EUROPEAN
pathways
NEWSLETTER FROM »PATHWAYS TO SUSTAINABLE EUROPEAN ENERGY SYSTEMS«

#3/2010

Project status

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Prof. Filip Johnsson
Project manager of
the Pathway project

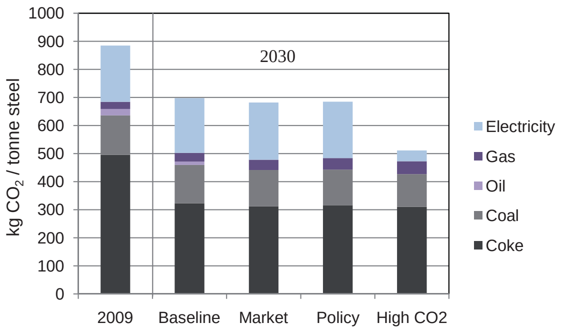
Pathways to Sustainable European Energy Systems is a project within THE AGS The Alliance for Global Sustainability

CO_2 emissions from iron and steel industry can be cut 20 to 40%

The total CO_2 emissions from the iron and steel industry can be cut by some 20 to 40 % to 2030. The reduction potential emanates from structural changes within steel production combined with process optimization and fuel substitution. Moreover, the CO_2 emissions profile of the electricity supply system affects the total steel industry emission heavily due to an increased reliance on electricity as an energy input.

The iron and steel industry is highly intensive in both materials and energy, and more than 40 % of the inputs end up as off-gases and solid co-products and residues. The iron and steel industry contributes roughly 30 % of industrial CO_2 emissions in Europe, equivalent to about 4 % of total European CO_2 emissions.

read more on page 7



Average EU15 steel industry CO_2 emissions per tonne produced steel in 2009 and 2030.

Great potential for energy combines in district heating systems

Biofuel production can be more resource efficient if integrated with the district heating system since such combines allows for utilisation of the surplus heat from the biofuel process. The district heating systems in the EU countries are sufficiently large to accommodate the surplus heat from a biofuel production at a scale that is significant compared to the EU 2020 renewable transportation target.

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Project status

Current work focuses on synthesizing the results and insights obtained from the project as well as planning for a book which summarizes the project results. Of course, we still continue to report the project results in conferences and workshops. I am happy that the project will again be represented at the 10th International Conference on Greenhouse Gas Control, the main international event for discussing and reporting work on the development of carbon capture and storage. I am also proud to announce that we have signed a letter of intent with the Joint Research Centre of Europe (EU-JRC). The aim is to co-operate around the analysis of important energy infrastructures such as the European Power plant stock and infrastructure for transport of captured carbon dioxide (from CCS). We have also completed an associated project on regional energy planning (the PATH-TO-RES project within Intelligent Energy Europe). The project points to the importance of local initiatives and decisions as basis for transforming the energy system, especially when it comes to energy efficiency measures and rational use of energy.

I am looking forward to the activities during this fall!

Prof. Filip Johnsson
Project manager of the Pathway project

CHALMERS ENERGY CONFERENCE 2011

Welcome to the Chalmers Energy Conference 26-27 January – a new forum for stakeholders in industry and governmental organizations involved in shaping tomorrow's energy system. The overall theme of the conference 2011 is "Bridging to Sustainable Energy Systems".

The conference is a two day event with plenary talks as well as parallel sessions on areas such as: Energy Systems Perspectives, Carbon Capture and Storage, Energy from Biomass gasification and combustion and Biorefineries. The first day of the conference is hosted together with the Alliance for Global Sustainability (AGS) Annual Meeting. Read more on www.ags2011.org.

Invitation and conference programme will be sent out during the fall of 2010.

Welcome to Chalmers!

CHALMERS ENERGY CONFERENCE
Bridging to Sustainable Energy Systems

Pathways at conferences

GHGT10 in Amsterdam, September 2010

Pathways researchers will participate at the International Conference on Greenhouse Gas Technologies (GHGT10), 19th-23rd September in Amsterdam.

Selected papers from the project (and associated projects) to be presented at GHGT10:

- CCS in the European Electricity Supply System – assessment of national conditions to meet common EU targets
- Establishing an integrated CCS transport infrastructure in northern Europe – challenges and possibilities
- CCS in the Skagerrak/Kattegat-region – Assessment of an intraregional CCS infrastructure and legal framework
- Thermal Integration and Modelling of the Chilled Ammonia Process

Read more at: www.ghgt10.info

International Conference on Greenhouse Gas Technologies (GHGT)

International Symposium on District Heating and Cooling inTallinn

September 5th – 7th, the 12th International Symposium on District Heating and Cooling was held in 2010 Tallinn, Estonia. The Pathway project was represented by Urban Persson who presented the new concept of *Effective width* in district heating (see Newsletter Nr. 4 2009) and Erik Axelsson who presented *Prospects for bioenergy combines*.

Urban Persson and Erik Axelsson participated at the 12th International Symposium on District Heating and Cooling in Tallinn.

Non fossil emission clusters are crucial for CCS within the pulp and paper industry

With increasing CO_2 prices, CCS could become a cost effective option for reducing CO_2 emissions in pulp and paper mills. If all mills with annual emissions above 0.1 Mt CO_2 would implement CCS, the total capture potential would be 80 Mt/yr. The capture potential would still be 50 Mt/yr if only including larger mills in capture clusters based on fossil as well as biogenic emissions. However, if restricting the focus to fossil emission capture clusters, the potential for capture is low, only about 8 Mt/yr.

Bottom-up approach and an aggregated European potential

Johanna Jönsson studies different possible technology pathways for the European pulp and paper industry (PPI). Based on detailed analyses on a mill level the overall potential on an European industry level can be estimated, thus a bottom-up approach is applied. This approach has, for example, been used to estimate the CO_2 mitigation potential through the introduction of carbon capture and storage (CCS) within the European PPI. The European PPI is currently experiencing a structural change and, therefore, only mills estimated to have a long-term viability are included.

Infrastructure and size are decisive

The implementation of CCS is dependent on CO_2 transport infrastructure and this aspect is accounted for by linking the geographical coordinates of the mills with the coordinates for other industrial capture clusters and potential storage sites; see Figure 1. The latter are an outcome of other research within the Pathways project. Further, it is reasonable to assume that the potential for profitable introduction of CCS is larger for mills with larger emissions than sites with smaller emissions. Based on these assumptions, a matrix was constructed containing six future cases for implementation of CCS in the European PPI; see Table 1.

Table 1. The six different future cases considered for implementation of CCS.

Mills with emissions	Capture done by all included mills	by mills in capture clusters	by mills in fossil capture clusters
>0.1 Mt CO_2/yr	A1	A2	A3
>0.5 Mt CO_2/yr	B1	B2	B3

CO_2 capture potential between 8 to 80 Mt

Figure 2 illustrates the CO_2 capture potential in the different cases and it can be noted that approximately 75% of all emissions derive from about one third of the mills (the ones with emissions >0.5 Mt/yr). These mills are mainly the kraft mills included in the study. Another result is that if CCS is only implemented for large point sources within the European PPI, the captured CO_2 will originate almost solely from biomass, see Figure 2. As can be seen in Figures 1 and 2, a large-scale introduction of CCS to reach significant CO_2 emission reductions in the European PPI requires an inclusion of the emission intensive Scandinavian kraft PPI in such a capture scheme. If only the mills located in fossil-fuel based capture clusters are included (as in cases A3 and B3), the capture potential is drastically reduced to about a fifth of the potential compared to when mills in both fossil- and biomass-based capture clusters (A2 and B2) are included.

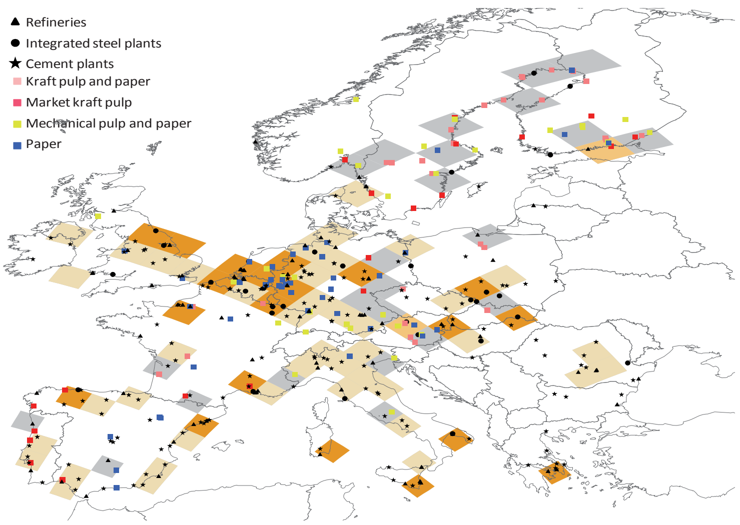


Figure 1. The geographical distribution of pulp and paper mills emitting more than 0.1 Mt CO_2/yr in relation to other large industrial point sources >0.5 Mt CO_2/yr. Possible capture cluster areas are represented by coloured squares (150x150 km); the orange squares represent clusters with more than 2 industries which together emit more than 5 Mt CO_2/yr and the yellow and grey clusters emit more than 1 Mt CO_2/yr.

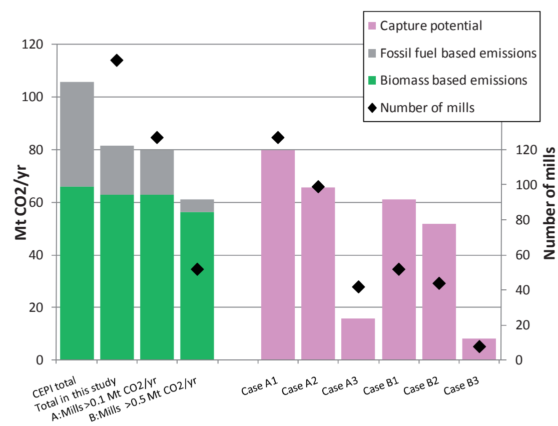
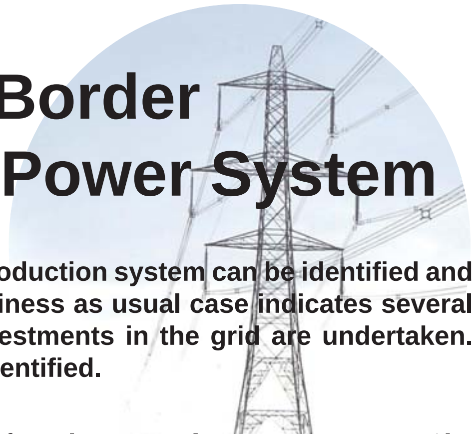


Figure 2. The distribution of included emissions divided by size and origin along with the potential for captured CO_2 emissions for the six studied capture cases presented in Table 1.

For further information:
JOHANNA JÖNSSON, Chalmers University of Technology



Investment Analysis of Cross-Border Interconnections of European Power System

With the DC-Power Flow model, grid bottlenecks for a future electricity-production system can be identified and different grid reinforcement options can be evaluated. Analysis of a business as usual case indicates several potential bottlenecks in the European transmission system, unless investments in the grid are undertaken. Profitable grid reinforcement options to avoid the bottlenecks are also identified.

Model for analyzing the power grid

Within the Pathways project, a complete modeling package for analyzing the power-generation system has been developed (see Newsletter 1, 2010). Included in this package is the DC-Power Flow model which uses the hourly electricity production estimated by the EPOD model as input. The DC-Power Flow model provides a detailed description of the electricity-transmission grid in the EU. Hence, this model is an efficient tool to identify grid bottlenecks and can also be used to evaluate grid reinforcements needed (or alternative generation siting) in the future European power system. Here a cost-benefit analysis of a business as usual (BAU) case is presented.

Bottlenecks identified

The grid situation in BAU is presented in Figure 1. Due to congested lines there is not a common price for the whole system, and three prices zones can be identified: red for expensive, blue for cheap and green for middle price zone. The most expensive area is the one corresponding to Italy implying that large amounts of power is transferred to the South from neighboring areas.

Germany, together with France, is the major exporter of the system and the most critical lines of the network seem to be the cross-border connections from Germany. The strategic position of Slovenia makes it a significant arbitrator facilitating the flows from the north to Italy and to the South Eastern Europe.

Profitable transmission reinforcements

According to the aforementioned observations five transmission expansion scenarios have been assessed as shown in Table 1. Cost-benefit analyses are performed for all scenarios, where the discounted investment costs are weighted against the discounted benefits from the proposed transmission project (the environmental benefits and the reduction of congestion costs in the network). The cost-benefit analyses show that all the scenarios are profitable for the whole analyzed period (2008-2032). The second scenario is assessed the most profitable among the scenarios even though it's not the cheapest alternative.

Table 1: Candidate transmission scenarios

	From	To	actual tran. capacity (MW)	additional tran. capacity (MW)	Inv. costs (M€)
scenario 1	7 (CH)	9 (AT)	1200	3000	500
	7 (CH)	8 (IT)	3890	5000	
	6 (DE)	9 (AT)	2000	4000	
	1 (PT)	2 (ES)	1300	2000	
scenario 2	6 (DE)	9 (AT)	2000	3000	365
	14 (SL)	15 (HR)	900	2000	
	6 (DE)	10 (CZ)	2300	4000	
scenario 3	9 (AT)	14 (SL)	650	1300	400
	6 (DE)	5 (NL)	3000	4000	
	6 (DE)	10 (CZ)	2300	4000	
	1 (PT)	2 (ES)	1300	2000	
scenario 4	6 (DE)	10 (CZ)	2300	4000	620
	6 (DE)	11 (PL)	1200	3000	
	1 (PT)	2 (ES)	1300	2000	
scenario 5	9 (AT)	14 (SL)	650	1500	300
	11 (PL)	12 (SK)	550	1500	
	6 (DE)	9 (AT)	2000	4000	

The Policy Pathway will reduce the stress on the grid

In the Policy pathway, which targets both CO_2 emission reductions and large demand-side efficiency improvements, the total electricity generation decreases. This, in turn, will reduce the stress in the future transmission systems. Therefore, the need for new investment will be lower with the Policy pathway. In the Market pathway, on the other hand, only targets for CO_2 emissions are postulated and focus is on mitigation measures in the energy supply-side sectors. The pathway suggests large structural changes with an increased demand of electricity. Obviously, the need for investment will, in most cases, be higher than in the Policy pathway. In whichever pathway, the method presented in this work will be applicable and provide important information.

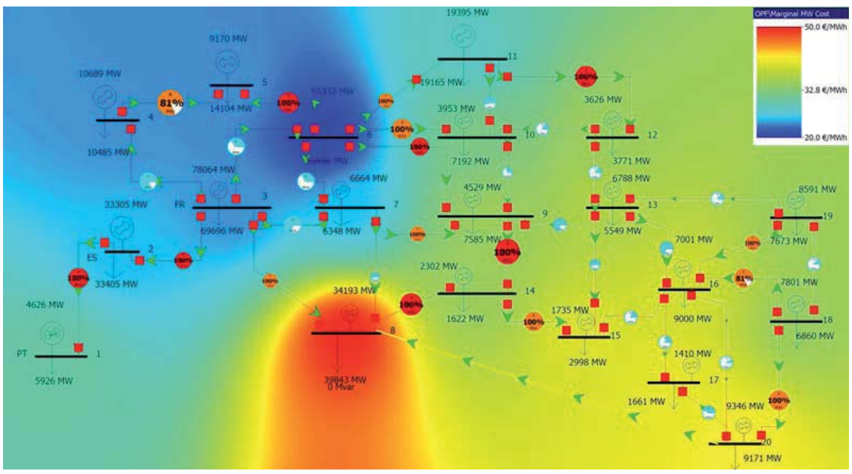


Figure 1: Price zones and congested lines in Europe (BAU)

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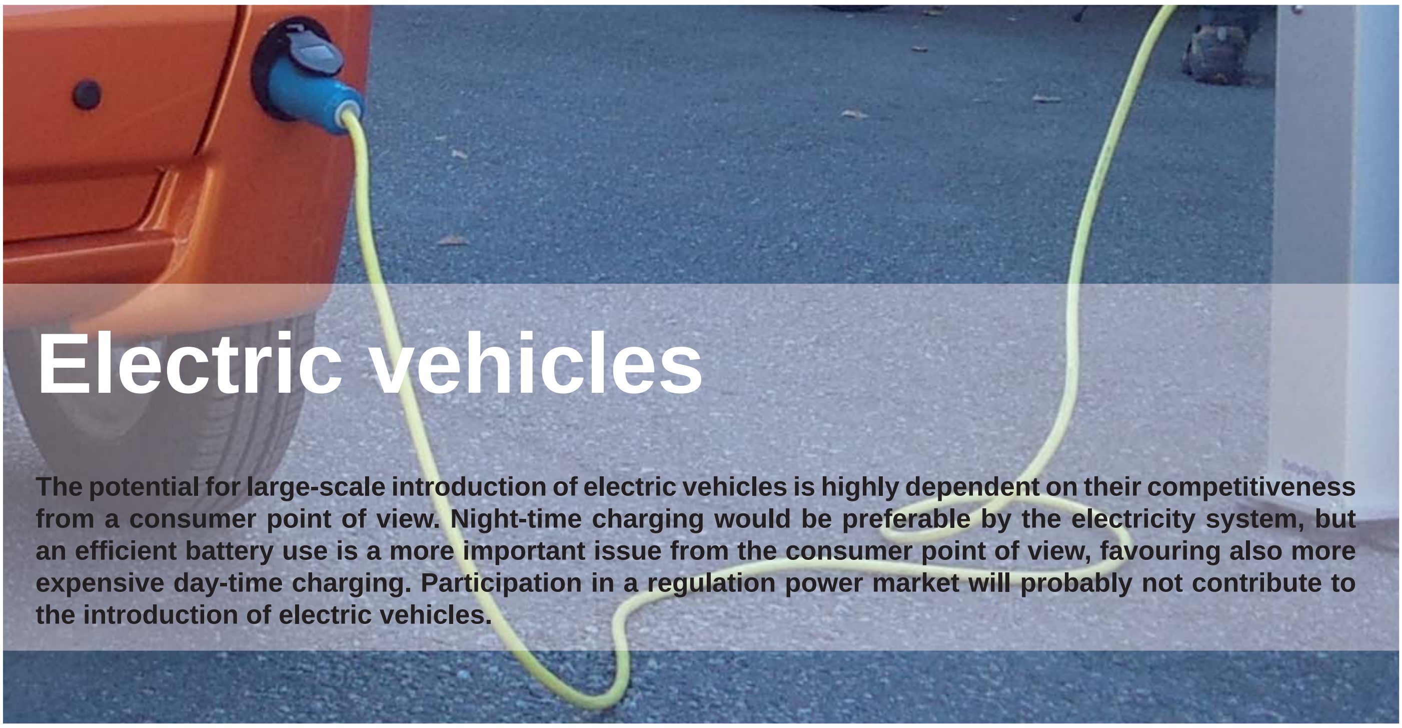

Electric vehicles

The potential for large-scale introduction of electric vehicles is highly dependent on their competitiveness from a consumer point of view. Night-time charging would be preferable by the electricity system, but an efficient battery use is a more important issue from the consumer point of view, favouring also more expensive day-time charging. Participation in a regulation power market will probably not contribute to the introduction of electric vehicles.

Analysis of PHEV's

Sten Karlsson and others at Chalmers have carried out a study on electric vehicles regarding their design, competiveness and potential. The study focuses on plug-in hybrid electric vehicles (PHEV's), but the results are, to a great extent, also applicable for pure electric vehicles. The study has been divided into three main parts:

- Analysis of the techno-economical conditions for PHEV's to provide a basis when developing scenarios including large-scale introduction of PHEV's.
- Analysis of the value of PHEV's in the electricity system to regulate intermittent electricity generation and to participate in the regulating power market.
- Analysis of the impact of the stationary sector for the choice of energy carrier for transportation.

Competitiveness crucial for large-scale introduction

The potential for large-scale introduction of electric vehicles is very dependent on their esteemed competitiveness from a consumer point of view. The competitiveness relies mainly on the development of costs and performance, particularly with respect to battery and charging options. This, in turn, is highly dependent on the individual car movement pattern and the development of battery-charging infrastructure. Other important external factors are the progress of competing technologies and the design of the regulatory regime surrounding the transportation system. The latter since electric vehicles are not competitive without support under current conditions and in an introductory phase.

Participation in a regulating power market does not facilitate introduction significantly

The opportunities for PHEV's to participate on the regulatory market depend on the design of the local regulatory system. For instance, the value for participation is virtually zero in Sweden, but relatively high on the German market. The reason for the difference is that in Germany participants on the regulating power market are paid for available capacity, while in Sweden only for energy exchange. In general, it is down regulation that seems profitable, which means recharging of the car. However, the market is small, and the necessary infrastructure and businesses for coordination of many vehicles is not in place. A general conclusion is that the argument that participation in a regulating power market could facilitate an introduction of PHEV's probably is wishful thinking.

Only night time charging not profitable for PHEV owner

Simulations based on Jutland's electricity production system indicate at a decreased cost of producing electricity if charging of the batteries can be done at night time. The benefits mainly result from a reduced number of start-ups and less part load use of thermal power plants. However, it is important to note that with today's expensive batteries the most profitable option from the consumer's point of view often implies using a smaller battery which requires day time charging as well.

CCS favours hydrogen before electricity

The technology used for long-term CO_2 neutral energy supply affects the prices of energy carriers, which in turn can influence the choice of energy carrier in the transport sector. The analysis shows that an electricity production system dominated by coal-fired plants combined with CCS favours solutions using hydrogen as an energy carrier for cars. The reason is that, in this case, the production cost of hydrogen from coal with CCS could be about half the cost of electricity.

For further information:
STEN KARLSSON, Chalmers University of Technology

Great potential for energy combines in district heating systems

Biofuel production can be more resource efficient if integrated with the district heating system since such combines allows for utilisation of the surplus heat from the biofuel process. The district heating systems in the EU countries are sufficiently large to accommodate the surplus heat from a biofuel production at a scale that is significant compared to the EU 2020 renewable transportation target.

Technical potential for combines in Europe's district heating systems

Andrea Egeskog and Julia Hansson have investigated the possibilities of cogenerating biofuels for transportation and heat for district heating systems. The surplus heat from the biofuel production unit can thereby be utilised as a heat source for district heating. The techno-economical potential for combined biofuel and heat production (hereafter referred to as CBH) is assessed based on a description of the existing (year 2003) and potential (year 2020)district heating systems in Europe. The CBH unit is here assumed to be in the form of second-generation biofuel production where 50% of the energy input (such as biomass) is converted to biofuel and 10% ends up as usable surplus heat (this corresponds to a gasification process). The CBH potential is estimated using the EuroHeatSpot model which is a simulation tool for national district heating analyses; see Figure 1.

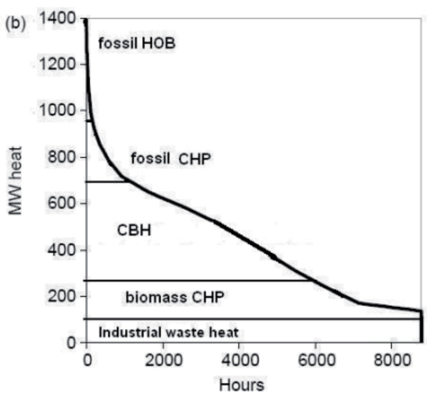

Figure 1. Description of the EuroHeatSpot model. Heat load duration diagram of the aggregated DH systems when CBH is introduced: before fossil CHP scenario.

Virtually all countries' district heating systems can absorb the excess heat

Figure 2 presents the heat production from CBH (corresponding to biofuel production according the EU's 2020 target) related to other district heating production sources in different EU countries, assuming that CBH heat is cheaper than heat from fossil CHP year 2003. The results indicate that all studied countries, except Italy, have district heating systems with a capacity to accommodate surplus heat from a biofuel production exceeding set the national targets.

Sizes are crucial

The overall potential is based on the aggregated national district heating system due to a lack of information on the individual/local district heating system level in the different countries. However, the size of the individual district heating system is of great importance for the possibilities of cost efficient CBH introduction. A complementary assessment considering this factor was therefore performed for Finland, France, Lithuania, Sweden and Germany (where information on different district heating systems is available). The assessment show that, assuming that CBH plants are cost-competitive only at 1000 MW of biomass input (corresponding to about 2.9 PJ heat output), about 20–30% of the DH systems in the above mentioned countries (except France with 5%) have the corresponding heat demand. Assuming that CBH plants are cost-competitive already at 250 MW the corresponding values are 60–75% for the assessed countries (except France where the corresponding value is 35%). The assessment indicates that the cost-competitiveness of smaller CBH plants is of importance for a large-scale implementation of CHB in the district heating systems in Europe.

The "Market Pathway" facilitates combines

The introduction of CBH plants could be facilitated if the future development of the energy system moves towards an increased demand for district heating in the end-use sector, as suggested by the Market Pathway. On the other hand, a development towards decreased demand of district heating, for example, due to large-scale implementation of energy efficiency measures, such as in the Policy Pathway, could diminish the opportunities for CHB plants.

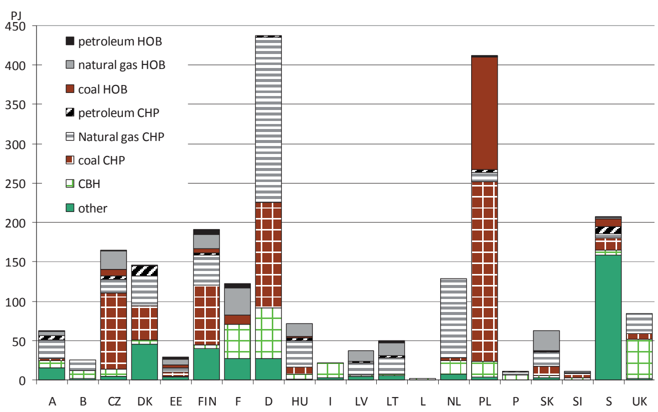

Figure 2. The heat-source distribution in aggregated national district heating systems when CBH (at a scale corresponding to the 2020 renewable transportation target) is placed ahead of fossil CHP (Figure 1) and in the merit order. The category "other" includes industrial waste heat, waste incineration as well as waste heat from nuclear power, biomass, geothermal and solar thermal energy.

For further information:
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CO_2 emissions from iron and steel industry can be cut by 20 to 40 %

The total CO_2 emissions from the iron and steel industry can be cut by some 20 to 40 % to 2030. The reduction potential emanates from structural changes within steel production combined with process optimization and fuel substitution. Moreover, the CO_2 emissions profile of the electricity supply system affects the total steel industry emission heavily due to an increased reliance on electricity as an energy input.

30 % of industrial CO_2 emissions derive from the iron and steel industry

The iron and steel industry is highly intensive in both materials and energy, and more than 40 % of the inputs end up as off-gases and solid co-products and residues. The iron and steel industry contributes roughly 30 % of industrial CO_2 emissions in Europe, equivalent to about 4 % of total European CO_2 emissions.

Capital vintage model to avoid pitfall of traditional modeling

Johan Torén and Stefan Wirsenius have assessed the potential for energy intensity reduction and for CO_2 mitigation in the iron and steel industry of EU15. For this, a dynamic computer model that uses econometric forecasting techniques to capture the main production stages and technologies has been applied. Embedded in the overarching econometric model is a capital vintage module that explicitly accounts for the age structure of the stock including age-specific efficiencies, production levels and capacity utilization. Capital vintage modeling is an attempt to avoid the pitfalls of more traditional bottom up and top down modeling.

Scenarios according to Pathways framework

To estimate the potential for energy intensity and CO_2 mitigation several scenarios for energy prices and cost of CO_2 emission have been adapted from the overarching Pathways framework. The scenarios are also applied to assess how the iron and steel industry reacts to high or low future energy prices and how lax or stringent CO_2 emission reduction policies affect industry structure, fuel mix, CO_2 intensities etc.

Scrap based production can become dominating

Initial modeling indicates that CO_2 emissions from the iron and steel industry can, to 2030, be cut by some 20 to 40 % compared to current levels. Emission reductions are stemming both from structural changes as well as process specific improvements and optimization, see Figures 1 and 2. Primary ore based steel production (Blast Furnace/Basic Oxygen Furnace Route) will under the scenario assumptions lose its current role as the principal steel production route. Instead, secondary scrap based production (Electric Arc Furnace route - EAF) will account for roughly 55 to 60 % of total EU15 steel production in 2030. Coupled with the increasing importance of secondary steel production is the effect of CO_2 intensity of electricity production for the steel industry's cumulative CO_2 emission profile. This is especially evident in the scenario with high CO_2 cost (High CO_2) where coal-fired power plants with CCS reduce the CO_2 intensity of electricity production towards the end of the analyzed period.

For further information:

JOHAN TORÈN and STEFAN WIRSENIUS, Chalmers University of Technology

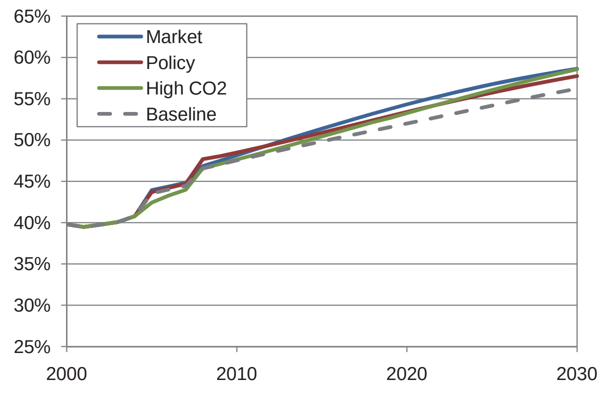

Figure 1. Electric Arc Furnace Share of total steel production 2000-2030, EU15

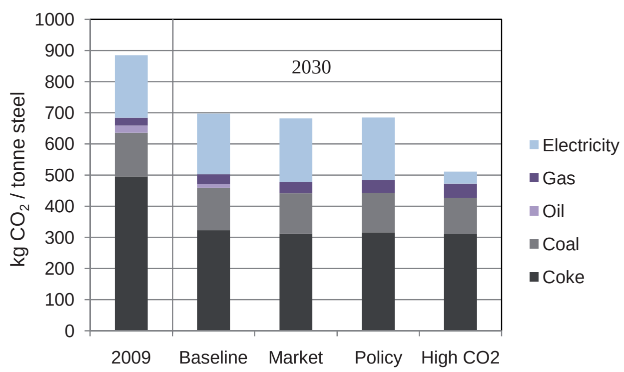

Figure 2. Average EU15 steel industry CO_2 emissions per tonne produced steel in 2009 and 2030.

Pathways for Space Heating in Sweden

Space heating in Sweden's residential sector accounted for 52 TWh in 2005 which amounted to 58 % of the energy use for the sector. By 2050 this amount can be reduced to between 38 TWh and 43 TWh with a combination of fiscal and regulatory measures. Without any such measures, energy for space heating falls to 47 TWh anyway, due to technical progress.

Market and Policy pathways

By using an econometric based model, Eoin Ó Broin has examined the role of the development of the economy and legislation on demand for energy for space heating in dwellings. To reduce energy use for space heating below 43 TWh by 2050 will require targeted fiscal measures, while to bring the total lower again to 38 TWh will require the same fiscal measures plus the addition of further improvements in efficiency. Within the framework of the pathways project two scenarios have been analyzed. One scenario, the market scenario, involves fiscal measures only while the other, the policy scenario, combines fiscal and regulatory measures. The development of energy prices for space heating to meet these different possibilities are listed in Figure 1. In the business as usual (BAU) scenario no additional carbon or energy taxes are envisaged and fuel costs remain relatively low. In both the policy and market scenarios a carbon tax is introduced with fuel prices remaining low. The carbon tax is however higher in the market scenario to compensate for the absence of regulatory measures in this scenario.

Regulation will accelerate technical progress

In both the business as usual and market scenarios, technical progress is expected to develop linearly over the four decade period examined. Higher prices will encourage additional efficiency measures and conservation in the market scenario. In the policy scenario, direct regulation of energy demand for energy services (including space heating) will accelerate technical progress. In this scenario, it is assumed that efficiency improvements due to non price effects (direct regulatory intervention) will accelerate by 25 %. Put another way, efficiency levels that would ordinarily be reached by 2060 will be reached in the policy scenario by 2050. Fiscal measures as applied to both the policy and market scenarios and the accelerated technical progress applied to the policy scenario result in the demand levels shown in Figure 2. Demand falls in all three scenarios despite increases in population and floor space per capita.

Continued district heating might be more optimal from distributed energy

The totals listed in Figure 2 are based upon unit consumption levels of 60 kWh and 67 kWh per square metre by 2050 for the policy and market scenarios respectively. Prices would have to be higher and/or efficiency improvements greater in order to reduce these figures to below an average of 15 kWh of delivered energy per annum which would be necessary to bring the Swedish housing stock to the passive standard as set by the Passive House Institute in Germany. Given, however, that 60 kWh per square metre amounts up to a 50 % reduction in unit consumption over 2005 levels, this would be a significant achievement in itself. In addition to this is the fact that district heating has widespread use in Sweden and, thus, from a systems perspective it may be more optimal to continue using distributed energy for heating. Thus, competition between end-use efficiency and supply side efficiency could contribute to keeping energy use for space heating above the passive standard.

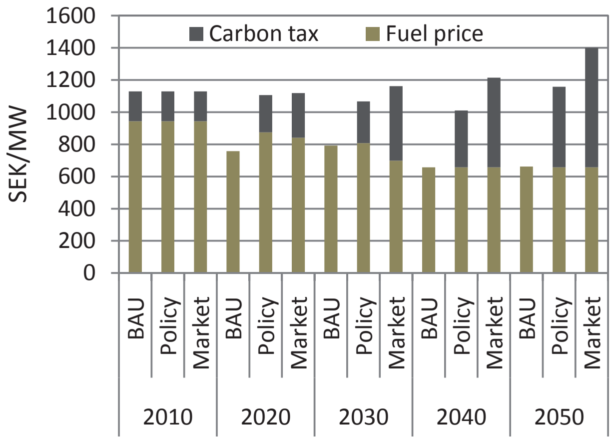

Figure 1 : Energy Prices for Households (fuel price and carbon tax) based on Axelsson and Harvey's (2010) wholesale prices for industry with adjustments for the residential sector to account for VAT, taxes and distribution costs.

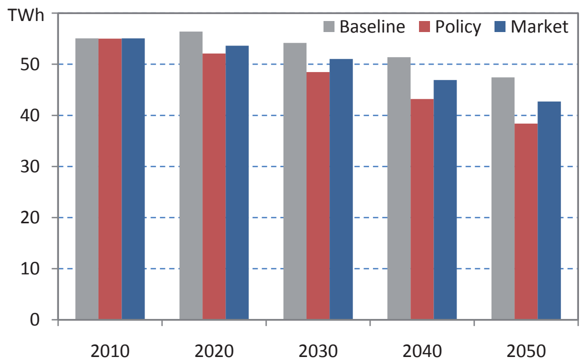

Figure 2 : Total energy use for space heating in Sweden in three scenarios. These results are despite increased population and floor space per capita and are as a result of fiscal and regulatory measures.

For further information:
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