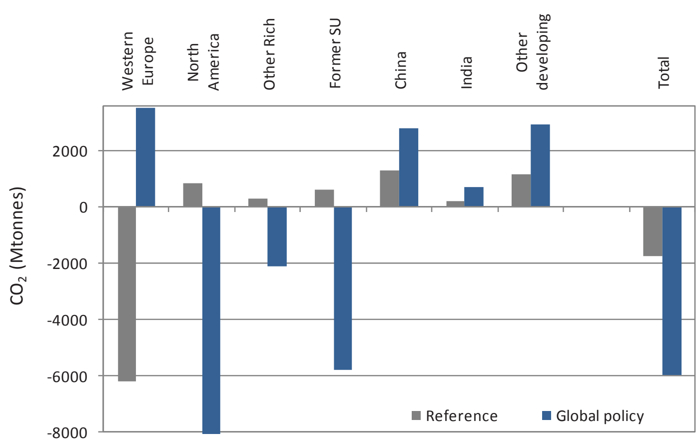
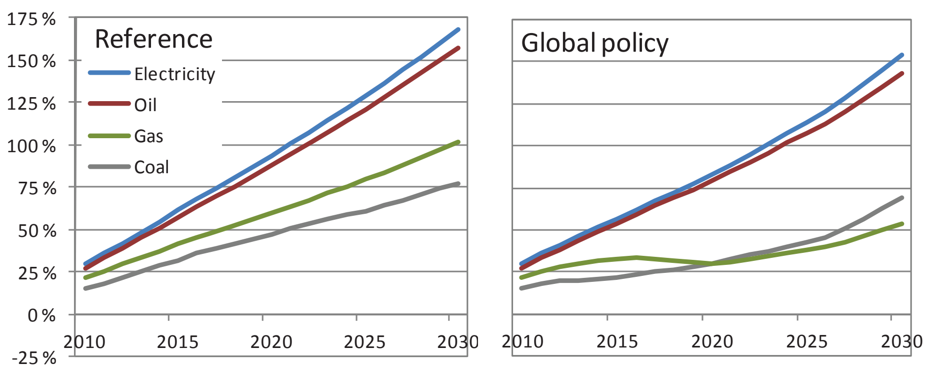


Figure 19.2: Carbon leakage. World emissions in 2020, difference to no climate policies in Megatons of CO_2

ping countries and the rest to former Soviet Union countries. In the “Global policy” scenario (with a commitment for all developed countries), EU emissions actually increase, as permits are bought from other countries, especially USA, where reduction costs are considerably lower. At the same time, the leakage to developing countries grows in absolute terms, but relatively speaking the total leakage is only half of the reduction in Annex I countries.

Whilst the overall energy demand grows steadily in all climate policy scenarios, there are significant differences between different forms of energy. Generally, electricity use is growing faster than fossil fuels, especially coal and natural gas use. It can be seen in Figure 19.3 that the difference becomes particularly prominent with ambitious emission targets in the “2°C policy” scenario. This result is in line with the electrification of the energy system suggested in Chapter 20, and also interesting in light of the implications to the Nordic electricity market presented in Chapters 8-9.



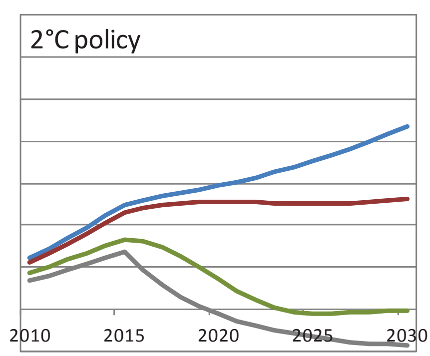


Figure 19.3: World energy use. Global demand for fossil fuel based primary energy and electricity under different scenarios, %-difference to the base year 2004.

Lower emissions with less cost by including more countries in climate policies

In chapter 20 it is shown that EU's CO_2 emission reduction target for 2020 could be achieved with an allowance price of 20-30 €/t CO_2 at global emissions trading market. The emissions prices generated by GTAP model for the "2°C policy" are somewhat higher, about 40 €/t CO_2 in 2020, since they do not take into account the energy efficiency or other technology improvements, and instead of marginal cost of technology, they represent the total economic cost of a policy. Figure 19.4 shows the development of the emission permit price under different scenario simulations as an index of simulated 2008 price (4-5 €/t CO_2).

In the "2°C policy", the price increases steadily as the target gets more ambitious. Although the overall emissions reduction target is highest in the "2°C policy" scenario, the CO_2 price increases more in the "Reference" scenario, especially in longer term. The "Global policy" scenario shows a drop in the permit price at the point where all Annex I countries join the trading scheme, after which it increases at approximately the same rate as in "2°C policy" scenario.

Other similar scenarios have been calculated in the NEP model group[x] . The results from those scenarios show both similarities and differences with the GTAP scenarios. The differences can largely be explained by the different modelling approach and assumptions about CO_2 price formation. The model group's other scenarios only include the Nordic region, and the global development is therefore only included as system boundary assumptions (e.g. different assumptions on climate-change mitigation goals in regions

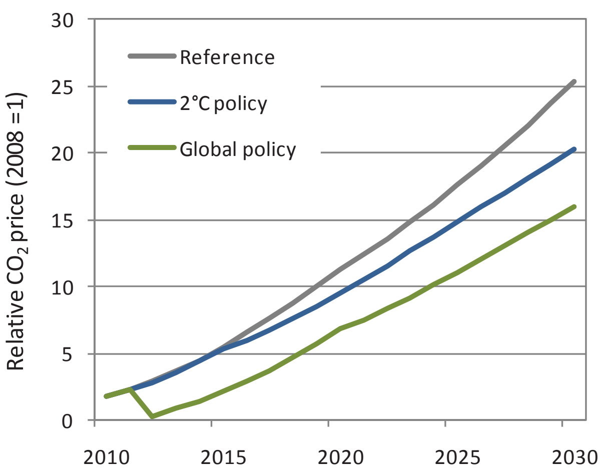


Figure 19.4: CO_2 price. Price development of CO_2 ton under different policy scenarios (2008=1)

x) see the NEP report "Insights from NEP policy scenario simulations" outside the EU), whereas in the GTAP simulations, unrestricted trading of emission permits between regions guarantees the lowest CO_2 price at any time as the reductions always take place where they are least costly. Another example of the modelling differences is that the technical bottom-up models assume that carbon capture and storage (CCS) will be commercially available 20 years from now, thereby establishing a ”backstop technology” that leads to an upper limit for the CO_2 price. Such technological development is not endogenously described in the GTAP model.

In the “Global policy” scenario, the emissions reduction target for the world is lower than in the “2°C policy” scenario, but for the EU, target is much stricter than in the “Reference” scenario. Thus, a climate policy regime that covers more industrialised countries implies lower CO_2 prices for European industries compared to present, even if this involves more reductions for the EU.

For further information:
Janne Niemi and Juha Honkatukia, VATT

20. Global climate challenge – a stimulant for a new Nordic business

The EU has agreed to adopt the necessary domestic measures to ensure that global average temperature increases do not exceed pre-industrial levels by more than 2°C. This target was also agreed in Copenhagen Accord at the United Nations Climate Change Conference in 2009. Tackling climate change to a safe level would require from 50 to 80% reductions in global greenhouse gas emissions compared to the present level by 2050, which would need a total change of the existing energy systems and could stimulate a new industrial revolution. Nordic countries have long traditions in developing and using low carbon technologies, like renewable energy technologies and CHP, as well as energy efficient solutions in residential and industrial sectors. Tackling climate change would create huge markets for clean energy technologies, and Nordic industry could take a great advantage on this. On the other hand, the cost efficient mitigation path indicates that electrification of the energy system could partly solve the climate problem. Nordic countries also have good possibilities to increase their "zero or even negative emission energy production" by 2050 and export renewable fuels or electricity to the neighbouring areas. Nordic business around clean energy could be developed both by technology transfer and energy export creating new possibilities for the Nordic welfare.

Long term development of Nordic, European and global energy systems have been studied to evaluate the cost effective transition towards low carbon energy systems. The energy and emission scenarios presented below take into account the whole energy system from fuel procurement and energy production to energy end use in different sectors as well as all the Kyoto greenhouse gas emissions and their reduction measures. The aim of these studies was to give a widened view of the impacts of long term climate policies on future energy systems as well as to evaluate demands of clean energy technologies on the global markets.

Two energy system models have been used: the Global TIAM model created under the IEA/ETSAP collaboration and Nordic TIMES model further developed by VTT. The scenarios studied include Baseline scenario and global policy scenario with deep emission reductions. The Baseline assumptions for GDP development are described in the Chapter 19. In the global policy scenario the impact of the 2 °C target on greenhouse gas emissions have been simulated assuming global emissions trading and global consensus to tackle climate change. The so called 2°C Market simulation case represents global minimum in costs (or global maximum in consumer welfare) to tackle climate change. The Nordic scenarios include also simulation results with different CO_2 allowance price levels. In these "EU policy" simulations it is assumed that only EU has climate targets after the Kyoto period, which is achieved by emissions trading.

2°C degree target would require zero CO_2 emission levels and radical decrease of all the greenhouse gases ...

The Figure 20.1 shows the global CO_2 emissions in the Baseline and global policy scenario with 2 °C mitigation target up to 2100. The scenario results illustrate the required emission reduction level and emission reduction path in the shorter term. The largest share of emission reductions would be realized by conventional technology change, i.e. by increased use of renewables, nuclear and other low carbon fuels, and especially by improvement of energy efficiencies through the whole energy chain. Large share of emission reductions could be realized by investing in carbon capture and storage (CCS) integrated to fossil fuel fired energy plants as well as to industrial processes. Even bio-CCS with "negative" net emissions seems an attractive option, i.e. CCS equipped with co-firing of fossil fuels and biomass or CCS integrated to a pulp industry. It should be noted that in these scenarios it is assumed that deforestation has been stopped and natural sinks have been increased by forestation. The opposite trend would make climate change mitigation even more challenging.

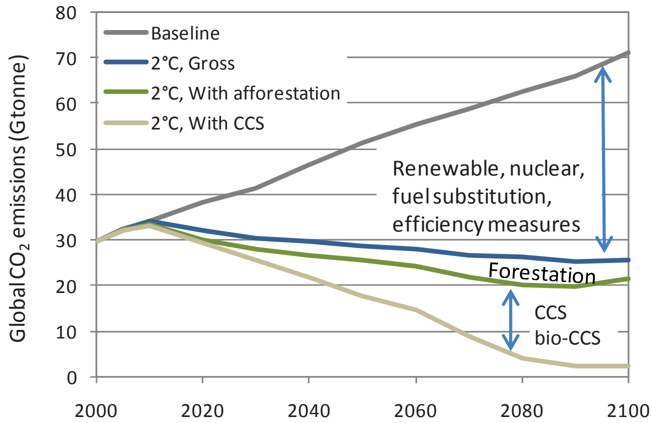


Figure 20.1: Global CO_2 emissions in the Baseline and 2 °C mitigation scenarios.

Figure 20.2 shows the development of greenhouse-gas emissions in Western Europe (i.e. EU-15, Iceland, Malta, Norway and Switzerland) by 2050 for the CO_2 price level of 50 EUR/t with regional climate policies. The results also indicate that EU's CO_2 emission reduction target for 2020 could be achieved without any other further measures than CO_2 price if the allowance price exceeds 20-30 €/t CO_2 in 2020.

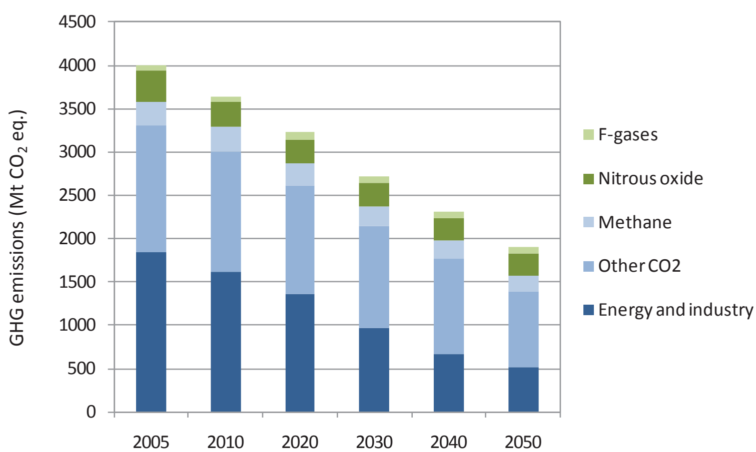


Figure 20.2: Greenhouse-gas emissions in Western Europe. The assumed CO_2 price increases linearly from 20 €/t in 2020 to the indicated price level of 50 €/t in 2040. Sector "Other CO_2 " includes emissions from transport and residential sectors.

Figure 20.3 shows the corresponding development of greenhouse-gases but includes different CO_2-price levels. The results show that by 2050 the EU's energy system could be CO_2 emission free with the highest emission price scenario assumed. In that simulation case the greenhouse gas emissions were reduced about 75% by 2050. The figure also indicate that radical reduction of non-CO_2 greenhouse gases as well as CO_2 emissions from other than stationary energy sector would be very expensive or even impossible. Much of those emissions originate from land use changes and agriculture, and reduction of those emissions would require changes of communities, human behaviour and strong policies. The slow renewal rate of buildings and infrastructures also restrain emission reductions.

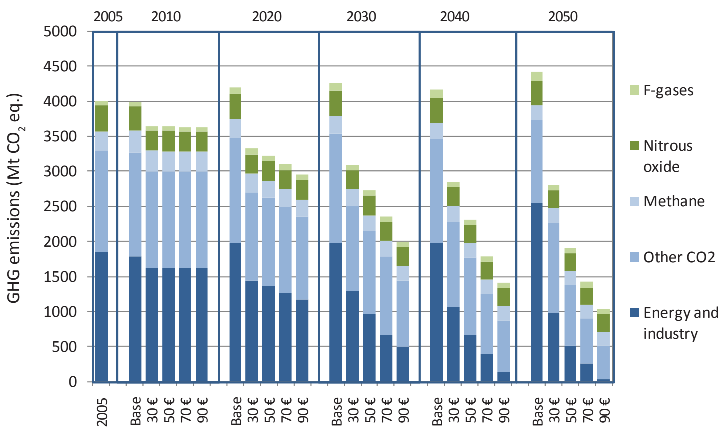
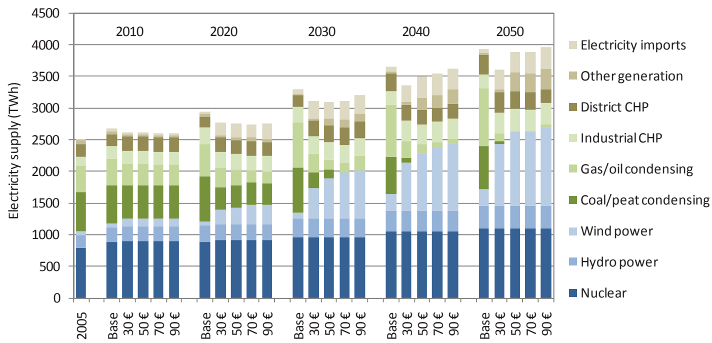


Figure 20.3: Greenhouse gas emissions in the Western Europe with different CO_2 price scenarios. The assumed CO_2 price increases linearly from 20 €/t in 2020 to the indicated price levels in 2040. Sector "Other CO_2 "includes emissions form transport and residential sectors.

Electrification of the energy system could be one solution for the climate challenge

Scenarios on future electricity production indicate that transforming the energy system from utilizing combustible fuels towards using electricity would be a cost efficient measure in climate change mitigation. However, this would require that electricity production is based on low carbon alternatives, i.e. renewables, nuclear and/or fossil fuels with CCS. The Figure 20.4 shows the total net electricity supply in the Nordic area and Western Europe in the Baseline and EU policy scenarios.



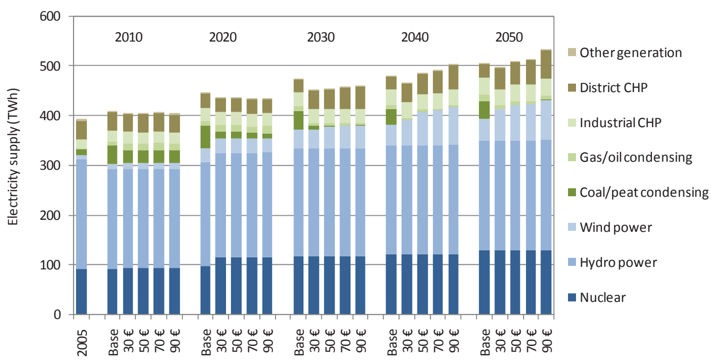


Figure 20.4: Total net electricity supply in the Western Europe (above) and the Nordic area (below). The assumed CO_2 price increases linearly from 20 €/t in 2020 to the indicated price levels in 2040. Sector "Other generation" is mainly other renewables than hydro and wind power.

It is clearly seen that in the longer term electricity production increases with increasing CO_2 price indicating electrification of the energy system. In 2020 the energy system is still largely based on existing generation mix and with increased CO_2 price investments in energy saving would dominate. However, it should be noted that in these scenarios the EU's targets for renewables has not been taken into account and therefore the share of renewables in 2020 could be even higher than presented. Another important result from the simulations is that Nordic countries would become net electricity exporters while Western Europe would import much of its electricity. The same conclusion has been drawn from the scenario calculations with the other Nordic models used in NEP project.

Climate change mitigation and increase in energy demand in the developing countries would create huge markets for clean energy

Global simulations indicate rapid increase in energy demand in the developing countries both in the Baseline and global policy scenarios. The primary energy consumption in developing Asia alone could comprise about 30% of the world's primary energy in 2050. The EU statistics indicate that the market areas of Danish, Finnish and Swedish energy technology exports differ greatly due to different energy technology expertises. All the Nordic countries have strong expertise on renewables, especially on biomass and biowastes (Finland, Sweden, and Denmark), wind (Denmark and Finland) and hydro power technologies (Norway, Sweden, and Finland). Norway has also developed and demonstrated CCS technologies, which is also becoming more important in Finnish R&D.

Figure 20.5 shows the capital expenditures needed for selected technology groups in power and heat generation in the global policy scenario with the 2°C mitigation target. It is clearly seen that in the longer term the largest share of investments would be in the non-OECD countries. For wind power, larger share of investments takes place in the OECD-countries, especially in the shorter term. It should ne noted, however, that capital expenditures for both nuclear power and hydro power would be very significant between 2020 and 2050. Both of these investments are usually regulated by national policies, which could prohibit these investments in the future, when the picture would be significantly changed.

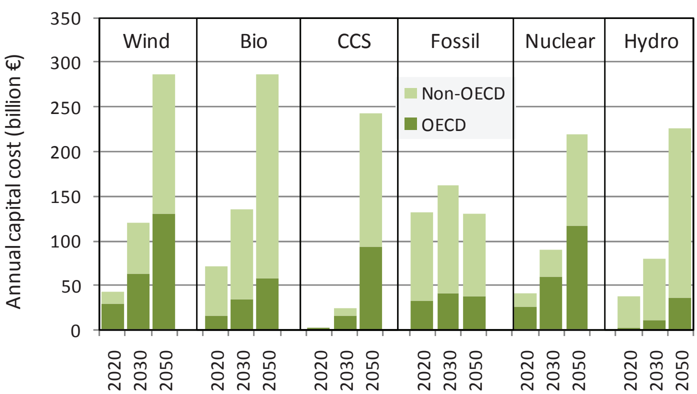


Figure 20.5: Annual capital expenditures on new power and heat generation capacity in 2020-2050, 2 °C Market scenario.

For further information:
Tiina Koljonen and Antti Lehtilä, VTT

21. Perspectives on security of supply issues in the Nordic countries

Security of supply (SoS) is one of three cornerstones of European energy policy. The EU Council of Ministers expediently approved the EU Renewables Directive after a proposal by the EU Commission. The reason for this quick acceptance of the Directive was a concern for energy SoS in the EU, possibly aggravated by SoS problems resulting from Russia shutting off all gas supplies to Europe through the Ukraine a few months earlier. In spite of all this, we have found that it is very difficult to discuss these issues in a Nordic context.

Mixed views on what the SoS issues are for the Nordic region

To get a feeling for what energy experts feel about SoS we constructed a questionnaire where respondents provided information on their opinions about various aspects of SoS in the energy sector in their own country and in the Nordic region as a whole. We asked energy experts, including participants in the research group and financiers of this project to participate.

Table 21.1: Summary of answers from the SoS questionnaire. Responses are graded on a four grade scale were low numbers signal SoS problems (red dots).

	Production capacity/ availability is greater than current consumption.	Availability of alternative sources of supply or alternative fuels, includes demand adjustment.	Nordic countries' ability to influence / control access, production and/or consumption.
FUELS and ENERGY (availability, supply & storage)			
Wood chips from harvest residue	3.0	2.8	3.7
Peat	3.4	3.0	3.6
Coal	3.6	3.0	2.1
Oil	3.7	2.7	3.0
Natural Gas	3.4	2.6	2.8
Nuclear fuel	3.3	2.2	2.7
ELECTRICITY SYSTEM			
Regulating power	3.3	2.3	3.1
Ability to handle maximum load	3.1	2.7	3.1
Ability to handle Nordic dry year	2.9	2.7	3.1
Electricity network	2.8	2.7	3.1
DISTRICT HEATING			
Production	3.2	2.5	3.6
Distribution	3.5	2.2	3.9
END-USE			
Heating	3.3	2.0	2.7
Forest industry's energy supply	2.9	2.5	3.0
Other industries' energy supply	2.4	2.7	3.0

From the table we can see that six areas out of 45 are regarded as problematic. We can also see that the red spots are spread over the table – there is not one single category that is regarded as especially problematic.

SoS is a geopolitical issue, not a technical or economical issue

Coal resources are spread relatively evenly over the world. This is not the case with oil. Approximately 70 % of global oil production takes place in only seven countries. Natural gas is even more concentrated - approximately 50 % of currently known global natural gas reserves are located in only three countries.

Throughout history, many different strategies have been implemented to secure the delivery of energy resources. Many European countries had colonies until the middle of the 20th century. There were many reasons for the establishment of colonies, but one reason was the desire to secure the delivery of critical goods. US foreign policy has consistently sought to secure deliveries of oil and other key fuels, as well as to obtain low prices for imported goods. China, with an expanding industry in need of raw materials and other inputs, has recently tried to secure deliveries of energy and other goods by signing treaties with other countries, or by buying access to various resources in other countries.

A common feature of these attempts to secure key supplies is a political game where buyers, or “takers”, play a very tough game – sometimes even resorting to war – to secure delivery of critical goods at low prices. Conversely, oil and natural gas exporting countries try to counteract the influence of importing nations in the West and Far East. The OPEC oil cartel that tries to maximize the price of oil is an example. Another example is Russia, which tries to use its natural resources in a geopolitical perspective.

These issues are important to world leaders, but countries often resort to secretive measures that often would not stand up to public scrutiny. Among the oil importing nations the major player is probably the US, but China is also very active, and several EU members are also good at securing supplies using more or less shady methods. Economics cannot be used to study these issues. The NEP project is strong on economics, but in-depth knowledge of international politics would probably be more valuable when studying SoS issues. For this reason, we should not expect too much from the NEP project when it comes to solutions to SoS problems.

Standard indicators give contradictory results

Import dependency

When calculating the share of imports in the Nordic region's total electricity consumption we have considered nuclear fuel, coal and electricity imports. We have left out oil and gas imports as the the Nordic region as a whole is a net exporter of oil and gas, even though Sweden and Finland by themselves are net importers. The results from the MARKAL and PoMo models running a number of different scenarios are presented below.

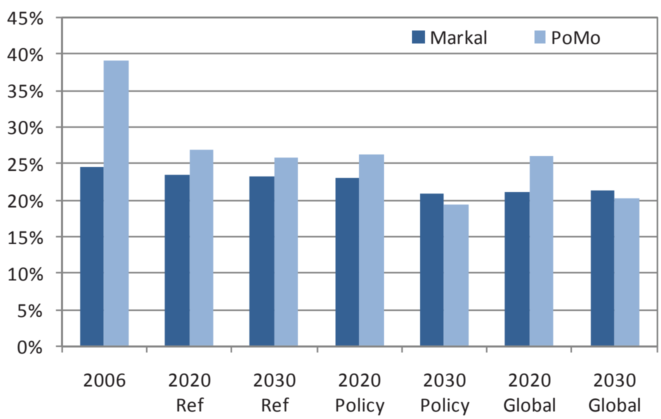


Figure 21.1: Import share, excluding oil and gas

Compared to 2006 (which is modelled as a normal year regarding temperature and precipitation), dependency on imports is lower in both 2020 and 2030, for both models and for all scenarios. This decline can be explained by three factors: lower use of coal condensing power plants, electricity imports turning into exports, and an increase in domestic renewable energy sources. This means that the European Union's climate change and renewable energy policies appears to result in reduced import dependency for the Nordic region.

Energy source diversity

The Herfindahl index is commonly used to measure diversity of supply. It is obtained by squaring the share (percent) of each type of supply source and then summing the resulting numbers. The principle is that the more energy alternatives there are, and the more equal they are in size, the better. Diversity is high where the Herfindahl value is low. A low value is a sign of low dependence on a few energy sources.

Once again, we have used the MARKAL and PoMo models to calculate how the Herfindahl index is expected to develop in the future. As we can see from Figure 21.2, MARKAL data indicates that the Herfindahl index will be higher in both 2020 and 2030 than in 2006, pointing to an increased dependency on imports. PoMo gives a slightly lower index for 2030, but higher for 2020.

This means that if we are to go by the Herfindahl index, the European Union's climate change and renewable policies appears not to contribute to strengthening security of supply. The reason for this is that instead of retaining a dependency of coal, oil and gas – which is positive for this index – the dependence on biofuels, hydropower and nuclear power, which was large to start with, increases. This results in a high Herfindahl value. The introduction of new wind power is positive, but it does not compensate for the negative effects.

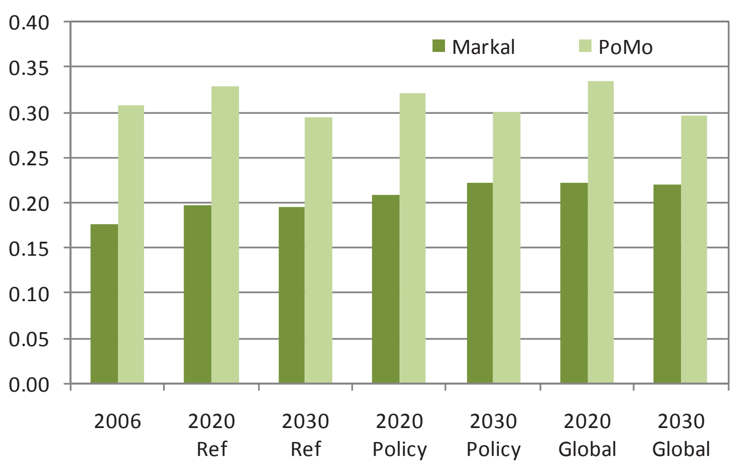


Figure 21.2: Energy source diversity, the Herfindahl index

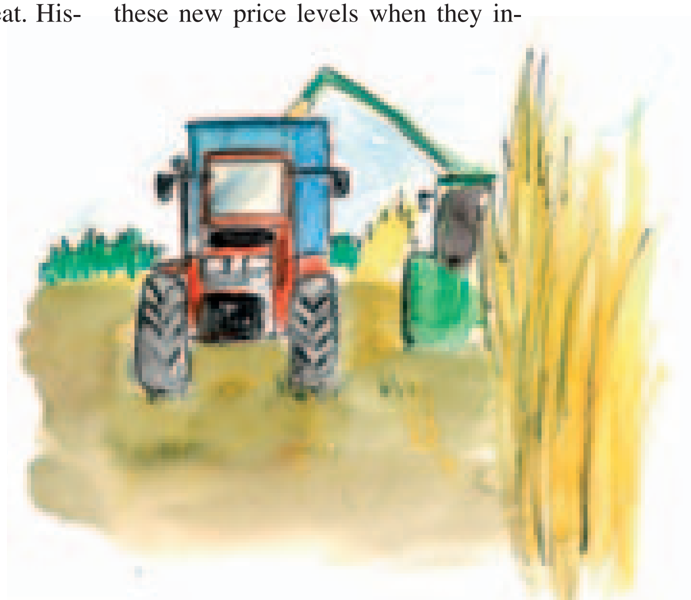
The situation in the Nordic region differs from that in the rest of Europe

In continental Europe, security of supply issues tend to focus on the strong and increasing dependency on imported natural gas from Russia. As discussed in Chapter 23, even though the use of natural gas in the Nordic region is limited, a severe delivery disturbance or a rapid price increase in continental Europe will also influence the Nordic region through interlinked electricity markets and other mutual economic dependencies.

From a Nordic perspective, the region's strong and increasing dependency on nuclear power and biofuels should be high on the agenda, next to traditional SoS issues such as the dependence of modern societies on firm deliveries of electricity and heat. Historically, we have seen severe disturbances to nuclear power production. Due to common constructions features in many reactors, even minor safety issues can cause long production stops in a large share of the installed capacity, causing capacity shortage in the region.

The strong focus on renewable energy in the Nordic region and in the EU has lead to a rapid shift from fossil fuels to biofuels in district heating and in combined heat and power (CHP) generation. Most often these plants cannot use any other fuel. Sudden delivery disturbances or price shocks can be problematic especially for district heating. This development can be explained by strong support systems for renewable energy and high CO_2 taxes/prices, which make investors reluctant to invest in plants that can burn other types of fuel in addition to bioenergy. We illustrate this in the figures on next page.

In the figures, we have increased the price of bioenergy by 50% compared to a base case scenario. The three bars in the upper left part show a rather large impact on the demand for bioenergy. In this case we have simulated a situation in which investors predict these new price levels when they in-



vest. The three top right bars illustrate a situation in which they do not anticipate higher prices when they invest. In this case, the possibilities to make short-run adjustments to their fuel mix are of course more limited. When including policies aimed at fulfilling the renewable directive we see that the sector's flexibility is reduced. Instead the renewable directive leads to a system change, where district heating is substituted by electricity – from biofuels to wind (wind power is the main component of "Other renewable" in the figures).

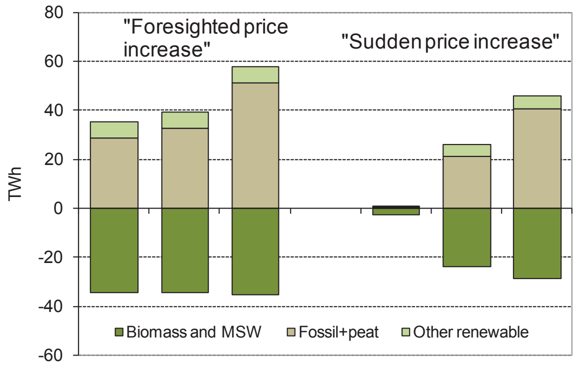


Figure 21.3: Difference in fuel use if biomass-prices increase significantly from 2016 and onwards. **Excluding** the renewable Directive.

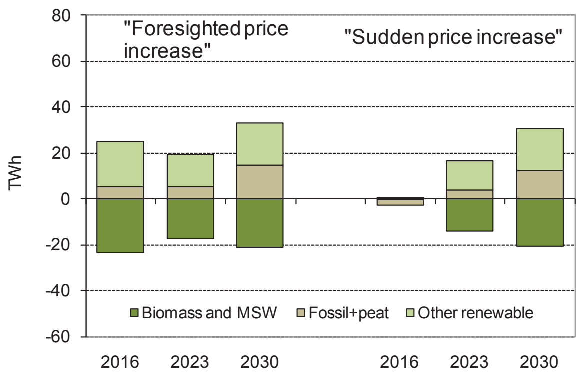


Figure 21.4: Difference in fuel use if biomass-prices increase significantly from 2016 and onwards. **Including** the renewable Directive.

For further information:
Peter Fritz, Andrea Badano, Sweco and Håkan Sköldberg, Profu

22. Is nuclear power a threat to security of supply?

- more wind power highlights capacity issues

Is nuclear power a threat to security of supply? The answer to this question may be yes. A heavy dependence on nuclear power for base load could be a threat to security of supply in the Nordic region and the potential problems will increase with more wind power in the system. Historically nuclear power has been a rather reliable source of electricity, but because of the extremely high standards of safety that the industry must follow, even minor faults can lead to the closure of reactors. Our analysis indicates that the Nordic power system is rather robust in terms of energy, and that even major nuclear power disturbances could be handled reasonably well. The problem will mainly be a capacity problem, securing the system during peak load periods.

Nuclear power is together, with hydropower, a dominant contributor to base load generation in the Nordic area. In a normal year, the 10 reactors in Sweden and the four in Finland produce around 90 TWh out of a total demand of around 380 TWh. Hydropower produces around 200 TWh and the remaining 100 TWh come from thermal power and a small share of wind power. This figure is based on model runs for 2006 with normal hydro inflow.

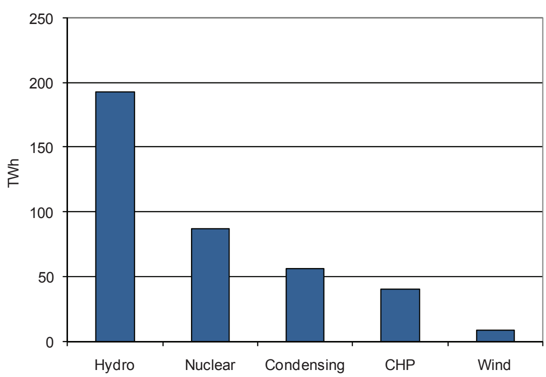


Figure 22.1: Generation mix in the Nordic region 2006 - a "normal" year.

In the near future, the share of nuclear power is expected to increase. At present there are fairly large ongoing or planned investments in the Swedish plants designed to extend their life span and to increase their capacity. These investments may add up to 10 TWh of annual output. In Finland a fifth reactor currently under construction will add another 13 TWh in a few years. Further, three consortiums have applied to the Finnish Council of State for permission to build a sixth and possibly even a seventh and eighth reactor.

However, nuclear power is still a sensitive political issue in Sweden. The industry has been living with a politically mandated phase-out program for a long time. Following a parliamentary decision, one of the two reactors at Barsebäck was closed down in 1999 followed by the second reactor in 2005. For the remaining ten reactors no firm decisions have been taken in terms of actual dates when the reactors should be closed, but the political will to eventually close all plants has never been in doubt. Recently, the political climate has changed and the present government is in favour of allowing new reactors to be built, replacing existing reactors when these reach the end of their economic life span. However, this parliamentary majority is very slim.

Two examples of major disturbances in nuclear generation

In 1992 and 1993, five out of twelve Swedish reactors were out of operation for several months. The reason for this was the discovery of a construction mistake in one of the safety systems. Since all five rectors hade the same basic design, the Swedish safety authority decided to temporarily shut down all reactors until the problem was solved. This is an example of how a failure in one reactor can create a severe reduction of generation capacity. At the time of these incidents, the Swedish electricity market was still heavily regulated through the State Power Board, and the consequences for consumers were negligible.

The next incident occurred this winter (2009/2010). Up to four of the reactors had serious problems during the winter, which during three specific days, contributed to prices escalating to, or above, 1000 EUR/MWh.

For two of the reactors, Ringhals 1 and Ringhals 2, there have been numerous delays in the planned restart after large upgrades. The official explanation for the delays from the reactors' owner is that the complexity of the projects had been underestimated. There have also been some security issues at Ringahals that had to be solved before the reactors could restart. The two reactors Oskarshamn 3 and Forsmark 2 have been running on reduced capacity during the three price peaks, also following major upgrade projects. In total, nuclear production in Sweden was reduced by between 3,5 to 4,4 GW during the winter months, creating price spikes on the spot market. Normal winter capacity in the fourteen nuclear reactors in Sweden and Finland is about 12 GW.

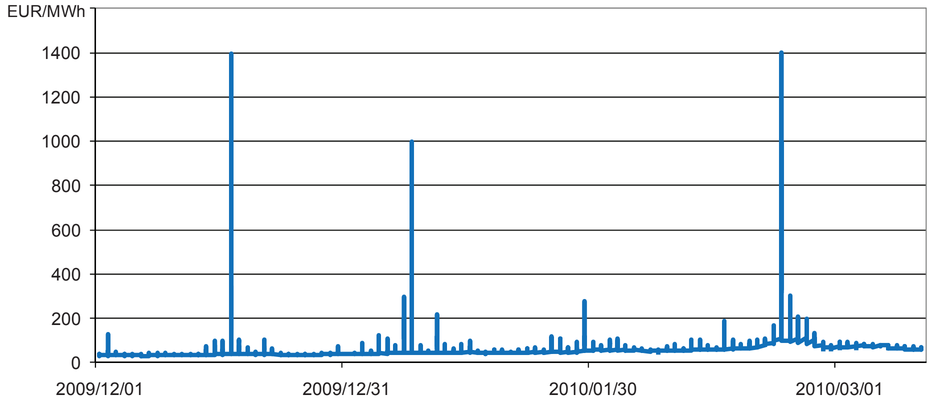
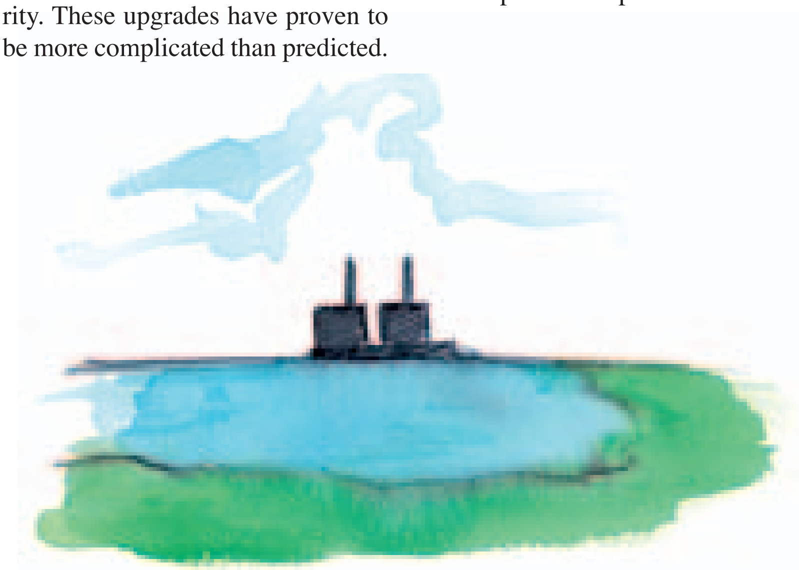


Figure 22.2: Hourly prices on NordPool Elspot the winter 2009/2010 in Sweden.

To summarise, nuclear capacity in Sweden in the winter 2009/2010 was reduced for two main reasons:

- Many reactors are undergoing programs to increase capacity, extend reactor lifetime, and increase security. These upgrades have proven to be more complicated than predicted. Planned restarts has been delayed a number of times this winter.
- The safety authority has been very critical of some of the companies. One of the reactors at Ringhals has been put under special surveillance.



The winter of 2009/2010 was also very cold in the Nordic region. Because of the large number of electrically heated houses this led to high power demand. Still, demand in Sweden during the price spike the 8th of January was still not exceptionally high, about 10%, or 2,5 GW, below the all-time high.

During the 8th of January when prices spiked at 1000 EUR/MWh, resources from the special capacity reserve in Sweden and Finland were used at NordPool (140 MW was accepted at Elspot). At the same time Svenska Kraftnät, the Swedish TSO, used the special capacity reserve to stabilize the grid. 1080 MW of generation from the reserve* was activated to allow for exports of hydropower from the northern part of Sweden to the south without violating security limits.

The Nordic electricity system is resilient to reduced nuclear generation in terms of energy, but not in terms of capacity

The Nordic electricity system is resilient to reduced nuclear generation in terms of energy, but not in terms of capacity.

We have in the NEP project used two of our electricity market models (PoMo and EMM) to simulate the effects of a severe production decline in nuclear generation. The assumption is that nine of the fourteen reactors are out of operation for one year.

In Figure 22.3 we have summarised the consequences in terms of energy. From the model runs we see that the reduction in nuclear power is compensated by increased imports, increased hydro generation, increased generation in condensing power plants, and a small increase in CHP. We also get a decrease in demand of 4-5 TWh in the electricity intensive industry because of high prices.

In the figure we have illustrated two cases: one in which the market actors believe that the nuclear plants will be back in operation within one year ("planned restart"), and one in which they do not know when the plants will be restarted ("uncertain restart"). The difference in results between the two cases is the use of water in the reservoirs. With planned restart, the hydropower companies are less interested in saving water for later, and are instead willing to produce more electricity while the nuclear plants are closed.

*) In the Swedish capacity reserve 1166 MW generation and 633 MW of demand reductions is contracted.

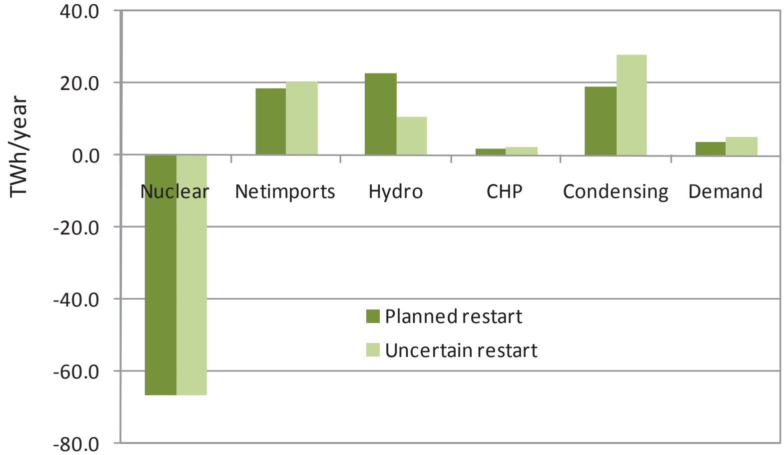


Figure 22.3: Estimated replacement energy using the PoMo model. Scenario with 9 nuclear reactors out of operation for one year.

Looking at the prices predicted by PoMo, we see that most of the time, prices are higher than normal, but not dramatically higher. The problems occur during periods of cold weather and high demand. This is illustrated by the peak prices during the winter weeks.

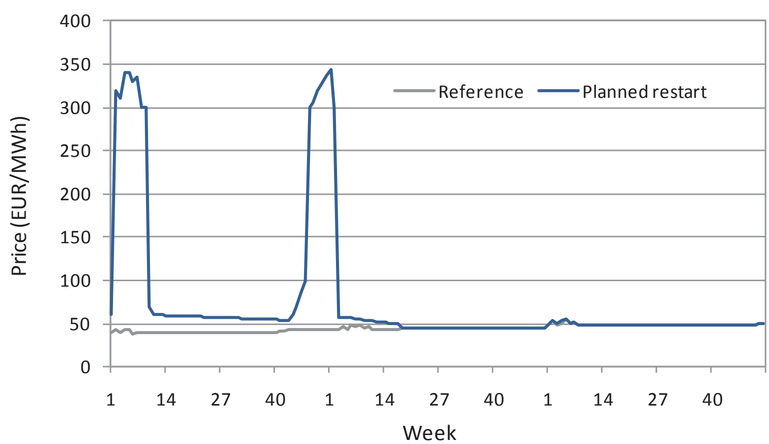


Figure 22.4: Estimated prices using the PoMo model. Scenario with 9 nuclear reactors out of operation for one year.

We get similar results for average price increases using the EMM-model, but in that model we do not get the high winter peaks. One reason for that is that the PoMo model and the EMM model treat bottlenecks in imports and exports differently.

Note that PoMo and EMM are models for market price calculations and not grid models. Transmission system congestions inside the market area are not taken into account well enough to simulate capacity limitations in the grid. These models are good in describing the challenge of over a year replacing the loss of more than 60 TWh of nuclear generation, but these models are not designed to capture short term capacity issues. In reality, temporary bottlenecks in the grid will cause situations much more severe than illustrated here. This is something we learned this last winter.

What these model runs illustrate is that the Nordic electricity system is rather resilient to reduced nuclear generation in terms of energy, but from experiences in real life we know that lack of base load generation during winter weeks will cause capacity problems, at least in parts of the Nordic market.

With more wind power in the Nordic market, the capacity issue will have to be highlighted further

In all of the scenarios for the development of the Nordic market used in the NEP project we see an increase in the use of wind power and a decline in fossil fuel based condensing power. We also know that even if wind power plants will most likely be spread geographically over the entire Nordic region, there will be periods with high demand and unusually low wind generation. This will increase the risk for capacity shortage in the region.

In Figure 22.5 we have illustrated this by looking at wind data and simulated the total production from wind power during a winter week. The assumptions are that we have 34 500 MW of wind power installed in Sweden, Norway and Finland. This amount of wind power will approximately cover 20 percent of the annual demand in these three countries. The different lines in the figure show the estimated hourly production for different years. The variations are almost three times the Swedish nuclear capacity.

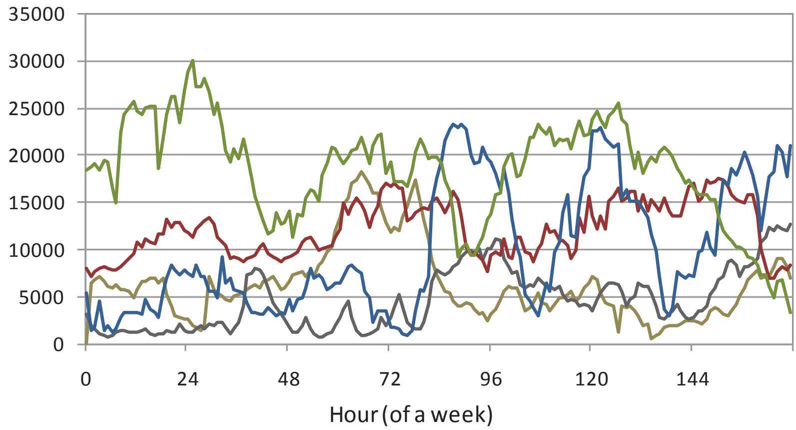


Figure 22.5: Estimated wind power production from installed capacity of 34 500 MW in Sweden, Norway and Finland. Source: The Sweco Wind Model, WiMo.

Is nuclear power a threat to security of supply?

The answer to this question may be yes. A heavy dependence on nuclear power for base load could be a threat to security of supply in the Nordic region and the potential problems will increase with more wind power in the system. Historically nuclear power has been a reliable source of electricity, but because of the extremely high standards of safety that the industry must follow, even minor faults can lead to the closure of reactors. Our analysis indicates that the Nordic power system is rather robust in terms of energy, and that even major nuclear power disturbances could be handled reasonably well. The problem will mainly be a capacity problem, securing the system during peak load periods.

One focus here is of course to manage the nuclear plants in a way that does not jeopardize the security and thus the production. Part of the solution is also to work hard to introduce more demand flexibility into the market, and to invest in more transmission capacity. To promote a more diversified mix of base load generation is another option.

For further information:
Per Erik Springfeldt and Peter Fritz, Sweco and Göran Koreneff, VTT

23. Potential effects on the Nordic region of a gas shortage in Europe

- increased demand of gas in EU and decreased production gives increased dependence of imports

The European Union is becoming more and more dependent on imported natural gas. This is a result of two trends; the demand for natural gas is increasing while production within the union is decreasing. Production is decreasing mainly in the gas fields in Great Britain and the Netherlands. Figure 23.1 shows the forecast for the EU-27 from IEAs World Energy Outlook 2009.

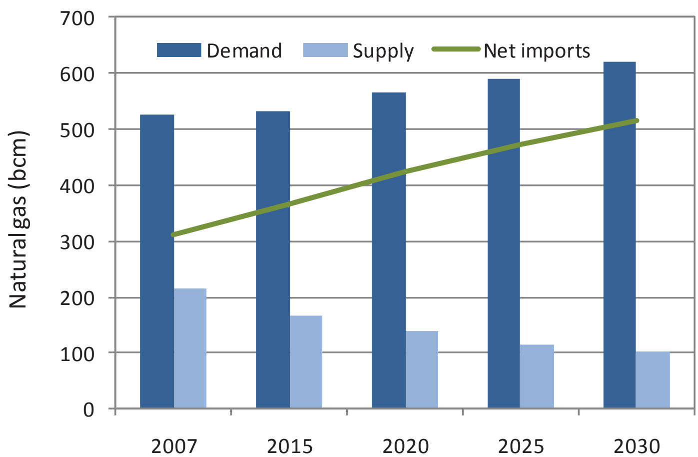


Figure 23.1: Demand, production and imports of natural gas for EU-27 according to IEA's World Energy Outlook 2009.

If we would include Norway (not an EU member) in the picture the situation would improve, but the share of imports would still increase over time.

There are a number of concerns in respect to this increased import dependency:

- Natural gas reserves are located in a few countries. An increased import dependency in a commodity of such dignity will be an issue high on the agenda for any government.
- Recent conflicts between Russia and Ukraine has led to severe reductions of Russian gas shipped via Ukraine, and in January 2009 the shortages persisted for several weeks.
- Long periods of gas delivery interruptions will cause disturbances in many sectors of the society in many central European countries.
- The power prices in UK, Germany, the Netherlands and France are highly correlated with the costs of gas. High gas prises will very soon spill over to high electricity prices to the consumers.
- The price of CO_2 within the EU ETS system is correlated to the price difference between gas and coal. High gas prices will drive the CO_2 price. This will hurt the industry in Europe both trough higher CO_2 costs and through higher electricity prices.

Prices for electricity gas and CO_2 are all linked together

Looking at the prices of gas, coal and CO_2 in the different commodity markets in Europe one can clearly se how these markets interact.

We start out with the formation of the CO_2 price. One common hypothesis is that the CO_2 price must be high enough for the natural gas fired power plants to be competitive compare to coal fired power plants. The reason behind this hypothesis is that substitution between coal and gas is one of the cheapest mean for the industry in Europe to reduce CO_2 emissions to comply with the emission targets.

In Figure 23.2 we have compared the running cost of producing electricity in gas fired CCGT plants with the running cost of producing electricity in coal fired condensing plants. In the gas plant we have assumed an efficiency of 50 % and in the coal fired plant an efficency of 40 %. In reality the efficiency rate varies quite a lot between different plants. What we see is that when we include the CO_2 cost the production costs are pretty much the same. This implies that the most efficient CCGT plants most likely will be running as base load most of the year, while the inefficient plants will mainly be used as reserve capacity. This is of course in line with the intension of the carbon market.

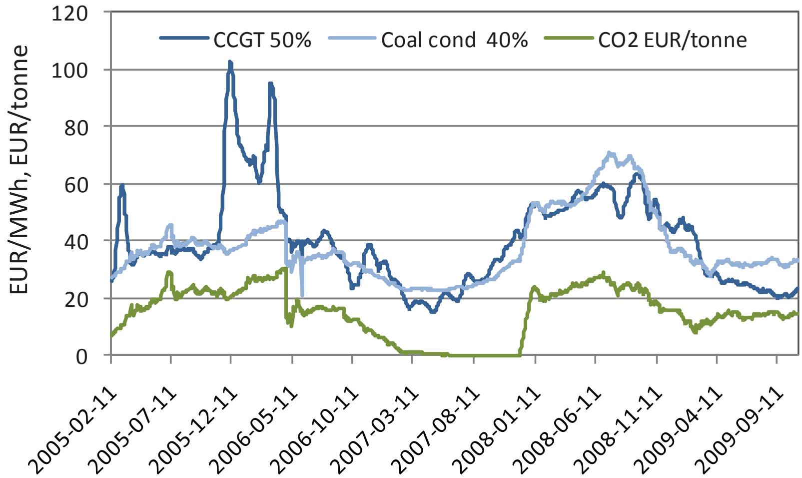


Figure 23.2: Running cost of gas fired and coal fired power plants including the CO_2 cost.

One problem with this hypothesis is that the price of natural gas also is set based on demand and supply on the European market. One could argue that the gas price is set so that gas can compete with coal given the CO_2 price. We have sort of a "hen and egg dilemma" what comes first the CO_2 price or the natural gas price?

One could also argue that since the power companies up to now got most of the emission rights they need for the electricity production for free, they would not include them in the running cost calculations. Both theoretical reasoning and statistical analysis have showered that this is not the case. Even if a company gets the emission right for free these rights have an alternative value and if not used for electricity generation they can be sold.

The next question is how the gas price influences the European electricity price. From the figure below we can see that there is a strong correlation between of peak electricity price and the running cost of CCGT with a 50 percent efficiency rate. (Since the running cost of coal and gas fired plants are pretty much the same we would get a similar picture if we substituted CCGT with coal condensing power in Figure 23.3). It is interesting to note that the peaking gas price in the end of 2005 and beginning of 2006 did not result in peaking electricity off peak prices. It did though lift the peak prices to rather extreme levels. In both Germany and France the prices were in line with or a bit higher than the running cost of CCGT. In the Netherlands the peak prices were a lot higher.

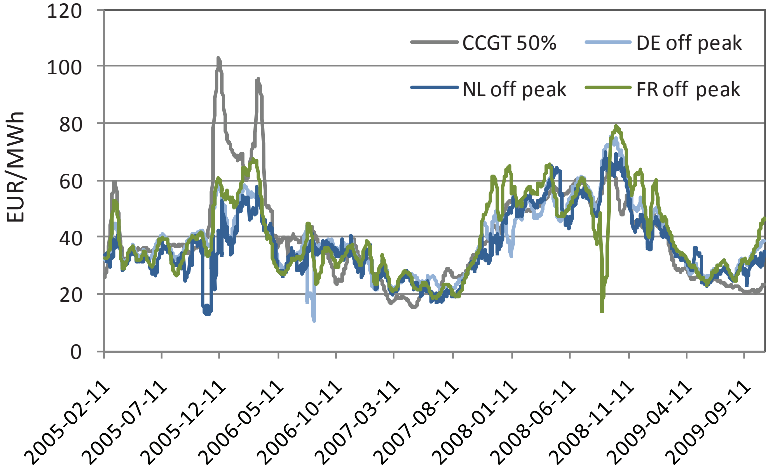


Figure 23.3: Running cost of a gas fired CCGT power plant with 50 percent efficiency rate and the off peak prices on the spot markets in Germany, the Netherlands and France.

The European electricity peak prices are normally substantial higher than the of peak price of fuels, and can mainly be explained by the running cost of gas power plants and start costs.

It is also interesting to see how well the prices on different European markets follow each other. Another observation is that in spite of the fact that most of the gas in Europe is bought on long term contracts, it is the gas spot market price that is used when electricity is bid into the electricity spot markets.

Gas shortage together with a dry year will drive electricity prices in the Nordic area

During normal circumstances the Nordic countries have lower prices than central Europe. A typical import /export scenario is that the Nordic countries export power during day time and import during night. This means that we often have the same or slightly higher off peak price compared to central Europe, but a lower peak price. During wet years we have enough resources to export even during off peak periods and thus increasing the price differences further. The larges effect will be seen during a dry year situation. Depending an the severness of the draught we could be depending on more or less maximum import most of the time. If we have a European gas shortage situation at the same time as there is a drought in the Nordic countries the electricity prices could reach price levels never seen before.

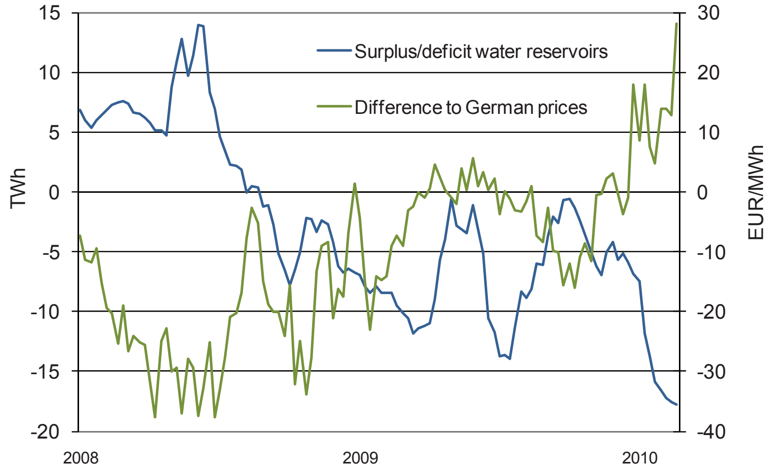
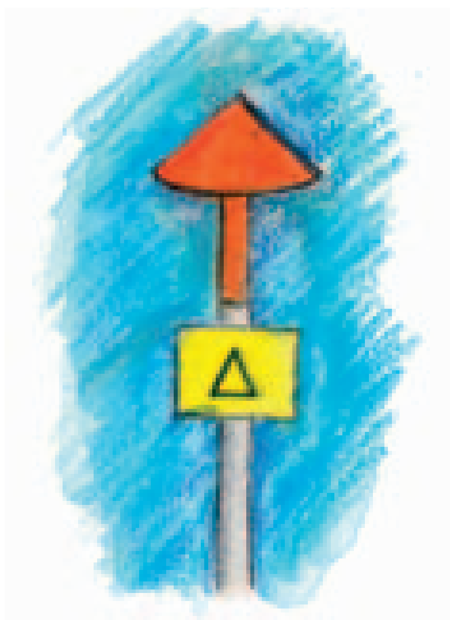


Figure 23.4: Price difference between Nordpool system price and EEX in Germany. The hydrological situation in the Nordic countries compare to an average situation.

How the price difference between the Nordic countries and central Europe are effected by the hydro situation is illustrated in Figure 23.4.

We see from the blue curve in figure 23.4 that the hydrological situation in the Nordic countries has deteriorated from a surplus situation in 2008 to a rather large deficit during the spring of 2010. At the same time we see that the price difference between the German spot market and Nordpool Elspot have gone from a situation with lower Nordic prices (negative price difference) to a situation were we have a lot higher prices than Germany.



For further information:
Peter Fritz, Andrea Badano and Per Erik Springfeldt, Sweco

The challenge to use energy systems modelling in a "wise and appropriate" manner in large multidisciplinary research projects

Lessons learned during the course of the NEP project

The insights that are presented here summarize the lessons that have been learned from using energy systems modelling during the course of the NEP project. This project is characterized by a number of distinguished features: a comprehensive multidisciplinary research project involving a multitude of complex research questions and using, and coordinating, a wide variety of different models from different countries and different scientific disciplines. The many research questions have defined and governed the modelling process of the project, which is essential. Model-related limitations may not affect, or govern, the choice of research questions. Furthermore, model analyses have frequently during the NEP project been complemented and scrutinized by other scientific disciplines from e.g. social and management sciences using methods such as deep interviews, questionnaires and statistical analyses. Thus, the findings presented here are based on this specific project context.

Every model is biased by traditions and preconceived opinions stemming from the model developer, the model user that constantly updates and develops the model and, finally, the model client for whom the model results are intended and who delivers feed back to model input as well as output. This fact also became very apparent during the course of the modelling process of the NEP project. However, a huge effort was done in order to liberate the models and model results from such influence. This does not necessarily mean re-coding or reorganizing the models or by changing a lot of input, but rather an awareness of the fact that model results differ and to expose the different fundamentals and assumptions of the models. Thereby, model results may be explained on a higher level than otherwise. The often quite interval in results may be used as an indicator of the relevant and actual uncertainties that are present in certain important

assumptions. Thus, the end result of such a modelling analysis is significantly more balanced, and thus more representative, than if only a single model approach would have been used. On the other hand, there are also differences in model assumptions based on traditions and opinions that in fact should be possible to harmonize once they have been identified and exposed. In some cases, there actually may exist "a single truth" or at least, agreed compromise. It is indeed an important, and cumbersome, challenge to balance assumptions which may be synchronized between different model approaches with assumptions that are better left in an unchanged state.

1. Use models to increase understanding of causes and effects!

Using energy- and climate-policy modelling is an efficient and feasible way of dealing, in a consistent way, with complex systems. The use of models provides new insights. Furthermore, gathering around a model or several models is a process that works as an objective platform, a "clearing house", where issues can be analyzed and discussed among participants with different interests on equal grounds.

2. Involve stakeholders and clients at an early stage

Model inputs and results should be validated and verified by other project participants and by external expertise during the entire project. This ensures a high degree of credibility to the modelling work.

3. Consider an interdisciplinary approach, and...

Many issues related to energy and climate policy analysis are truly interdisciplinary in their nature. Therefore, research within the field should reflect that fact and should, if possible, use more than one scientific discipline or method. Thus, model results and insights become supported by not just one but several scientific disciplines.

...organize model users with complementary model approaches

The NEP project has used an approach which has proven both efficient and successful, namely to involve several model approaches developed independently of each other. Using several models means that the issues in focus may be tackled from different angles, different scientific approaches and disciplines can be used simultaneously, and the risk of bias due to a "common background" is reduced.

However, working closely with several models representing different methodologies rarely is a walk in the park. The models must be coordinated and one of the main challenges involves input data.

4. It is not possible to harmonize all input assumptions

A large number of assumptions have to be made before model simulations are carried out. Even though the input assumptions have been harmonized to an extensive degree in all NEP models, it has not been possible to reach full harmonization. The reason is that the models are designed differently. Some of these differences make it impractical to fully harmonize model input without compromising the functionality of the models, and some of these differences turn out to significantly affect important model results.

5. Important results are similar in different models

The extensive model analyses of the NEP project have shown that several and important results are similar when comparing model outputs. This indicates robustness of the results.

6. Some results may vary substantially between the models…

For other model results, variations between the models have been rather significant.

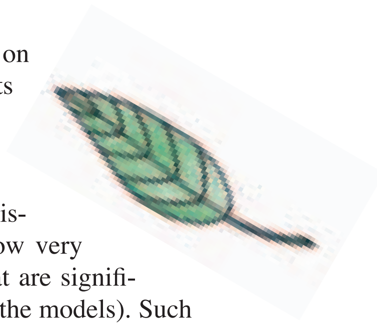
… but we can explain why ...

Differences in model configurations and coverage yield different results, but also increase the understanding of the crucial drivers for developments in e.g. power market balances, wholesale prices and CO_2 emissions from the Nordic power market.

Model output should actually, to a certain extent, differ between different models since they are designed differently and for different purposes, they rely on different philosophies, and they cover different systems (both in terms of geography, time horizon and part of the energy system/macro economy). Furthermore, some of the output is simply not fully comparable.

…and the differences in model output give an added value to the analysis!

It is the differences in model output that actually give an added value to the analysis since the differences reflect the uncertainties in the system in focus. If



the output is relatively similar among all models, this is, on the other hand, a strong indication that such specific results are robust.

7. Use each model where it is best suited.

The models can be used to address the same (or similar) issues. Thereby, results that are robust (many models show very similar results) may be separated from model results that are significantly more uncertain (model results vary largely among the models). Such model comparisons are also very efficient for increasing the understanding and for validating the models. However, it must also be recognized that certain models simply are not properly designed for analyzing all the issues that are dealt with.

8. Linking the models: Use output from model A as input to model B

The intention of the NEP project has not been to develop nor use a super model which includes as much of the issues to be analyzed as possible. Instead, the NEP project has used several separate models. However, these have to be coordinated in terms of input (refer to the discussion above) and in terms of benefit from each other, i.e. linking input and output between models. While performing the linking, let there be a "human touch" in between models.

9a. Recognize the "cultural" differences of the models and the modellers

The modeller makes his or her own considerations. Therefore, each model is in a sense biased. Furthermore, there exist "cultural" differences in the view on how to use models and apply different methods. Some of these cultural differences stem from the fact that modellers may have different educational background. During the NEP project also "cultural" differences with respect to e.g. the principals and practices of energy markets, policy measures etc. were identified. One such example is the view on the relation between the two commodities, electricity and district heating, from combined heat and power schemes which differs somewhat between the Nordic countries.

9b. Recognize the "national" differences of the models and the modellers

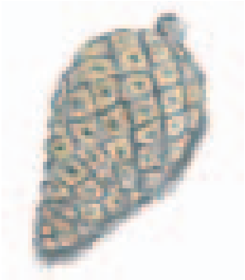
As for "cultural" differences, "national" differences may involve e.g. how to consider and describe e.g. energy markets, policy instruments and taxation. "National" differences also relate to the view on e.g. future available options for the development of the energy system. This is strongly influenced by the "energy history" of a certain country. Models originating from countries where a certain fuel or technology to the existing date has played an important role tend to look generously on the prospects for that fuel or technology also in the future. And not only in the country of origin but also in other countries also described by the model.

10. Recognize human errors

There is always a risk of errors or bugs within a model, especially if it is a complex and comprehensive model. Such errors may be minimized by performing a vast amount of model runs and carefully analyzing results and let them be scrutinized by other experts. Furthermore, as in the case of the NEP project, working with several models, harmonizing input data and compare outputs also reduces the risk of using a model with a non-discovered error.

Success factors recognized and identified by the NEP project

Based on the experiences of the modelling work during the NEP project, we here summarize the findings that we encourage others to consider when using several energy-systems models in multi-disciplinary analyses. The list on next page is based on the "success factors" that we have identified during the course of the NEP project. Even though we do not claim to have identified all the success factors associated with working with several energy systems models at the same time, we firmly believe that the following items may come in very handy for those considering to work with energy systems modelling in an interdisciplinary way. This may involve projects where modellers as well as clients are responsible for the modelling process and the model coordination.



20 success factors recognized and identified in NEP

Modelling process

Define research questions and let them govern the modelling activities. Model limitations shall not decide the contents of the research.

Early involvement of stakeholders (feedback on input and output)

Initiate model runs as early as possible, prior to the finalization of input synchronization. Such early model activities are very important for starting the learning process and for achieving a general acquaintance with the model package available to the project for modellers as well as clients.

Identify an appropriate balance between the number of model runs (e.g. sensitivity analyses) and the effort put into the analysis of the model runs. Not all model runs need to be reported unless they generate additional knowledge.

Establish a well-organized clearing-house where modellers and models are gathered with a shared and agreed view on the research questions and a shared model "language". Keep these gatherings on a frequent basis

Ensure that model input and output becomes scrutinized also by other scientific methods such as deep interviews, questionnaires and statistical analyses.

Model synchronization

Synchronize important input data – within reasonable limits

Use output from model A as input to model B where it is appropriate

Model validation

Models should be well validated (and documented)

Put effort in tracking down human errors (by e.g. comparing model outputs)

Differences in model approaches

Choose models with different methods aiming at a final overall interdisciplinary approach. Models should be complementary (and not too similar)…

..but recognize model overlaps and use it to highlight selected issues with more than one (in this case similar) model approach. This enables quality assurance for the models used and adds value to the analysis.

Identify similarities in model output among the models – Robustness?

Identify differences in model output among the models used. Expose and explain the differences! Highlight differences explained by realistic assumptions rather than differences explained by model imperfections or shortcomings

Identify system-boundary differences between the models

Identify differences in geographical scope – How is the "surrounding world" described

Use each model for what it is aimed for …

…but also identify areas or issues where a specific model is less useful

Identify the "cultural" differences in the models (or in the use of models) when working with different approaches, e.g. differences in the way markets are described

Identify "national" differences between models from more than one country. This may be due to national differences in existing energy systems

Reports and synthesis sheets

The following reports and synthesis sheets are published during the second phase of the NEP project and are found on the web site: www.nordicenergyperspectives.org.

40% CO_2 reduction in the Nordic energy system; EU's goals for renewables and efficiency have significant CO_2 impact"

Areas in sustainable energy sector where companies in the Nordic countries will have both valuable experience and growth opportunities in the home-markets

Biomass market and potentials

Business development on the environmental sustainability agenda; the case of the Swedish clean-tech initiatives in biomass combustion industry

CO_2 emissions from the transport sector in the Nordic countries

Cooperation with the GoReNEST project; incl. two joint workshops

Decreased import dependence with EU´s 20% goals - the import dependence decreases in the Nordic energy system as a consequence of increased use of renewable energy and decreased use of fossil fuels

Decreased import dependence with the EU 20% goals; results from the SoS work in the second phase of the NEP program - results from the MARKAL model

Electric vehicles in the Nordic countries – analyses and experiences from the NEP project

Expensive to reach all EU goals; the climate goal demands the least effort!

Global economy scenarios

Insights from the NEP policy scenario simulations

KOMPAS – comparative analysis of 7 Nordic energy models (in Norwegian)

KOMPAS – improving the description of the demand side in the NEP models

Less DH when EU´s three 20% goals are applied

Millions of electric cars in the Nordic countries- impacts on the Nordic electricity system

Natural gas in the Nordic countries

Nordic electricity almost free from CO_2-emissions already by the year 2020; all new capacity that will be built in the Nordic countries is renewable or nuclear.

Nordic industries in a global context

Nordic perspectives on the EU goals relating to CO_{2s}, renewable energy and energy efficiency - results from the MARKAL model

Perspectives on renewable energy and energy with low CO_2 emissions, with special focus on biomass

Prominent strategies for environmental sustainability in the stationary energy sector

RES deployment profoundly changes the market balance of the Nordics

Synthesis results: Conclusions from the research work in the second phase of the project

Technology options for a low CO_2 energy system; export markets for Nordic knowledge and products

The complexity of climate change mechanisms

The development of District Heating in the Nordic countries - Impact of pricing structures

The future of the Nordic district heating

Widened view of energy efficiency and resource management, including preliminary results from the MARKAL model

Winners and losers among the renewable energy alternatives

Wood markets and the situation of the Forest industry in the Nordic countries

The group of researchers

Bo Rydén
Profu
bo.ryden@profu.se

Håkan Sköldberg
Profu
hakan.skoldberg@profu.se

Thomas Unger
Profu
thomas.unger@profu.se

Anders Göransson
Profu
anders.goransson@profu.se

Peter Fritz
Sweco
peter.fritz@sweco.se

Per Erik Springfeldt
Sweco
per.erik.springfeldt@sweco.se

Andrea Badano
Sweco
andrea.badano@sweco.se

Anders Sandoff
School of Business, Gothenburg University
anders.sandoff@handels.gu.se

Gabriela Schaad
School of Business, Gothenburg University
gabriela.schaad@handels.gu.se

Juha Honkatukia
VATT
juha.honkatukia@vatt.fi

Janne Niemi
VATT
janne.niemi@vatt.fi

Hans Ravn
RAM-løse edb
hansravn@aeblevangen.dk

Tiina Koljonen
VTT
tiina.koljonen@vtt.fi

Göran Koreneff
VTT
goran.koreneff@vtt.fi

Raili Alanen
VTT
raili.alanen@vtt.fi

Berit Tennbakk
Econ Pöyry
berit.tennbakk@poyry.com

Tobias Jakobsson
Econ Pöyry
tobias.jakobsson@poyry.com

Monica Havskjold
Xrgia
mha@xrgia.no

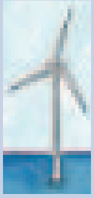
Benedicte Langseth
Xrgia
bla@xrgia.no

Antti Lehtilä
VTT
antti.lehtila@vtt.fi

Martti Flyktman
VTT
martti.flyktman@vtt.fi

Esa Pursiheimo
VTT
esa.pursiheimo@vtt.fi

Miika Rämä
VTT
miika.rama@vtt.fi

Towards a

Sustainable Nordic Energy System

20 Perspectives on Nordic Energy
10 Opportunities and Challenges

Nordic Energy Perspectives (NEP) is an interdisciplinary energy research project with the overall goal of demonstrating means for stronger and sustainable growth and development in the Nordic countries. The Nordic energy system is the point of departure, seen from a European and a global perspective.

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.

Nordic Energy Perspectives