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The Pathways project in Bangkok

During 19-22 March, the AGS Annual Meeting 2006, was held in Bangkok, Thailand. This was a well visited event with approximately 300 scholars, thought leaders and decision-makers of public interest groups, industry and governments from all around the world.

The AGS energy flagship program, including results from the Pathways project, was a centre piece for a series of workshops on regional differences at the Meeting. Professor Filip Johnsson

discussed also the research effort that will be required within the AGS if feasible pathways for the 5-15 year period are to be identified.

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Co-firing - a bridge to renewable electricity

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Low cost, short time

Existing plants can be rebuilt for biofuel combustion at a low cost and in a reasonably short time.

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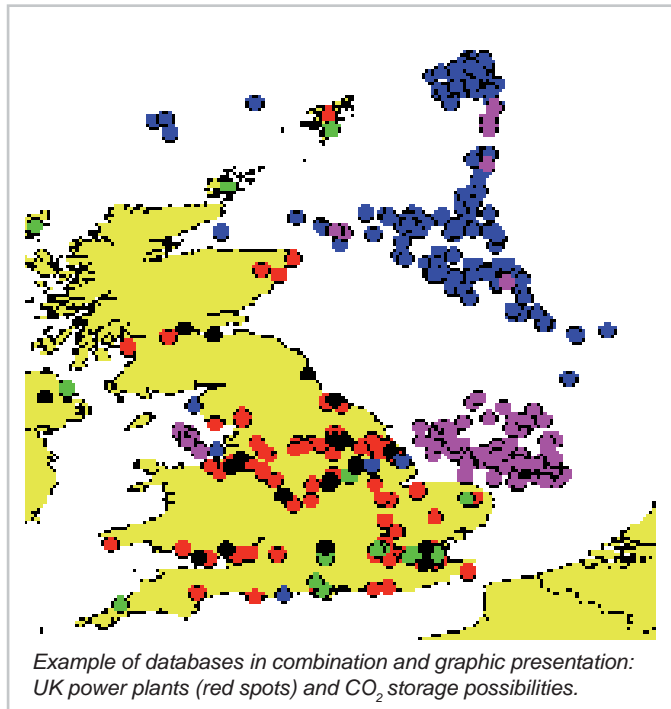


Chalmers databases in progress ...

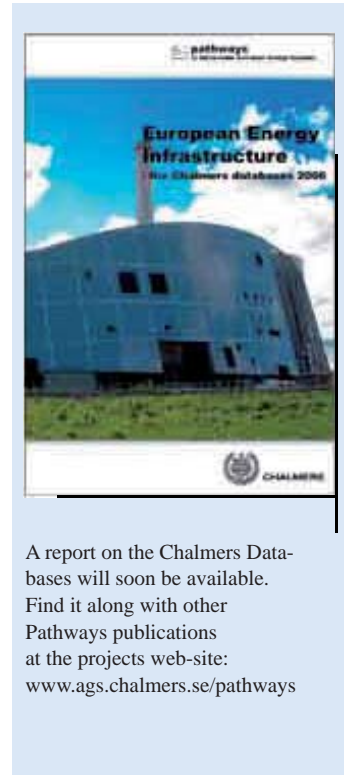
Power grid and coal data added to the Chalmers Databases

The Chalmers databases are an essential part in the search for Pathways. They will be used in the modeling process by generating a considerable share of the input data. They will also be used as input into GIS-programs for combining maps with information.

Coal and Power Grid
The Power Plant, the CO₂ storage and the Member state databases are continuously updated. During 2006 focus will be on incorporating coal infrastructure into the database where most of the European coal fields are already in place. The work on a power grid database



will also be finished during the year.



... and in use

Present and future power generation systems

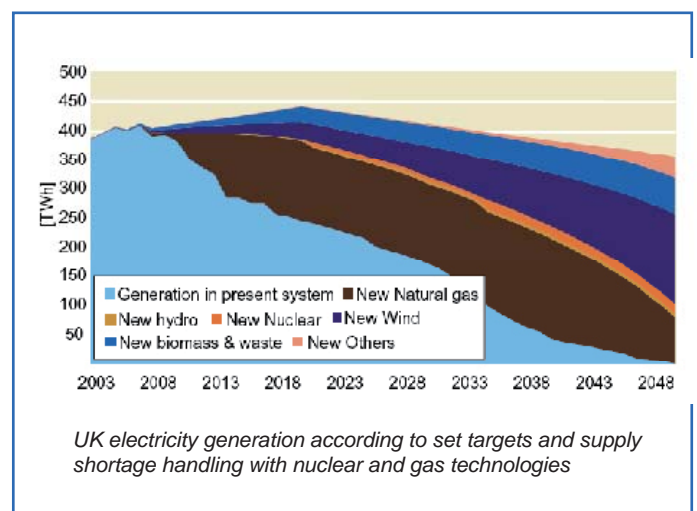
The Chalmers Databases have been practically used in recent studies. A description of the current and planned power plant structure in both Germany and the UK with respect to capacity, age and fuel mix was recently finished.

Wind in Germany
In Germany there was a significant growth of wind capacity during the last decade which seems to continue. Also, there is no obvious switch to gas even though both coal and lignite have decreased since 1970.

Natural gas in the UK
On the other hand for the

UK, the switch from old coal power into natural gas power is clear. Similar to Germany, wind power is increasing but not in the same extent.

UK development
In a third study, the development of the UK power generation system has been modelled. It is based on the Chalmers power plant databases and a specific scenario including for example a reduction of CO₂ emission by 60 % in 2050. The figure shows the phase out of the current power plants and the development of primarily new natural gas, wind,



biomass and waste and also some nuclear power generation.

In another study the potential for co-combustion

of biomass for electricity production in Poland has been evaluated.

More about this at page 6.



Public gives priority to environment before economy

More than 50 % of the public in the UK, US and Sweden considers the environment to be the first priority. This is one of the results from a study of the public opinion of energy and the environment. Similar studies have been directed to the public in the US, UK, Sweden and Japan.

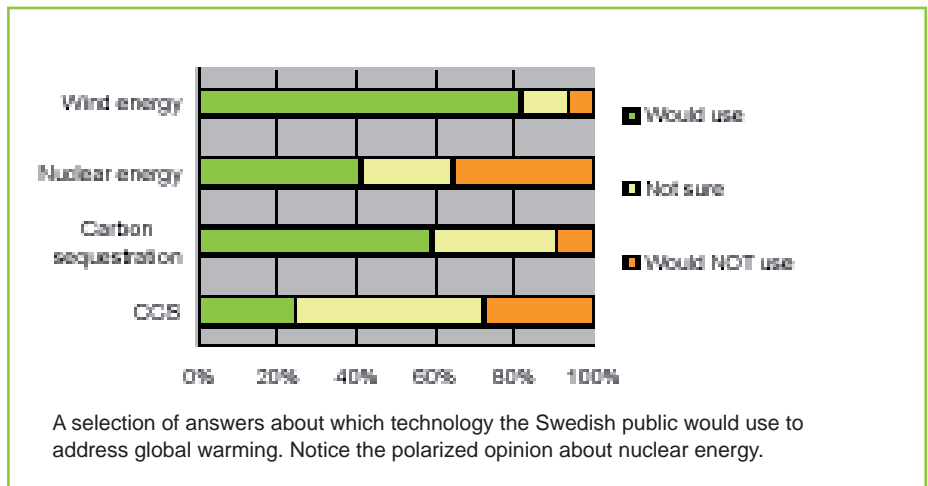
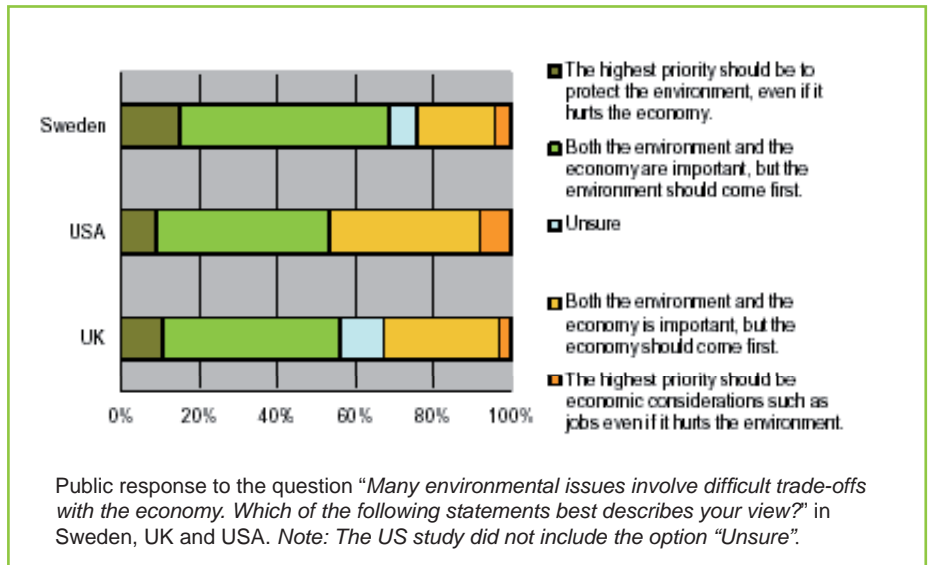
Public opinion of energy

The aim of the work was to increase the understanding of the perception of the public within the area of energy and climate as part of identifying non-technical barriers for the introduction of various technologies and measures to mitigate CO₂ emissions. Of particular interest were CCS (Carbon Capture and Storage) related issues. A questionnaire was used, which was separated into three sections; public understanding, public attitudes and willingness to pay to solve global warming.

Little knowledge about CCS

The public was asked about their familiarity of CO₂ reduction technologies in general. Many of the respondents had heard or read about more efficient cars, nuclear energy, wind energy, solar energy and more efficient appliances.

More than half of the respondents had heard or read about biomass/bio energy but only about 15 % had heard or read about carbon capture and storage (CCS). Less than 10 % had heard or read about carbon sequestration (e.g. CO₂ capture in trees).



The full report will soon be available from the Pathways web-site: www.ags.chalmers.se/pathways

Forming the Pathway toolbox

A toolbox of models for the Pathways program is being assembled. Using energy-system models enables the transforming of a very complex reality into a simpler, yet representative, form that is more suitable to comprehend and analyze. Today the model toolbox contains five different models and the Chalmers databases. A modeling strategy is under creation and new models could be added to this toolbox, others might be excluded. We will briefly present one model in each edition of this newsletter.



Current status of the model tool box

The models currently employed by the Pathways project are all technology and engineering oriented, and in different stages of their development. So far the project includes the following models:

- The PEEP (Perspectives on European Energy Pathways) model,
- The MARKAL (acronym for MARKet ALlocation) model,
- The Power Simulating model,
- The EPOD (Electric POWER Dispatch) model,
- The Martes model.

Involving clients

The use of energy system models is preferably done in order to improve decision making for a certain client or clients. Thus, these clients should also be included in the modeling process since modeling to a large extent is a learning process. This also enables feed-back to the model and the modeler.

MARKAL

By using the MARKAL (acronym for MARKet ALlocation) model combined with a database that includes the stationary energy system of the Nordic countries, this region may act as a test arena for several of the research issues that will be addressed in the project. These issues may not be as thoroughly investigated for other regions where the regional modeling lacks the corresponding high resolution as is included in MARKAL for the Nordic countries. Some of the research questions addressed are:

- The interrelationship between policy measures, e.g. tradable emission permits, tradable green certificates (electricity certificates) and CO₂ and energy taxes.
- The future development of the energy system and the role of different energy carriers such as electricity, district heating, gas and biofuels.
- Costs for meeting specific climate-policy targets
- The impact of climate and energy policy on energy markets
- The distribution of cost-efficient climate-policy measures between different stationary energy sectors, e.g. residential,

Optimized use of biomass and CO₂ reductions

- the PEEP model leads the way

The PEEP model can be used to analyze several issues under a varying context regarding development in the transport and energy fields. The focus within the Pathways project will be on cost-effective bioenergy production, trade and use. For example the model can be used to analyze

- the implications of high biofuel scenarios for the development of heat and power generation in EU25+
- in which sector biomass is most cost-effectively used, given externally defined policy regimes, development of mobility patterns and energy use, and development of relevant technologies and markets.
- the distribution of cost-efficient CO₂ reductions between different sectors, e.g. the stationary sector and transports,
- an indication of an all-European tradable emission permit price for different CO₂-reduction targets.



Will a European deregulated market path the way for sustainability?

That is one of the questions to be analysed in the Pathways project during 2006. Seven opening questions have been identified as essential for the project and therefore allocated to this first year.

Opening Questions 2006

1. Description of "pathways"

What are the criteria for a description of "pathways to sustainable energy systems". How will the choice of criteria influence the design of the pathways?

2. The current "pathway"

Will the *current* "pathway" lead to a sustainable energy system?

3. Two-three pathways to sustainable European energy systems

How can pathways to a sustainable energy system be characterized and visualized and what are the consequences of these pathways?

4. Key technologies and systems

What are "key" technologies and systems for the identified "pathways"? Where are the greatest uncertainties in technology choices?

5. Will a European deregulated market path the way for sustainability?

Are the deregulated energy markets suitable to facilitate a development towards a sustainable energy system? Are the present market conditions suitable for a development along a pathway towards a sustainable energy system?



6. Political action and decisions

What kind of political action is necessary? What can and should the EU and/or the Member States do politically? What issues have to be addressed at an international level?

7. Acceptance of the society?

What possibilities and obstacles can be foreseen? What are the choices that consumers would like to make which lead to sustainability? How will these affect political decisions, and vice versa?

Workshop:

Sustainable development

The term sustainability was the subject of a workshop in April. Participants from different scientific fields joined an exciting discussion about sustainability from economic, social and environmental points of view.

Important framework

The Brundtland definition of sustainability is widely accepted. But what does sustainability mean in an economic or social sense? The workshop was the start of a process where sustainability is defined for the Pathways project.

An important finding of the workshop was that sustainability is a concept to relate to and use as a platform



Sustainability is used in the context of social, economic and environmental sustainability. But what does this mean?

in discussions about development. It is a concept in change as society and environment changes. It is also a concept where nature is an in many ways vital resource that like everything else is in constant change, used and affected by mankind.

Co-firing - a bridge to renewable electricity

Co-combustion of biomass and coal is one way to increase the share of renewable energy in the energy system. In this way, existing plants can be rebuilt for biofuel combustion at a low cost and in a reasonably short time.

As part of the EU accession treaty, Poland has set a target to increase the share of renewable energy to 7,5 % by 2010 (in 2002 the share was about 2 %). Co-combustion for electricity production is expected to contribute to a large extent.

In the study, data from the Chalmers power plant database was used and expanded with information about boiler type. The focus was on boilers fueled with coal, corresponding to 95 % of the installed capacity in Poland. They represent the most reasonable way to co-fire fossil fuels and biomass.

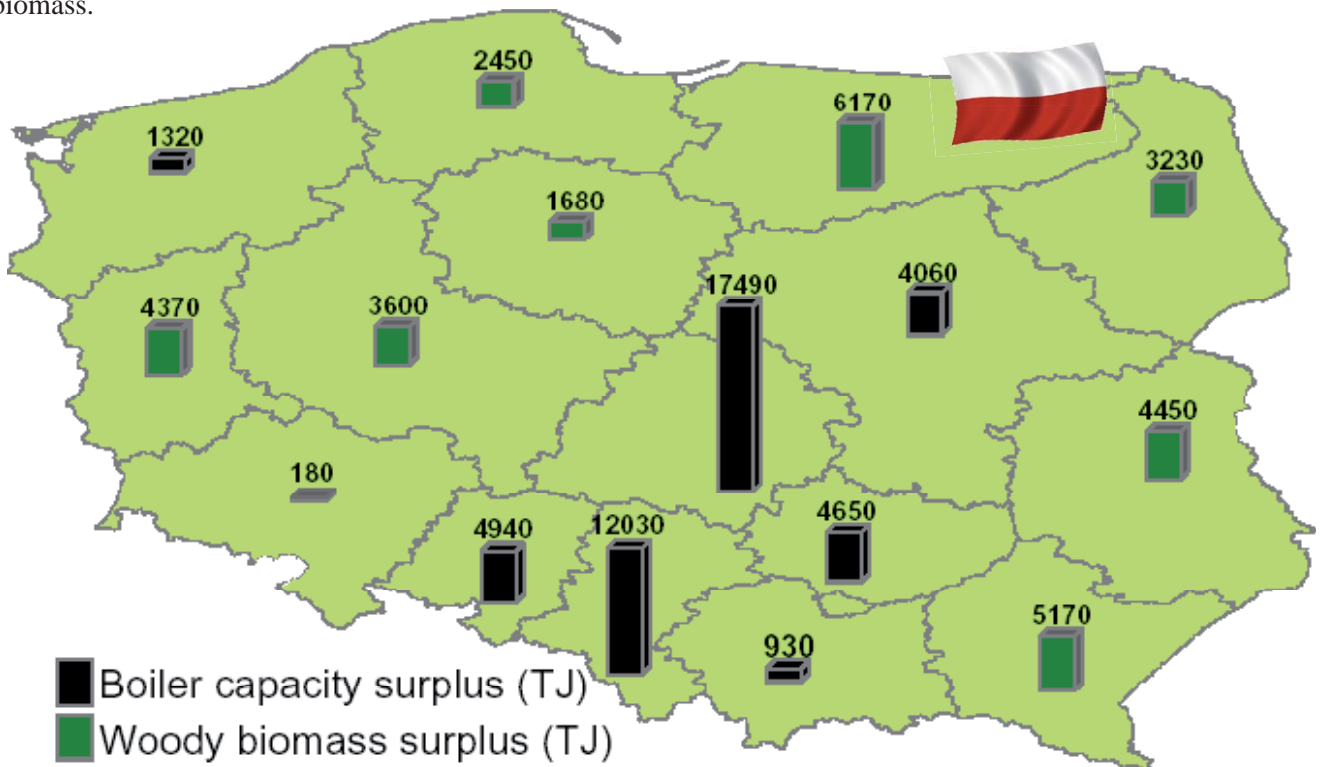


Cooling towers with their pillars of steam

As presented in the picture, there is a great surplus of boiler capacity for co-combustion in the south-central parts of Poland, where most of the power plants are situated, whereas other regions have a surplus of biomass.

If the target of surplus biomass is permitted to regions with boiler surplus, the total potential for co-combustion is between 1,6 % and 4,6

% of the total electricity production, depending on estimations made for the potential of biomass. It could contribute to a large part of Poland's commitment to the EU. However, other sources of renewable electricity production must also increase from 2 % to between 2.9 % and 5,9 %, if the stipulated share of 7.5 % is to be attained.



For optimal use, surplus biomass from the outer regions could be transported into the central-south regions with surplus boiler capacity

Carbon dioxide free combustion

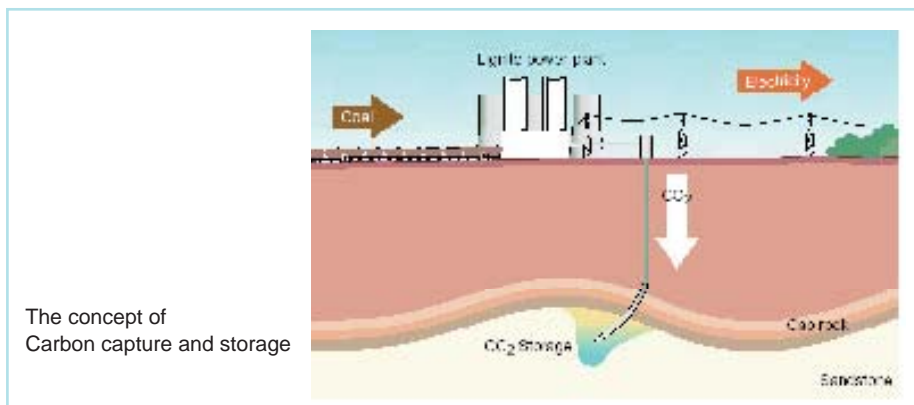
- a bridging technology on the path to sustainability

Capture and storage of CO₂ has the potential to contribute to a significant and relatively quick reduction in CO₂ emissions from power generation, allowing fossil fuels to be used as a bridge to a non fossil future while taking advantage of existing power-plant infrastructure.

Developing technique

So far no power plants with CO₂ are available on a commercial scale, but things are about to change and interesting pilot plants are planned. The long term storage of CO₂ however, is currently applied and evaluated in the North Sea showing promising results.

Three techniques for capture of CO₂ in power generation is the oxy fuel combustion process, amine-based absorption processes and integrated gasification combined cycle. The first two of these are often considered suitable for retrofitting of existing coal fired units, although the process power demand is to be considered as the plant efficiency is reduced.



The oxy fuel process

The oxy fuel process is intensively studied at the Chalmers University of Technology. The process combines a conventional combustion process with cryogenic air separation, so that the fuel is burnt in CO₂ and recycled flue gas. This gives high concentrations of CO₂ in the flue gas, which reduces the cost for its capture.

The plant efficiency, compared to a reference plant, is reduced by approximately 20 %. From 0,426

to 0,335-0,343, depending on the sulphur dioxide capture design. In addition, however, emissions of dust and NO_x is also reduced compared with the reference plant.

The full report will soon be available from the Pathways web-site:
www.ags.chalmers.se/pathways



Schwarze Pumpe

Full scale plant soon in service

Vattenfall is active in the development of CO₂ free power generation. A pilot power plant (30 MW) is being built next to the german power plant Schwarze Pumpe, south of Berlin.

The plant will be based on the oxy fuel process, explained above. It will be in

CO₂ free examples from Industry

service for at least 10 years, gathering experience and refining the technique. If the pilot plant is successful, Vattenfall will construct a 250 MW power plant beyond 2010.

This is a part of the CO₂ free power plant-project, where Vattenfall aims for fossil fueled power generation with minimal emissions of CO₂ at a cost below 20 €/ton CO₂. The technique should be developed into commercial status by the end of the next decade.



Tjeldbergsodden

Statoil is planning a 860 MW gas fired power plant in Tjeldbergsodden in Norway. The power plant will increase the Norwegian CO₂ emissions by 4,5%. However, a capture and storage facility is also planned and discussed with the Norwegian authorities. There will be more to report in this matter ahead.

AGS meeting in Bangkok

The AGS Annual Meeting 2006, was held in Bangkok, Thailand in March.

The AGS (Alliance for Global Sustainability) annual meeting in Bangkok was directed towards unveiling regional differences in the way we address global issues in sustainability. The Chalmers researchers were given the task of presenting recent European research on energy efficiency. Presentations were made by Professor Filip Johnsson (Energy Technology), Professor John Holmberg (Physical Resource Theory) and Professor Carl-Eric Hagentoft (Building Physics). These presentations were complimented by examples from the US and Japan, providing a basis for the energy workshop discussions. Professor Filip

Johnsson also held a plenary lecture where he gave a detailed account of the AGS energy flagship, with emphasis on the European pathways project, providing perspective on the research effort that will be required within the AGS if feasible pathways for the 5-15 year period are to

be identified. His presentation further exemplified with new results from the databases and modeling activities being developed at Chalmers and which are starting to give an appreciation of the natural gas sector in a European context.



AGS Technical Meeting at Chalmers 2005

During 7-8 November 2005, the AGS Technical Meeting 2005 was hosted by Chalmers in Göteborg, Sweden. It was entitled "Critical Barriers to a Sustainable Energy Future" and focused heavily on the European Pathways project.

The meeting drew approximately 80 participants from the four AGS member schools, Nordic universities and institutions, students, industries, governments and non-governmental organizations.

Among other subjects discussed were the need for a global policy framework to address climate change issues and the need for international regulation that ensures a correct price on emissions on a global and a regional scale.



AGS Technical Meeting at Chalmers 2005

www.ags.chalmers.se/pathways