EUROPEAN
pathways

NEWSLETTER FROM »PATHWAYS TO SUSTAINABLE EUROPEAN ENERGY SYSTEMS«

#4/2009

Project status

"This newsletter gives illustrative examples of activities in focus during the last quarter. Work is also ongoing with analysing the Pathways to Sustainable European Energy System (see page 4-5). These Pathways will cover several key sectors and all 35 to 40 researchers in the project will contribute.

The work on Security of supply has also been intensified."

Prof. Filip Johnsson
Project manager of the Pathway project

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Emission standards can cause EU ETS to fail
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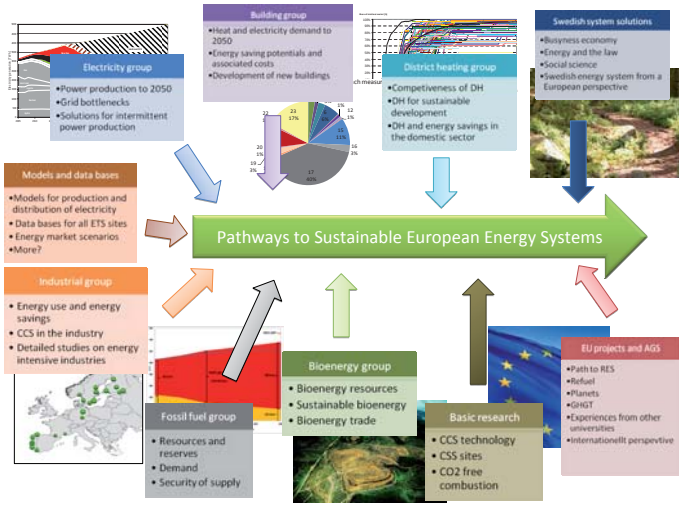
Pathways to Sustainable European Energy Systems
THE AGS The Alliance for Global Sustainability

All researchers contribute to the Pathways synthesis work

The overall task in the project is to evaluate and propose robust pathways towards a sustainable European energy system. These "Pathways" are built up through a comprehensive synthesis work, in which results and knowledge from all research groups are gathered.



The project gathers some 35 to 40 researchers at Chalmers as well as at other universities which make it possible to apply a wide range of knowledge to address the key questions identified in the beginning of the project.

read more on page 4-5

The competiveness of District Heating

Researchers at Halmstad Högskola show that the district heating can be competitive in urban areas even with 20 % energy savings in the domestic sector. With 50 % energy savings, however, the competitiveness decreases dramatically.

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The potential for CCS in the European industry

The potential for carbon capture and storage in the industrial sector is being assessed. The first results show that about 50 % of all CO_2 emissions from industrial part of EU ETS can be captured with capture cost up to 45 €/tonne CO_2.

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Project status

This newsletter gives examples of activities in focus during the last quarter. Work is also ongoing with analysing the Pathways to Sustainable European Energy System (see page 4 to 5). These Pathways will cover several key sectors and all 35 to 40 researchers in the project will contribute.

The work on Security of supply has also been intensified. Below the Pathways indicators and scenarios are gives in brief.

As during previous periods, results from the project have been presented to different audiences in conferences and workshops. The project follows the plan and I am looking forward to the continued activities during 2009!

Prof. Filip Johnsson
Project manager of the Pathway project

Security of Supply work in Pathways

We have evaluated a number of possible indicators. Based on this evaluation we have identified seven indicators that we will use to analyse security of supply issues. The first four indicators (1 to 4) deals with energy related issues, whereas the indicators 5 to 7 focus on issues related to the electric power balance. Our indicators are in line with indicators used in official international analyses. The seven indicators will also be used in the evaluation of the future development of the European energy system, calculated by means of the Pathways modelling toolbox.

We see at least three applications for the security of supply indicators:

- The indicators could be calculated for all Pathways that will be studied in the Pathways project. Most of these Pathways are not triggered by security of supply related issues, but will regardless of this have security of supply implications. This will be illustrated through the indicators.
- We will design specific "security of supply scenarios", where different aspects of this issue are illustrated.
- Some of the indicators could also be analysed in analytical papers. In these papers different aspects of the indicator could be discussed, e.g. strengths and weaknesses of each indicator could be presented. How the indicator is affected by different input conditions could also be discussed. The discussion could be both qualitative and quantitative.

1. Import dependence

- Discussion about "Risk related to import dependence" can be included.
- Nuclear power is presented separately (neither imported nor domestic).

2. Energy source diversity

- This indicator shows total energy supplied, split into a number of source for each energy carrier. Different risks could be discussed in relation to the energy sources.
- The risk presentation could e.g. be made through a Herfindahl index (the sum of the squared market shares held by each energy carrier). Another possibility could be to attach a "risk factor" (political risk, market risk, technological risk, possibility to store, etc.) to each energy source and carrier.

3. Natural gas import to the EU countries – number of import options

- This indicator comprises both the number of import pipelines and import facilities for LNG.

4. Total final use of energy per capita

- This indicator shows how dependent people and countries are of energy. If this indicator increases it will put an additional strain on security of supply.

5. The EU power balance

- The indicator shows the installed, or assumed available, electricity production capacity compared to the yearly maximum hourly power demand.
- Effects of bottle-necks should be considered, see indicator 7.
- Different availability assumptions should be considered for different production alternatives. For example, the capacity for intermittent production, e.g. wind power, may need to be reduced before going into the indicator (see also indicator 6).

6. The share of intermittent electricity production

- Intermittent electricity production, e.g. wind power, require back-up capacity due to the unreliable basic energy resource (wind). Other intermittent production could be wave power, solar power, etc.
- The indicator could also include the geographical dimension by presenting the share of intermittent production for certain areas.

7. Bottle-necks in the EU electricity transmission system

- Differences in area prices indicates these bottlenecks today.
- The Pathways model toolbox will also be used for calculating this indicator.

Great potential for CCS in the industrial sector

In the industrial group the potential for carbon capture and storage in the industrial sector is being assessed. The first results show that about 50 % of all CO_2 emissions from the industrial part of EU ETS can be captured at a capture cost less than 45 €/tonne CO_2.

First estimate on potential for CCS

As a part of his PhD project, Johan Rootzén assesses the role of CCS in reducing CO_2 emissions from the European industrial sector. He has done a first estimate of the potential for CO_2 capture and a preliminary geospatial analysis to match sources and sinks. This work was recently presented at the conference *Sustainable Development of Energy, Water and Environment Systems* which was held in Croatia this year.

Data base with all industrial installations

As part of the project a database covering all industrial installations included in the European Union Emission Trading Scheme (EU ETS) has been established. Based on facility level, data on CO_2 emission for 270 large point sources (> 0.5 Mtonne/year) in the three industrial sectors (mineral oil refineries, iron and steel, and cement manufacturers) have been singled out as promising candidates for CO_2 capture. These sources are responsible for about 75 % of the industrial EU ETS emissions, see Figure 1.

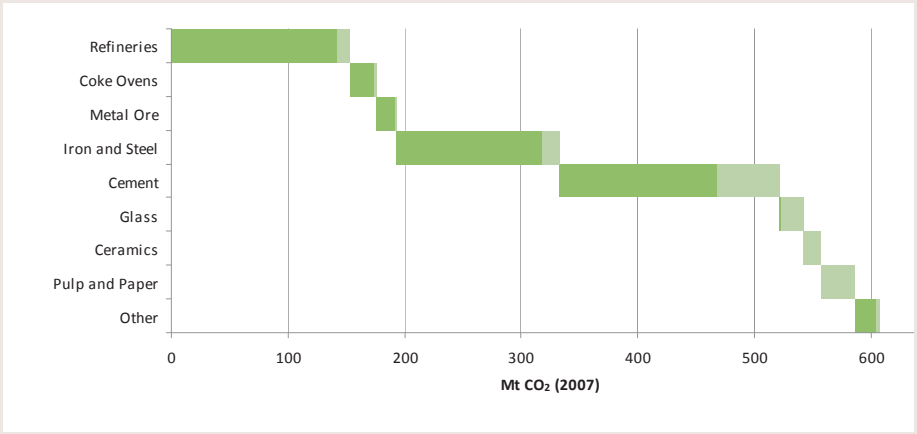


Figure 1: Overview of the share of the different sectors of the overall emissions in the EU ETS. Large emission sources (> 0.5 Mt CO_2/year) share of total emissions are highlighted in dark green. 270 plants in three industrial sectors (refineries, iron and steel, and cement manufacturers) are collectively responsible for about 75 % of the industrial EU ETS emissions.

Considerable emissions reductions

By applying different capture technologies and taking sector specific conditions as well as plant specific conditions into considerations, a first approximation of the capture potential for different capture costs have been made, see Figure 2. Many challenges still remain in all parts of the CCS chain but this assessment show that by introducing CO_2 capture at a relatively few large industry emission sources considerable emissions reductions could be achieved.

The work will now continue by:

- *Widening the scope to include also large pulp and paper industries*
- *Adding more thorough analysis of the different technological options for CO_2 capture in the different branches.*
- *Including the power and heat sector in the geospatial analysis.*
- *Analysing the influence from the structure of the existing capital stock age on the timing of the deployment of CCS.*

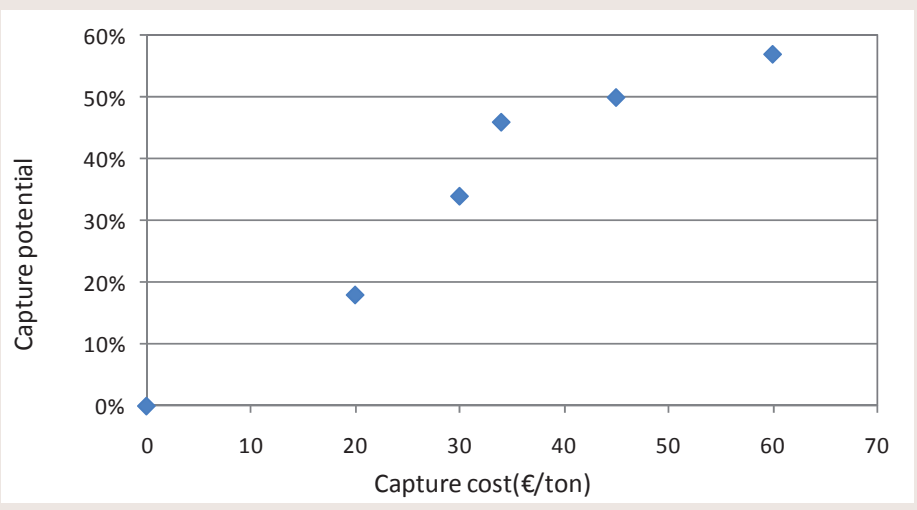
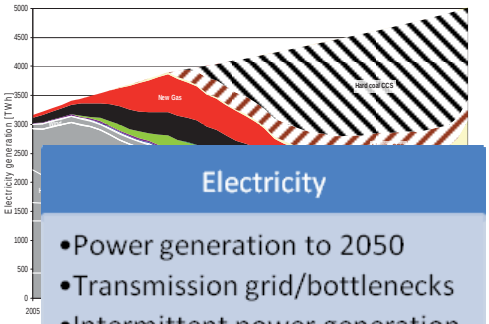


Figure 2: CO_2 capture potential (total part of the ETS industrial emissions) for different capture costs.

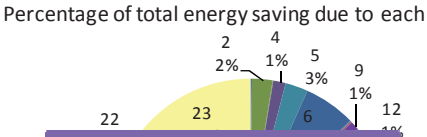
A comprehensive synthesis

The overall task in the project is to evaluate and propose robust pathways towards a sustainable European energy system. These “Pathways” are built up through a comprehensive synthesis work, in which results and knowledge from all research groups are gathered. In the synthesis work, we will also have valuable exchange with international research and policy makers, through our wide co-operation in AGS and EU projects and international networks.



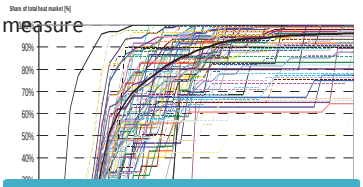
Electricity

- Power generation to 2050
- Transmission grid/bottlenecks
- Intermittent power generation
- The role of CCS
- Transformation from the pre-sent system to a sustainable



Buildings

- Heat and electricity demand to 2050
- Energy efficiency and costs
- Performance of the new building stock



District heating

- Competiveness of DH
- DH for sustainable development
- DH and energy savings in the domestic sector

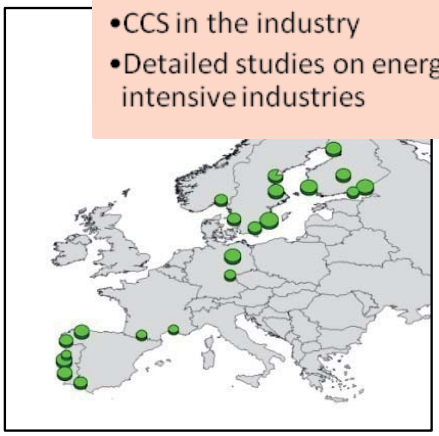
Models and data bases

- Model toolbox for power generation and transmission
- EU energy system models
- Energy demand models for the building and industrial sector
- District heating models
- Energy infrastructure databases
- Energy price scenario generator

Pathways to Sustainable

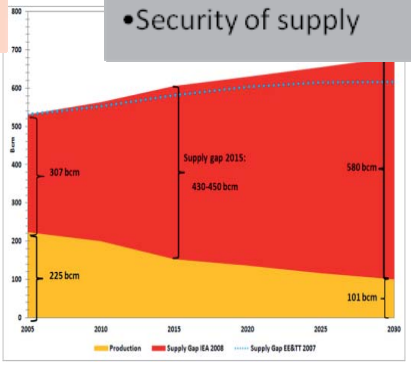
Industries

- Energy use and energy efficiency
- CCS in the industry
- Detailed studies on energy intensive industries



Fossil fuels

- Resources and reserves
- Development of demand
- Security of supply

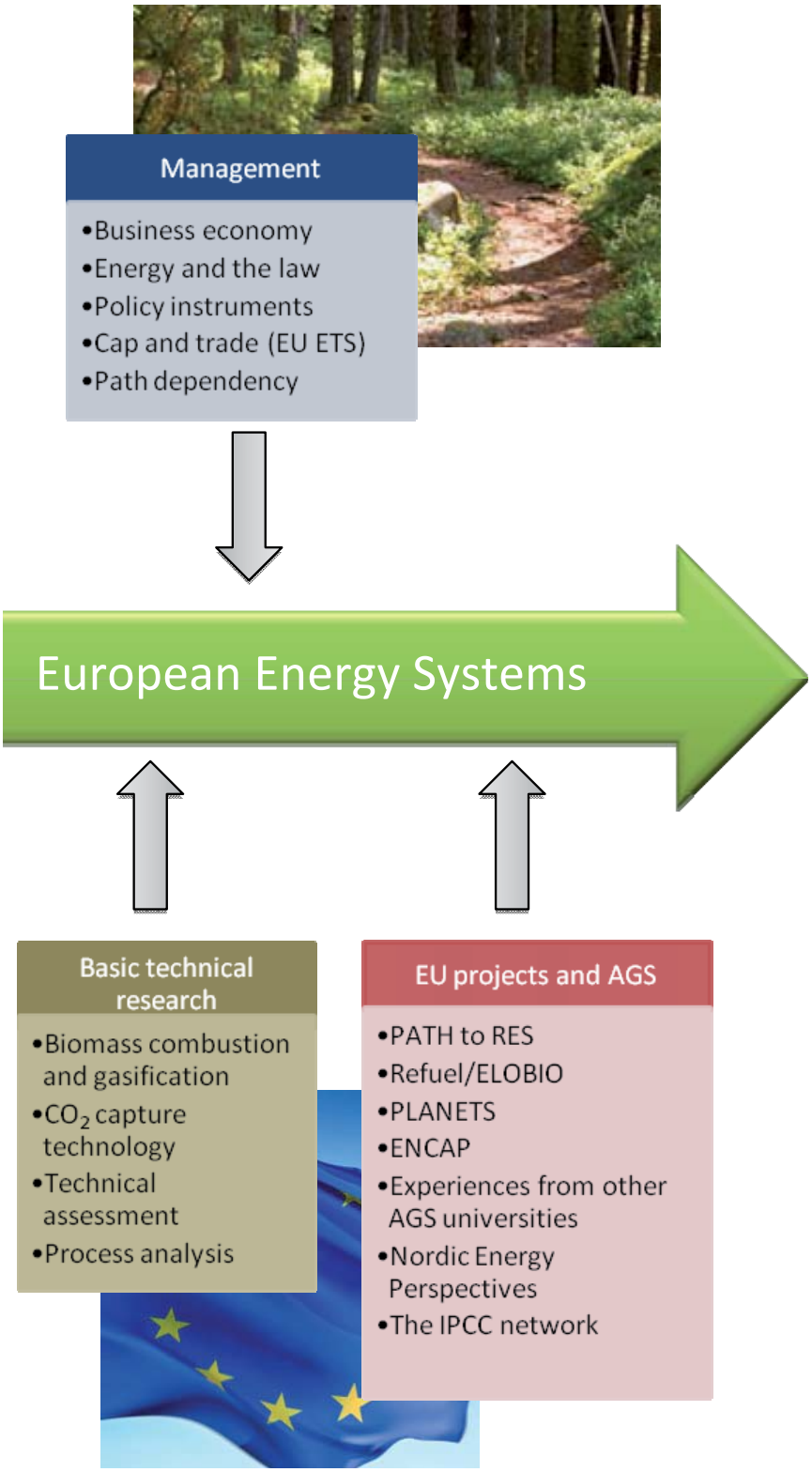


Bioenergy

- Bioenergy resources
- Sustainable bioenergy
- Bioenergy trade

analysis

The first two preliminary Pathways were presented in the Pathways newsletter 2009:2, and work is ongoing to develop these further.



All researchers contribute to the Pathways

The project gathers more than 35 researchers at Chalmers as well as at other universities which make it possible to apply a wide range of knowledge to address the key questions identified in the beginning of the project.

Sustainable Pathways

Work is ongoing with identfying the *Pathways to Sustainable European Energy System* up to the year 2050. The work takes departure in a "business as usual" scenario as a reference. This is a work that was initiated recently and will continue with the aim to put together a solid synthesis from the various works in the Pathway project. The Pathways will cover several key sectors with contributions from all researchers.

Model toolbox - EU power system

The Pathways modelling package for the electricity generation system is being developed to comprise four different models which can provide an analysis of the most important aspects which must be considered when transforming the electricity generation system.

Fossil fuels

The mapping of the global markets for gas, oil and coal is complete. The work has been proven valuable to understand the need for CO_2 capture and storage and also serve as input to the modelling and assessment of Pathways for the European energy system.

Pathways databases

The solid description of the European energy infrastructure from the various databases being developed in the project are of great value for the analyses (power plants, CO_2 storage sites, global fossil fuel infrastructure, district heating, demand side and Member States policies).

EU projects

There are several EU projects related to the project; e.g. PLANETS, PATH-TO-RES and ELOBIO. These give all valuable exchange with the international research community and make it possible to communicate and discuss specific Pathway results with a wider scientific audience.

The Competitiveness of District Heating

- consequenses of energy savings in the domestic sector

Urban Persson and Professor Sven Werner from Halmstad University show that the competitiveness of district heating only decreases moderately with 20% energy savings in the domestic sector but considerably with 50% energy savings.

Theoretical study on 83 cities

The main research question in the PhD project of Urban Persson is: "To what extent can Europe´s 5 000 district heating (DH) systems contribute to sustainable development?" This main question is broken down into several sub questions were one is "How does energy efficiency measures in buildings change the prerequisites for DH expansion?" This sub question has now been answered by a theoretical study of in total 1703 city districts and 83 cities in Belgium, Germany, France and Netherlands.

Focus on the distribution cost

Perssons and Werners starting point for this project was that in order to be competitive, the total cost of district heating must be lower than the cost of a local heating alternative, see Figure 1. In case of increased energy savings in the domestic sector, the specific heat production cost is almost constant while the distribution capital cost (Cd) is affected. Consequently, the focus in the project has been on the Cd.

Reformulating the linear density

The Cd can be formulated as a function were the linear density (heat load/piping length) is the decisive parameter. However, the linear density cannot be found in official data for urban areas. Hence, the linear density was reformulated to be based on properties which can be found in data bases for urban areas. With this approach, the potential for district heating can be evaluated also for areas where there is currently nodistrict heating network.

Distribution cost modell

Based on the reformulation of the distribution capital cost (Cd), an Excel-based model was created (DCM – Distribution Cost Model). Gathered data for urban areas in the four included countries was processed in the modell to give the theoretical district heating market share as a function of the Cd.

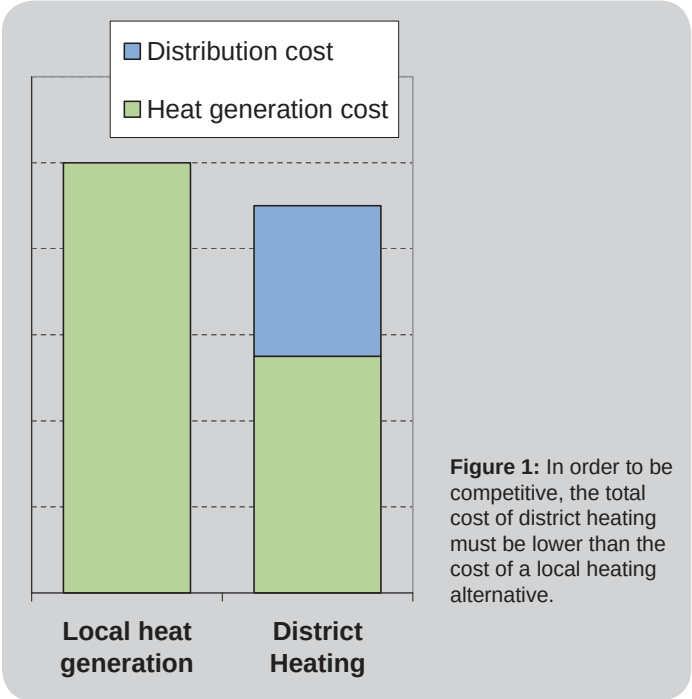


Figure 1: In order to be competitive, the total cost of district heating must be lower than the cost of a local heating alternative.

The market share of DH decreases with energy savings

The DCM model can present results for individual city areas as well as taken togehter to represent cities, countries or all 83 city areas included. The latter is presented in Figure 2. As can be seen, the marginal Cd does not increase liniary with the potential market share of district heating, but increases dramaticaly up to about 60-80 % market share. As also can be seen, the Cd is sensitive for reduced heat loads and the competitiveness of district heating decreases if system heat loads are reduced. Assuming that a feasible Cd is 2,0 EUR/GJ, the potential market share of district heating would be 60 % without any energy savings. The market share decreases to 40 % and 10 %with energy savings of 20 and 50 %, respectively.

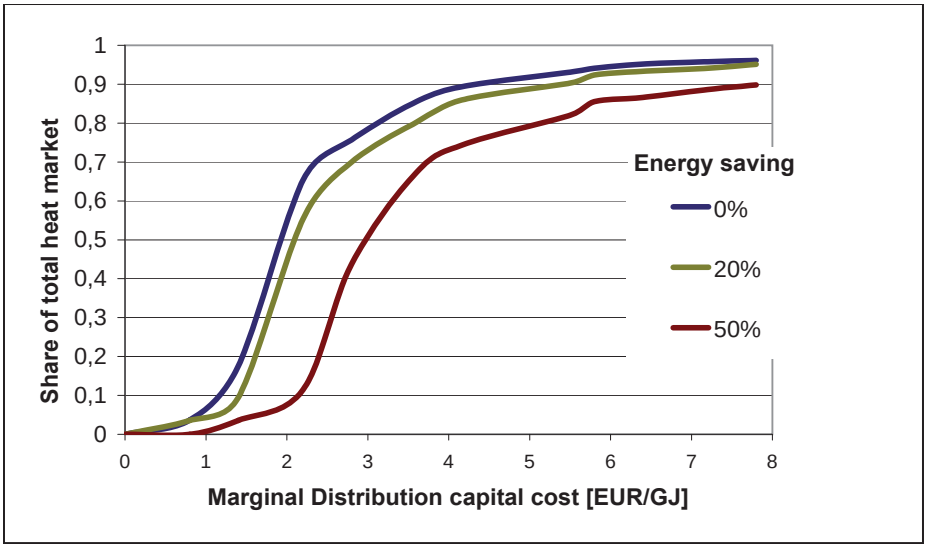


Figure 2: District heating market share as a funtion of distributed capital cost in all included urban areas.

Interreg Project: Pathways for CCS in the Kattegat/Skagerrak region

The Interreg project with the aim to investigate the opportunities for CSS in the Skagerrak region is now launched. Chalmers is responsible for *work package 3* covering the political, judicial and economical perspectives of CCS in the area.

Border crossing programme

Interreg IV is a border crossing EU-programme geographically concentrated to the regions of Öresund, Kattegat, Skagerrak. The vision of the programme is to make the region more competitive and attractive with comprehensive cooperation in the area and with focus on sustainable development.

Opportunities for CCS in Skagerrak

As a part of the interreg programme, Chalmers University and Gothenburg University will participate in a project investigating the opportunities for CCS in the Skagerrak region. The aim of this project is to:

- Bring forward the knowledge basis for the development of infrastructure for capture, transportation and storage of CO_2 in the region.
- Investigate the technical and economical conditions for CCS in the region
- Identify opportunities and obstacles for CCS in the region and illustrate what roll CCS can play.

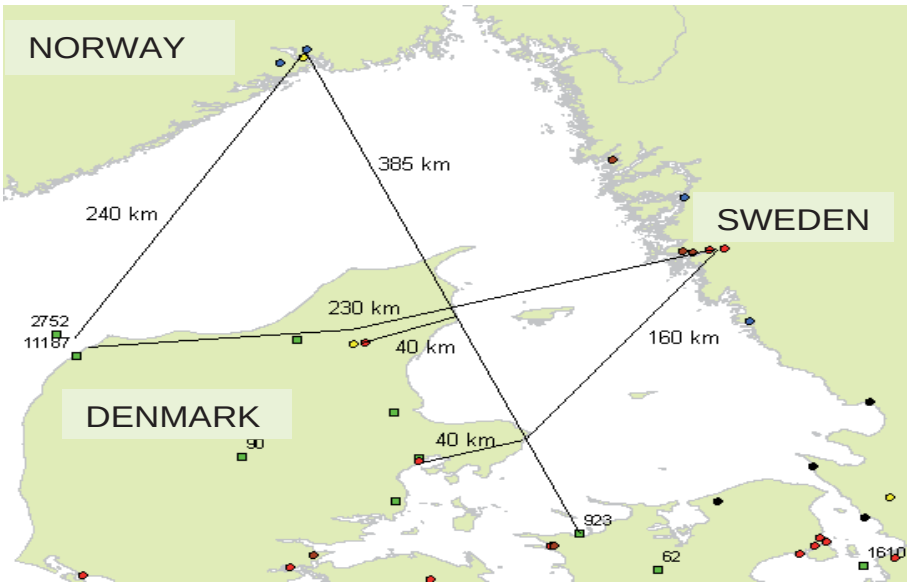
Suitable sinks will be identified

All CO_2 sources above 0,5 Mtonne/year in the region will be included, which are 3 power plants, 3 refineries, 2 cement plants, 1 petrochemical plant, 1 paper & pulp mill, 1 ammonia and 1 ethylene plant. The total emissions from these plants are about 12 Mtonne/year. There are many potential sinks in the region including onshore and offshore aquifers as well as oil and gas fields in the North Sea. A first preliminary survey based on current knowledge suggests that storage in Danish offshore

aquifers seems to be the most appropriate solution, but this will be investigated further in the project.

Carbon leakage and CCS infrastructure will be investigated

The project is divided into four work packages (WP) with Chalmers leading WP 3 which will investigate political, judicial and economical perspectives of CCS in the region. Chalmers will for instance discuss the relevance of using a CO_2 abatement cost, derived from modelling the electricity sector, on the industry sector and the effect of so-called carbon leakage for the industries in the region. Chalmers will also look at capture at some of the industries located in the region and evaluate various CCS infrastructure systems along with other relevant solutions to reduce industry related CO_2 emissions.



The Figure shows relevant CO_2 sources and potential sinks with CO_2 storage potential in Mt CO_2 (green squares) along with distances between some of the sources and sinks. The solid lines are just to indicate typical distances in the region.

Emission standards can cause the EU ETS to fail

It is possible that there will come emissions performance standards (EPS), setting a roof for the CO_2 emissions (CO_2/kWh_{el}) from the power production. With the ELIN model, Mikael Odenberger shows that introduction of EPS can collapse the carbon emission trade system (ETS) and cause larger imports of gas to Europe as well as higher cost of reaching emission targets.

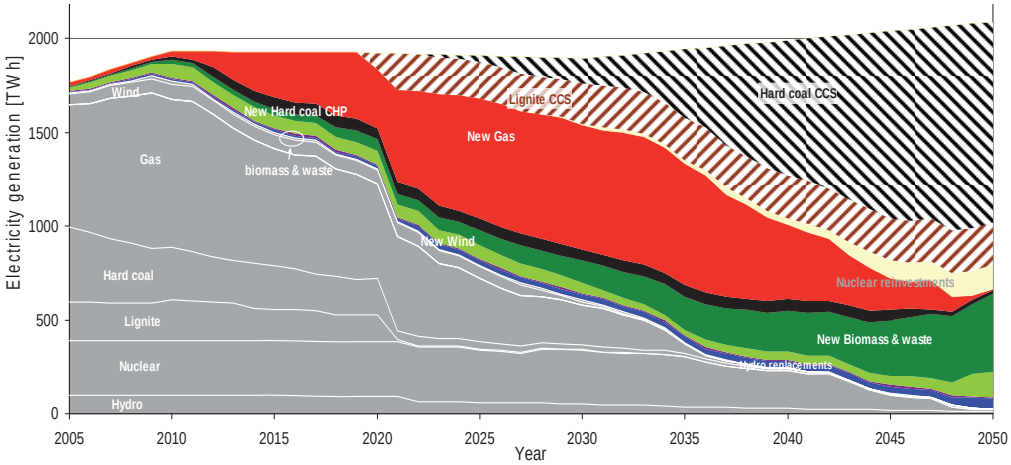


Figure 1. EPS of 350 g CO_2/kWh from 2015 for new power plants and 500 g CO_2/kWh from 2020 for existing ones.

Proposed EPS

In amendments to the IPPC-directive, it is proposed that emissions performance standards (EPS) on the level of for example 350 gram CO_2/kWh electricity could be applied by e.g. 2015 for only new or both new and old power plants. The implication of EPS for the EU electricity supply system are investigated in the ELIN model by Mikael Odenberger.

Different combinations were modelled

Three different levels for EPS where simulated: 500, 350 and 150 g CO_2/kWh and the results are compared with a reference case without EPS. The EPS levels were introduced in different years, with different combinations of new and on old plants. Some interesting results from the simulations are:

Reference case

In the reference case, the most cost effective way of meeting the EU-20-20-20 targets to 2020 and 85% CO_2 emission reduction by 2050 without any restrictions from EPS, is simulated.

EPS of 500 g CO_2/kWh from 2015 on new plants only:

No major difference from the reference case, but there will be more investments in new coal power plants before 2015, since the EPS will not allow this after 2015. In this scenario there is also a risk for life time expansion of existing plants.

EPS of 350 g CO_2/kWh from 2015 for new power plants and 500 g CO_2/kWh from 2020 for existing ones:

This will force the market to invest in gas power plants, see Figure 1. With heavy investments in gas power plants the introduction of CCS will be slowed down. In this scenario the ETS will collapse (zero prices on emission permits) and not recover until CCS is the build margin.

System cost increases

In total 12 different combinations of EPS have been simulated. A general result is that the system cost for power production (net present value) will be higher than in the reference case. The work with continue with deeper studies on how EPS can interact with the ETS. This will be done within the Pathways project and in cooperation with Vattenfall.

Pathways to Sustainable European Energy Systems

A five-year project

The European pathways project is a five year project with the overall aim to evaluate and propose robust pathways towards a sustainable energy system with respect to environmental, technical, economic and social issues. The focus is on the stationary energy system (power and heat) in the European setting. Evaluations are based on a detailed description of the present energy system and focus on how the present system can be developed into the future under a range of enviromental, economic and infrastructural constraints.

Independent results to support decision makers

The Pathways project is a response to the need for a large and long-term research project on European energy pathways, which can produce independent results to support decision makers in industry and in governmental organizations. Stakeholders for this project are: the European utility industry and other energy related industries, the European Commission, EU-Member State governments and their energy related authorities.