EUROPEAN
# pathways

SPECIAL ISSUE FROM »PATHWAYS TO SUSTAINABLE EUROPEAN ENERGY SYSTEMS«

January, 2011

## Special issue

### Project status

*"Two new books report results from the project "Pathways to Sustainable European Energy Systems", a 5-year project (2006-2010) that has evaluated pathways to a sustainable European energy system, with a focus on the stationary energy system and the time period up to the year 2050."*

**Prof. Filip Johnsson**
Project manager of
the Pathways project



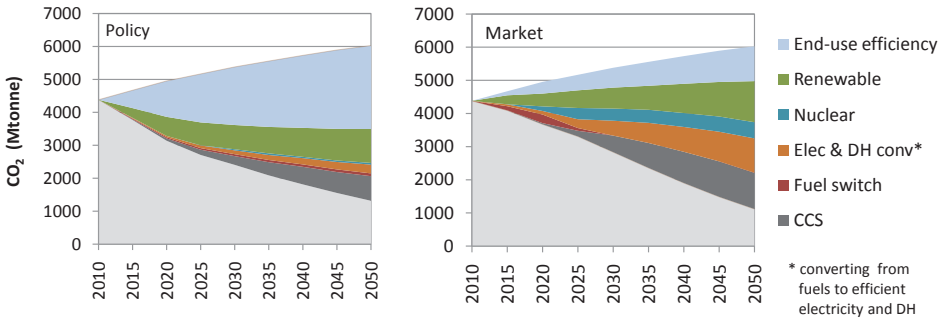
*Pathways to Sustainable European Energy Systems* is a project within AGS

The Pathways project presents

# Two European Energy Pathways

**To meet the challenge of climate change, the world must substantially reduce emissions of greenhouse gases (GHGs). This must be accomplished in a way that maintains security of supply and competitiveness.**

The Pathways project presents two pathways towards sustainable European energy systems – the "Policy Pathway" and the "Market Pathway". These two pathways differ with respect to where the main responsibility lies for transforming the energy system in following the pathway. The Policy Pathway takes its departure from the EU Energy and Climate Package, and has a strong focus on targeted policies that promote energy efficiency and energy from renewable sources. The Market Pathway relies more on the market to transform the energy system, and presents a future in which the cost associated with emitting $CO_2$ (and other GHGs) is the dominating policy measure.




*$CO_2$-emission mitigation measures, as "wedges", for the Policy Pathway and the Market Pathway. The targets for reductions in $CO_2$ emissions are the same in both pathways, i.e., 70% reduction by 2050.*

*New books:*
## "*European Energy Pathways*" and "*Methods and Models*" summarizes the results from the project

*This project shows that there are great opportunities for Europe to transform the energy system to comply with the emission reductions targeted by the European Commission"*

*Karin Markides, president, Chalmers University of Technology*

# 20 key results

*The project covers a broad range of topics related to how the European energy system can be transformed from now up to year 2050, to meet targets for emission reductions while maintaining security of supply and preserving social and economic sustainability. The following overall conclusions can be drawn from these efforts:*

## *1. There are several possible pathways towards a sustainable energy system*

There are several possible pathways towards a more sustainable European energy system. Although extensive changes in the energy system are required to follow the pathways, in general, the technologies and measures are already available. Thus, the major challenge for transformation of the energy system is a political one, even though significant technological developments are certainly needed.

## *2. Two pathways are proposed*

The Policy Pathway takes its departure from the EU Energy and Climate Package and has a strong focus on targeted policies that promote energy efficiency and energy from renewable sources. The Market Pathway leaves more of the responsibility for transforming the energy system to market forces. In the latter pathway, the cost of emitting $CO_2$ (and other GHGs) is the principal policy measure. The pathways represent examples of different strategies for Europe to meet the challenges of climate change and other sustainability goals, rather than predictions of the future.

**The Policy Pathway**

- Focuses on the end-use with respect to technologies and measures.
- Gives a well-balanced mix of technologies, involves strong reduction in primary energy use and is therefore favourable with respect to security of supply.
- Requires large investments in the electricity transmission network to accommodate the large fraction of intermittent (wind) power generation.
- Represents a significante decrease in energy use per capita over time, i.e. a substantial cange from the historical trend. This trend alteration would typically require life-style changes.
- Represents a future in which a large number of decision makers at all levels down to private consumers will have to take responsibility for the transformation of the energy system.

**The Market Pathway**

- Requires large-scale dissemination of all technologies and measures, including xtensive CCS with coal as a fuel.
- Is supply-oriented with respect to choices regarding technologies and measures, and will exert less pressure for life-style changes.
- Benefits from existing infrastructure through increased use of electricity generation and district heating, as well as through shifting fuels to produce these energy carriers.
- Represents a significante decrease in energy use per capita over time, i.e. a substantial cange from the historical trend, although not as significant as in the Policy Pathway.
- Represents a future in which most of the responsibility for the transformation of the energy system is in the hands of large energy companies and professional market actors.

## *3. All technologies and measures are required to follow the pathways*

It is possible to make deep cuts in emissions until 2050, while at the same time maintaining the security of supply. However, this will require that all available technologies and measures are used. If we choose to reject certain technologies and mitigation measures, there is a high risk that the necessary transition will either not take place or will progress too slowly.

## *4. Bridging technologies can facilitate early reductions in emissions at lower cost*

Several of the key options for transforming the energy system constitute what in the project are termed 'bridging technologies'. Bridging technologies take advantage of the existing energy infrastructure and facilitate the development of new energy technologies. Important bridging technologies are: co-firing of biomass in existing power plants, using incineration and industrial waste heat in district heating systems, applying process integration in industries, the retrofitting of the existing building stock, and the application of carbon capture and storage (CCS). Although entirely new and more "sustainable" technologies (e.g., hydrogen-based technologies, solar cell technologies, and nuclear fusion) will undoubtedly be developed, these technologies are unlikely to play major roles in the four decades leading up to the year 2050, which is the time-frame for the two pathways presented in this project.

## *5. There has to be a cost associated with emitting GHG*

A prerequisite for achieving a market that drives the energy system towards following one of the two pathways presented in this project (or for that matter, any other pathway that results in the same level of emissions reduction) is that there must be a cost associated with emitting GHGs, most importantly, $CO_2$. This cost could be in the form of a tax or a charge in an emission trading scheme.

## *6. Electricity and district heating will be increasingly important energy carriers*

Reaching the ambitious climate targets in the two pathways presented in this project requires efficient use of the available resources. The electricity generation and district heating systems have the potential to facilitate efficient use of primary energy while reducing $CO_2$ emissions.

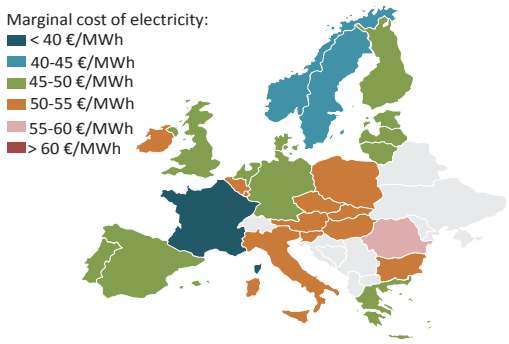
## *7. The existing energy infrastructure will strongly influence the pathways*

An important condition for transforming the energy system is that there is already a system in place, i.e., the present energy infrastructure with associated actors and institutional framework. This comprises a large capital stock with a long turnover time. Furthermore, there are legal and social structures,

as well as valuable know-how attached to the technologies that currently predominate, all of which offer possibilities for rapid implementation of the bridging technologies. However, they also limit the possibilities for large-scale introduction of entirely new systems. The key is to use the existing infrastructure to initiate the transformation on a large scale and to create the optimal conditions for new technologies.

## *8. Existing and new infrastructures must be developed*

Although the bridging technologies take advantage of the existing energy infrastructure, this infrastructure also needs to be developed, as a new support infrastructure must be established together with the corresponding institutional framework. The implementation of CCS and increased use of bioenergy will require an extensive transport infrastructure, e.g., $CO_2$ transportation and storage networks, and biomass handling facilities. The production of second-generation biofuels requires substantial changes in the agricultural and forestry sectors. Large investments will have to be made to strengthen, expand, and upgrade the electricity networks so as to accommodate increased levels of wind power and other forms of intermittent electricity generation. Expansion of district heating networks will be a challenge in terms of new investments, public support, and planning. Synergies can be created if the transition of the energy systems is co-ordinated with the transformation of other sectors, such as industry, transport, waste, and agriculture.




*Regional distribution of long-range marginal costs for electricity in 2020.*

## *9. Pathways for the juridical framework must be in place*

A sustainable energy and climate policy needs not only technical advances, but also a legal system that clearly supports the implementation of policies. This situation does not currently exist in the EU. In many cases, there are clashes between EU or national energy policies and other interests, e.g., with respect to impact on the local environment, and these interests are often supported by legal restrictions. In other instances, the technologies are so new that they are not covered by existing legislation. Even if the cost barrier for a technology is removed, barriers to its implementation may emerge in the design of the legal and administrative systems required for that technology. Thus, it is of great importance to develop legal systems that support the implementation of the policies required to transform the energy system.

## *10. To follow the pathways requires structural changes across sectors*

Reversal of the current situation and moving towards sustainability are complex processes that require fundamental changes across society. This project gives several examples of what needs to be accomplished and how this can be broken down by sector (e.g., the electricity, industry, transport, and waste management sectors).

## *11. The two pathways offer synergies between sectors*

Although the required structural changes imply great challenges for society, these changes also represent opportunities for synergies. Seizing these opportunities will be cost-efficient and will contribute to maintaining, and perhaps even strengthening, Europe's competitiveness on the global market.

## *12. Companies are preparing to respond to the requirements of the energy pathways*

Companies that are active in the stationary energy sector are already preparing to respond to requirements for sustainable development and are intensifying their efforts to integrate sustainable practices into their business models. By applying a strategic perspective to the environment, companies can develop new business opportunities and contribute to sustainable development within their sphere of activities.

## *13. Global fossil fuels resources are too large – this is the challenge!*

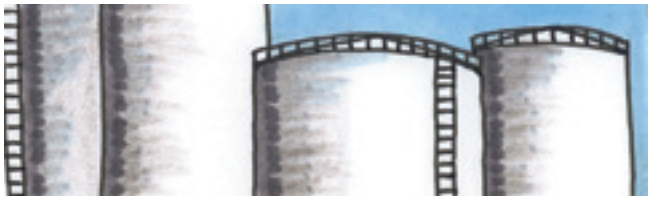
From a climate change perspective, there is far too much fossil fuel. Although the world may be running out of conventional oil, from a climate perspective, this is not happening fast enough. Moreover, the availability of oil is not the major issue. Instead, there exist large resources of coal, natural gas, and other reservoirs of hydrocarbons, such as tar sands and oil shale. These large resources are constantly being developed, which means that it is of great importance that a price is attached to $CO_2$ emissions and other GHGs, so as to stimulate the development of renewable technologies, energy efficiency measures, and technologies that allow the use of fossil fuels without $CO_2$ emissions.

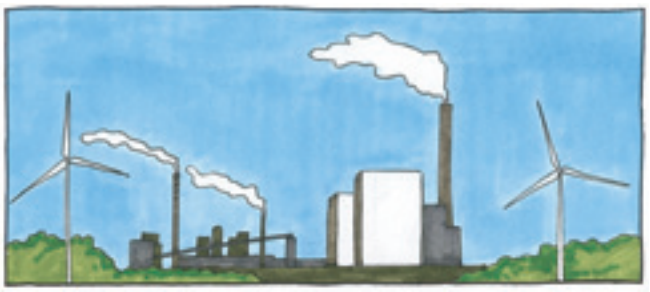
## *14. Carbon Capture and Storage is a key technology to meet the fossil fuel challenge*

The threat from the abundant resources of fossil fuels makes it crucial to develop CCS technologies. If CCS is not applied, it will probably be very difficult to get fossil-fuelled regions and countries to comply with stringent GHG reduction targets, i.e., to reach a global agreement on emission reductions. In addition, for the EU, it will be difficult to reach its climate goals for 2050 without successful implementation of CCS.

## *15. Both pathways strengthen the security of supply*

Security of supply (SoS) is one of the cornerstones of European energy and climate policy towards a sustainable energy system. Dependence on imports of natural gas and oil has serious implications for the EU and strongly influences the union's energy politics. In both pathways the SoS is strengthened through reduced import dependency and increased diversification of technologies and fuel mixes.





## 16. Energy efficiency must be implemented on both the supply and demand sides

Cost-effective implementation of energy efficiency improvements should include all parts of the energy system, from supply to end-use. The estimations made in the work upon which this book is based show that cost-effectiveness (in the long run) in the European energy system will be attained with approximately 30-50% energy conversion efficiency measures and 50-70% end-use measures. Most of these energy efficiency improvement measures will, in addition to increasing energy efficiency, reduce GHG emissions and lead to the increased use of renewable energy sources in the EU countries. These synergies will make the measures more cost-effective.

## 17. Biomass holds promises as a source of fuels for near-term bridging technologies

Biomass is the only renewable primary energy source that inherently generates carbon-based fuels, which is the basis for much of present-day energy technology. This makes biomass very suitable for use in both heat and power production and in the transport sector. Promotion of bioenergy use that exploits existing energy infrastructures in order to reduce risk and reach lower costs is proposed as an attractive near term strategy.

## 18. Industry has to consider all options to follow the Pathways

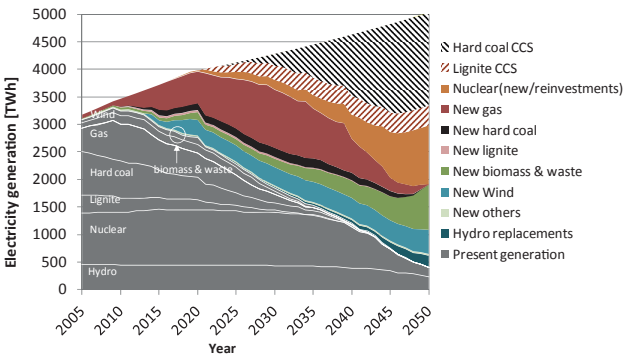
European industry has the potential to contribute significantly to reducing $CO_2$ emissions and to development towards sustainability, directly through large reductions in emissions and indirectly through changes in the energy that is used and delivered. Adaptation strategies may include structural changes, energy efficiency improvements, fuel substitution, and the implementation of CCS.

## 19. Implementing pathways requires responsibility at all levels, from global to local

Although the two pathways discussed in this book differ with respect to who in society assumes the major share of the responsibility for transforming the energy system to follow the Pathways, they also require governance at the international, national, and local levels.

## 20. An integrated methodology for Pathway analysis has been developed

The results presented in this book are the outcomes of applying in a co-ordinated way a variety of energy-related methods and models, which originated from different scientific disciplines and traditions. Most of these elements are described in the Methods and Models book. Some of the analytical tools used are well-known, well-documented, and widely used in academic research. The others have been developed (or refined) during the Pathways project and are therefore unique. The aim is to add value to the many scientific publications that have emerged from the project, which although they are on a more detailed level, are limited to specific scientific disciplines or address a specific sector of the energy system.




*Electricity generation in the EU27 countries and Norway, as obtained from the modelling work in the project.*

## "Good news"

*The two pathways both represent extensive changes in the energy system and implementing these will impose a great challenge for Europe. Yet, the "good news" are:*

**It is possible to follow the pathways using commercially available technology,** while maintaining security of supply and, in spite of that a cost to emit $CO_2$ is imposed, most likely also maintaining competitiveness of Europe.

There are **great possibilities for synergies** by integrating different sectors (electricity, industry, transportation, agriculture, waste).

**Companies are already preparing** to respond to requirements from conditions similar to that required by the pathways proposed by the project.

**EU can reach the 2020 20% emission reduction target**. Both the Policy Pathway and the Market Pathway provide great opportunities for reaching the targets set for 2020 within the EU. The Policy Pathway even shows a possible GHG emission reduction greater than 20%.

**Energy efficiency on the supply side** is as important as energy efficiency in end-use, and should be easier to achieve since it demands less incentives and offers synergy opportunities for other targets.

THE AGS The Alliance for Global Sustainability

**More information about the Pathways project:**

www.energy-pathways.org