EUROPEAN
pathways

NEWSLETTER FROM »PATHWAYS TO SUSTAINABLE EUROPEAN ENERGY SYSTEMS«

#1/2009

Project status

2008 was an exciting year for the project. The project gathers some 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. Several new results have been obtained and the methodologies developed make it possible to address new research questions which have emerged during 2008. The very first Pathways´ Doctoral thesis was also finalized and presented. In all, the project follows the plan and I am looking forward to an inspiring 2009!

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

Pathways to reduced CO_2 from kraft pulp mills

For chemical pulp mills there are many technology pathways which can increase energy efficiency and thus contribute to reduction of global CO_2 emissions.

Applying a high cost of CO_2 alone may not be enough to reach the full potential of CO_2 emissions reduction in the forest industry, since this also profits the well-tried pathways. To reach the full potential the new and emerging technology pathways may also need some direct support, e.g. technology specific subsidies.

cont'd on page 5

New dissertation

Renewable Energy Development and the function of Law

The thesis describes and analyses the function of law with reference to the implemenation of renewable energy policy objectives, with focus on the development of wind power.

"A realization of the Swedish wind power planning goal will presumably require changes of the law. The most important issue is perhaps to reduce the implementation deficits by improving the legal framework governing the planning and installation processes."

cont'd on page 3

New licentiate thesis

Wind Power in Thermal Power Systems

This work investigates consequenses of large-scale wind power integration in a thermal power system. Operation of wind power in a regional thermal power system have been investigated and quantified by modelling.

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New results show that it is possible for the European electricity to meet strict emission targets at a cost ranging from approximately 20 to 50€/ton CO_2 over the period up to year 2050, provided CO_2 capture and Storage (CCS) is used as an option. For UK and Germany, it is shown that a matching transport and storage infrastructure can be developed although this implies significant challenges with respect to provide timely investments in a CCS infrastructure (See page 6).

Filip Johnsson discussing CCS with Prof. Lars Nilsson from Lund University, at the GHGT:s meeting in Washington, November 2008.

For the pulp and paper industry new results have been obtained concluding that applying a high cost of CO_2 alone may not be enough to reach the full potential of CO_2 emissions reduction in the forest industry. To reach the full potential the new and emerging technology pathways may also need some direct support, e.g. technology specific subsidies. (See page 5).

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 modeling and assessment of pathways for the European power generation system. A general result from the work is that there are tremendous resources of fossil fuels which obviously impose a great challenge to meet CO_2 emission targets, especially when considering security of supply.

The solid description of the European energy infrastructure from the various databases being developed in the project (power plants, CO_2 storage sites and global fossil fuel infrastructure) has been of great value in the analysis, i.e. the analysis being made rests on a solid description of the present energy system.

An interesting option which links the electricity generation system and the transportation system is Plug-In Hybrid Electric Vehicles (PHEV:s). Possibilities with the PHEV technology were studied in the project and the PHEV technology is shown to be a promising option for moderating intermittent wind power. Yet, it was shown that the ability of PHEV to manage wind power variations depends strongly on the choice of PHEV integration strategy. Ongoing work has the aim to investigate the possibility of the so called Vehicle to Grid (V2G) integration of PHEVs. Also, during 2008 wind power integration in general has been studied.

Work is ongoing with identifying the first Pathways to Sustainable European Energy System. The work takes departure in a "business as usual" scenario as a reference. The plan is to formulate the first Pathways during spring 2009. Thus, the Pathway will cover several key sectors.

As explained in this newsletter (See page 8), the Pathway modeling 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.

We cooperate with the project Nordic Energy Perspectives around several research questions (See page 7). The Nordic countries are special in that they hold large resources of renewable energy (hydropower, biomass resources and wind power). Thus, the region is a potential resource base for the EU renewable directives.

There are three EU projects related to the project; PLANETS, PATH-TO-RES (See page 4) and ELOBIO. These give all valuable exchange with the international research community and make it possible to communicate and discuss specific Pathway results in a wider scientific audience.

Prof. Filip Johnsson
Project manager of the Pathway project

New dissertation:

Renewable Energy Development and the function of Law

Maria Pettersson, Department of Social Science, Law Division, Luleå University of Technology

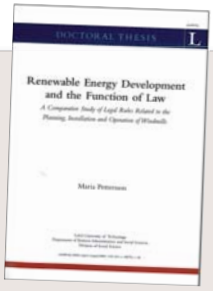
The thesis describes and analyses the function of law with reference to the implemenation of renewable energy policy objectives, with focus on the development of wind power.

This involves legal rules related to planning, location and operation of windmills. The legal system is evaluated in respect of its capacity to facilitate or impede the development of wind power. The study includes a comparative analysis of the legal functions in Sweden, Denmark, Norway and England. The result of the analysis of Swedish law indicates that the legal system governing the implementation process encompasses barriers to the development of wind power.

The examination of the corresponding legal functions in Denmark, Norway and the United Kingdom presents important differences with respect to planning control and permit requirements, as well as regarding substantial provisions. Generally, it looks as if there is a correlation between the level of overarching control over the physical planning on the one hand, and the potential to successfully implement renewable energy policy objectives on the other. Time-limits for permit procedures, legal standards for emissions, explicit rules for the balancing of opposite interests and so forth, are other interesting features that may be employed in Sweden. A realization of the Swedish wind power planning goal will thus presumably require changes of the law. The most important issue is perhaps to reduce the implementation deficits by improving the legal framework governing the planning and installation processes. A few of the discussed factors emerge as crucial in this respect and that is roughly: to remove the general permit requirement, and thus leave the entire trial to the planning system; and to breach the municipal planning monopoly.

> "A realization of the Swedish wind power planning goal will thus presumably require changes of the law"

The disseration "Renewable Energy Development and the function of Law" by ***Maria Pettersson*** *is available at: http://epubl.luth.se/1402-1544/2008/65/LTU-DT-0865-SE.pdf*



New licentiate thesis:

Wind Power in Thermal Power Systems

Lisa Göransson, Department of Energy and Environment, Chalmers University of Technology

This work investigates consequenses of large-scale wind power integration in a thermal power system. Operation of wind power in a regional thermal power system have been investigated and quantified by modelling. The possibility to reduce the influence from wind power variations by means of introducing a variation moderator or demand sida management has been evaluated.

Model simulations show that for 24% wind power grid penetration, variations in wind power generation results in start-up emissions corresponding to 5% of the total CO2-emissions of the power generation system. It also shown that the inclusion of start-up and minimum load level aspects has an impact on the dispatch of units in the system. By integration of a moderator in the wind-thermal system, emissions are reduced with 7.2% mainly due to a decrease in power plant cycling. At wind power grid penetration levels of around 20%, a daily balance moderator is sufficient, whereas more extensive storage capacity is required at higher wind power penetration levels such as for the 40% penetration level investigated in this work.

The Licentiate thesis "Wind Power in Thermal Power Systems" by ***Lisa Göransson*** *is available at Energy Technology Division at Chalmers University Technology, Göteborg.*

Progress in the Path-to-RES project

PATH-TO-RES is an Intelligent Energy Europe (IEE) project aiming to develop a 7-step assessment tool which can evaluate and define pathways to sustainable local energy systems in European.

The seven steps are:

1. analyze and formulate initial conditions
2. establish a detailed description of the present system
3. assess local, EU and global goals on sustainable development
4. identify and assess key technologies which can bridge to a future sustainable system
5. identify key actors in the region (to ensure correct decisions and competitive markets)
6. formulate and analyze pathways towards a more sustainable energy system
7. establish pathway (with respect to technologies, markets, institutions)

Case studies

Case studies are used as the main method to develop the 7 steps from which the roadmap for transforming local energy systems to sustainable systems is formulated.The following case studies will be the basis of the analysis with the aim to be generally applicable (i.e. at least to the EU):

1. The natural gas bridge, the Göteborg case (Sweden)
2. The Valencian Region case (Spain)
3. The City of Dunkerque case (France)
4. De Stoere Houtman, the Arnhem case (Netherlands)
5. The case of Cross border community of Lochem Netherlands)
6. The City of Gdansk case (Poland)

Pathways descriptions

Examples of Pathway descriptions from the case studies, in short:

Dunkerque

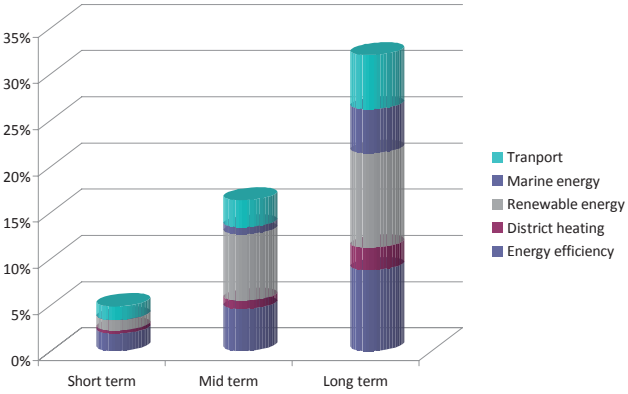
The Pathway is based on Grenelle Environment Forum held at the end of 2007 at national level and the development of existing actions at local level. The strategy is threefold:

• Changing the transport strategy with priority on changing from road to rail and waterway transport

• Energy efficiency of buildings with priority on 800,000 social housing units

• Renewable energies with the aim of surpassing the European target of obtaining 20% of energy from renewable sources by 2020 (see figure below).

Furthermore, special emphasis is put on marine energies, taking into account the position of Dunkerque as a port.



Increase of RES-index in Dunkerque,France

Gdansk

The basic strategic goal is to ensure energy for sustainable development of region with reasonable energy prices. Polish CHP units are primarily operated with coal as a fuel. A phase out of these coal-fired CHP units could lead to rapid growth of energy prices.

Valencia

The Valencia Region is committing towards increasing the role of natural gas in the energy system of the Region. This is shown in several actions carried out by key actors such as AVEN, Gas Natural, municipalities, etc. The Pathway presented here aims at transforming the energy system towards a hydrogen based society in a long term future.

Göteborg

For society as a whole a Pathway implies early expansion of renewable electricity production and heating savings in buildings. Where applicable, the use of waste heat instead of primary energy for heating is preferred choice.

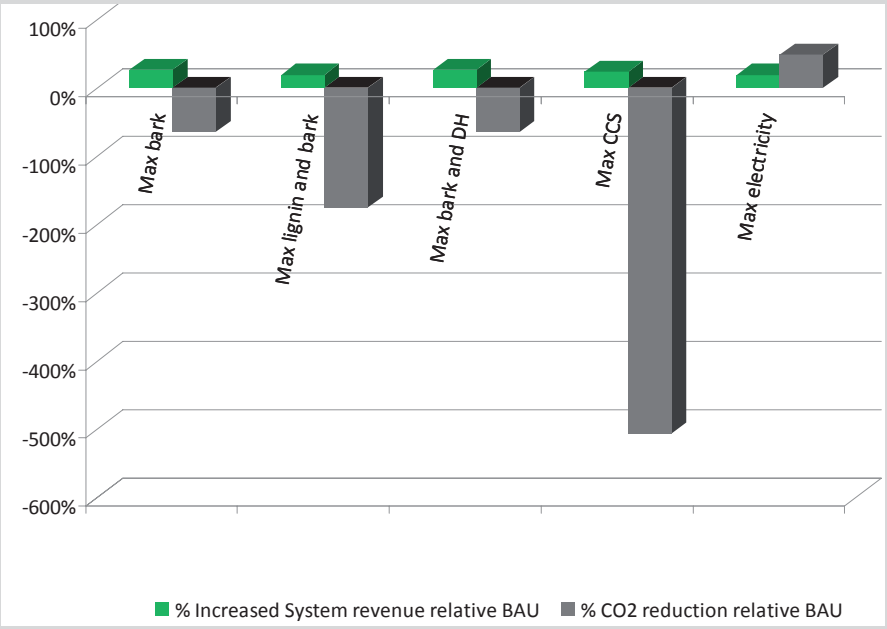
PATH2RES
PATHWAYS TO RENEWABLE AND EFFICIENT ENERGY SYSTEMS

Pulp and paper industry

Trade-offs between different technology pathways for kraft pulp mills

For chemical pulp mills there are many technology pathways which can increase energy efficiency and thus contribute to reduction of global CO_2 emissions. Which technology pathway that holds the greatest potential for future profits and reduction of global CO_2 emissions depends both on mill specific conditions and on the surrounding energy system (e.g. policy instruments and energy market prices).

In the paper four different technology pathways for utilization of excess heat at a chemical kraft pulp mills are investigated: 1) Increased electricity production in new condensing turbines, 2) Production of district heating, 3) Increased sales of biomass in the form of bark and/or lignin and 4) Carbon capture and storage.



In a scenario with a high CO_2 charge all of the technology pathways are profitable compared to business as usual (BAU), but the combination of maximum bark and district heating (DH) sales is the most profitable solution. The reduction of global CO_2 emissions, however, varies and for increased electricity production the global emissions even increase.

The results show that conventional pathways such as increased electricity production, selling bark and district heating production are economically robust, while the profiability of emerging technology pathways such as carbon capture and storage and lignin extraction are more dependent on the development of the energy market. However, emerging technologies hold a larger potential for reduction of global CO_2 emissions.

Consequently it can be concluded that applying a high cost of CO_2 alone may not be enough to reach the full potential of CO_2 emissions reduction since this would profit the existing technology pathways. To reach the full potential the new and emerging technology pathways may also need some direct support, e.g. technology specific subsidies.

For further information:

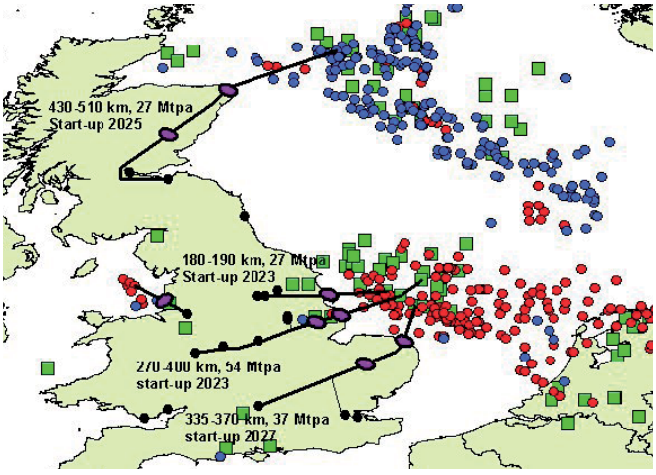
Johanna Jönsson and Jessica Algehed,
Heat and Power Technology, Chalmers, Göteborg

Pathways in Washington

discussing the role of CCS in the European electricity supply system

Project results were presented at the 9th International Conference on Greenhouse Gas Control Technologies (GHGT), the main international event on CCS with more than 1200 attendees. The GHGT conferences are held every two years in IEA GHG's member countries. The conference series rotates between, North America, Europe and Asia. Three scientific papers were presented from the European Pathway project, two of the papers presenting possible role for CCS in pathways for the European electricity system up to the year 2050.

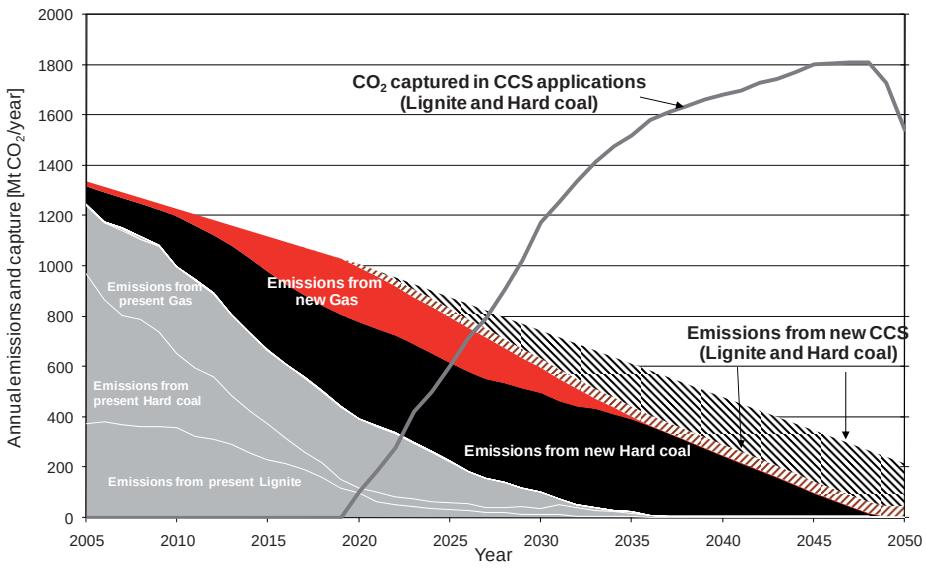
Pathways investigates the role of CO_2 capture and storage (CCS) technologies as part of a portfolio for reducing CO_2 emissions from the European electricity supply system until the year 2050. Since the ability of different EU Member States and regions to facilitate and to benefit from CCS will most likely depend on local conditions in terms of current energy mix, fuel supply chains and distance to suitable storage locations, special emphasize is put on analyzing turn-over in capital stock of the existing power plant infrastructure, timing of invest-ments and the infrastructural implications of large scale introduction of CCS on a regional perspective. The results show that it is possible to meet an 85% CO_2 reduction target by 2050, but this will require large contribution from CCS. As expected, regions which are currently high in carbon intensity and which are located nearby suitable storage sites will benefit mostly from CCS as an option. With the assumption that CCS will be commercially available in 2020 the model results give a steep ramp-up in the use of CCS post 2020 which imposes challenges for timely investments in corresponding CCS infrastructure.



CCS infrastructure as obtained from the analysis of this work. UK

Ramp-up of large-scale CCS infrastructure

The analysis shows also that most MS have identified structures that may be suitable for subsurface storage of CO_2. Fourteen MS have so far identified onshore reservoirs only. Several MS have clusters of large power plants along with considerable national or regional concentration of plant ownership, factors that may both facilitate the ramp-up of a bulk CCS infrastructure. Phasing in of CCS plants over time will obviously play a key role in building up large-scale transport infrastructure. CCS plants are likely to be located on existing sites and coal plants currently under construction may choose to retrofit the plant for CCS instead of building new plants. CO_2 pipeline trajectories are likely to follow existing trajectories for natural pipelines, minimising inter-ference with the surroundings and facilitate and speed up permitting processes. Timing, conflicts of interest and public acceptance, especially onshore, are other factors that may become an issue with regard to transport and storage of CO_2. According to model results, some 5.2 Gt CO_2 is transported and stored in Germany between 2020 and 2050 while the corresponding figure in the UK is 3.7 Gt. Based on assumed injectivity, total system costs up to 2050 range between € 18 and € 23 billion in Germany and between € 20 and € 30 billion in the UK while specific costs range between € 3.4 and € 4.4 per ton of CO_2 in Germany and between € 5.4 and € 8.1 in the UK.



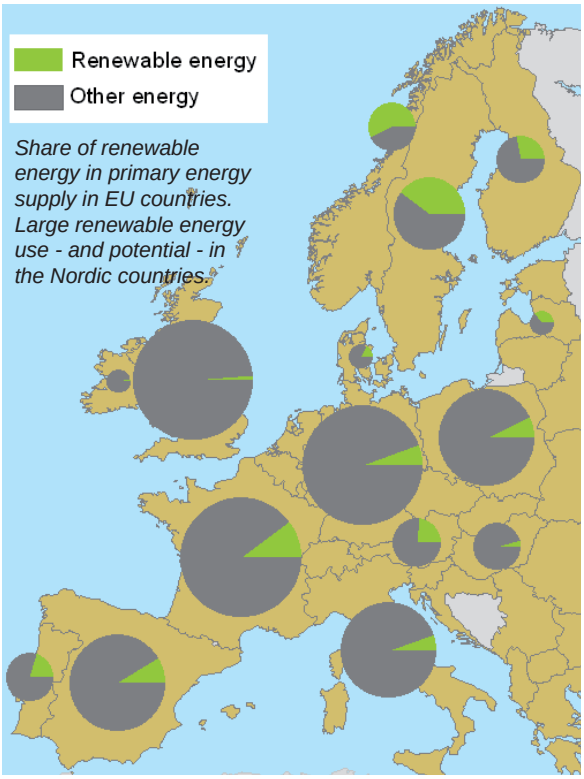
For further information:

Filip Johnsson, Mikael Odenberger, Jan Kjärstad, Energy Technology Division, Chalmers, Göteborg

The RES directive changes the market balances

- the Nordic countries may become a large exporter of electricity

Implementation of the RES directive shifts power market balances and trade patterns in Europe significantly. Large sources for renewable energy in the Nordic countries together with the EU RES directive lead to large electricity export.



Share of renewable energy in primary energy supply in EU countries. Large renewable energy use - and potential - in the Nordic countries.

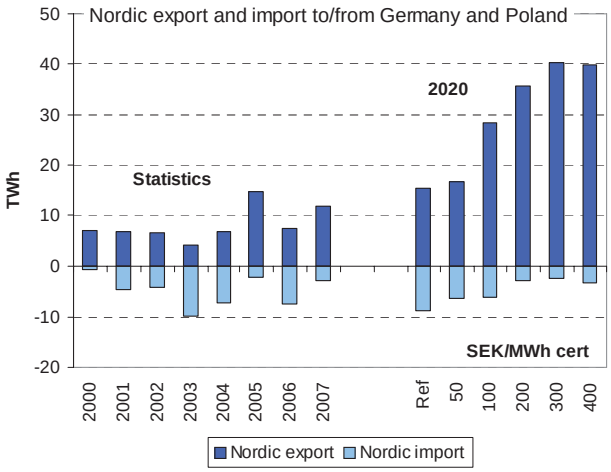
The Nordic area has large and relatively cheap potentials for renewable energy sources (RES), as shown in the map. The EU RES directive aims at increasing the share of renewable energy in the EU countries. Although a burden sharing between the EU countries has been proposed, analyses from the Pathways project indicate that the Nordic countries may become a large exporter of electricity. This electricity export may increase even further if international renewable electricity certificates are applied, making it possible to fulfil the common RES targets by means of the most cost effective alternatives.

Finland, Norway and Sweden exporters

By means of the MARKAL-NORDIC model an increased electricity production based on renewable energy sources (RES) in northern Europe has been studied (the Nordic countries + Germany and Poland). The analysis has been made by introducing a common renewable electricity certificate system in the North European countries, where different levels of electricity certificate prices has been studied. Higher electricity certificate prices increase the electricity production in the Nordic countries. The figure shows the power exchange between the Nordic countries and Germany/Poland for the year 2020. High electricity certificate prices increase the net export from Finland, Sweden and Norway significantly; from 5 – 10 TWh to 35 – 40 TWh.

New interconnectors profitable

This leads to investments in additional interconnectors (which is dealt with in the calculations). The large Nordic electricity export is a clear indication of the comparative advantages for renewable electricity production in the Nordic countries.



Nordic export and import to/from Germany and Poland. (The reference case assumes that the present policy instruments are applied, not national RES targets).

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.*

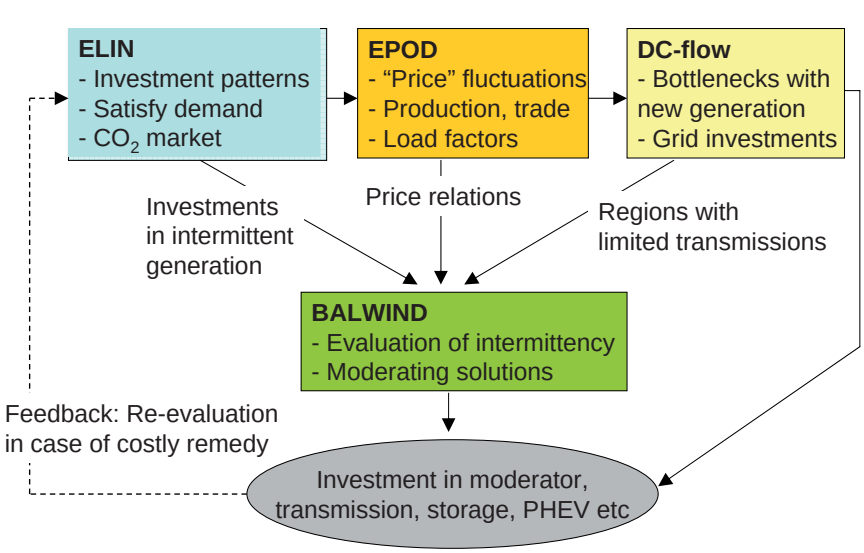
For further information:
Thomas Unger and Håkan Sköldberg, Profu, Göteborg

Modelling the European Electricity-supply System

Four models are used to analyze the long-term development of the European electricity system in the Pathways project. Due to several reasons it is in this case more efficient to use four models each addressing specific issues rather than one "super" model trying to incorporate "as much as possible".

Four models are used specifically to analyze the long-term development of the European electricity system. ELIN is an investment model which generates cost-efficient investment strategies for the European electricity supply system during the coming 40-50 years. EPOD is a production model for a selected year using the output from the ELIN model as main input. Other important input used both in ELIN and EPOD is taken from the extensive Chalmers Power Plant Database. DC-flow is a grid-capacity model which uses output from both ELIN and EPOD with the objective to identify grid bottlenecks during e.g. high-load situations. BALWIND is developed as an add-on to the BALMOREL model aiming specifically at analyzing system effects of short-time fluctuations from wind power.

Due to reasons of transparency and computational limitations it is in this case more efficient to use several models each addressing specific issues rather than one "super" model trying to incorporate "as much as possible". Therefore, these four models work closely together. In the figure below, the modelling process involving all four models is shown for an ongoing project activity where the objective is to assess consequences of a significant wind-power penetration in a selected North European region.



For further information:
Thomas Unger, Profu, Göteborg, Lisa Göransson and Mikael Odenberger, Energy Technology Division, Chalmers, Tuan Le Anh, Electric Power Engineering, Chalmers

Calender 2009

January	Research meeting, Chalmers, Göteborg
26-29 Jan.	AGS Annual Meeting, ETH Switzerland
11-12 March	Pathways at Energitinget, Stockholm
April	Prel. workshop on European Energy, Amsterdam

More information about the Pathways project:
www.energy-pathways.org

THE AGS The Alliance for Global Sustainability