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NEWSLETTER FROM »PATHWAYS TO SUSTAINABLE EUROPEAN ENERGY SYSTEMS«

#3/2013

Filip's column

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Prof. Filip Johnsson
Project manager of
the Pathways project

Bioenergy from forests:
the timing of GHG benefits

A new report statement from the IEA Bioenergy network addresses the issue of the timing of greenhouse gas (GHG) emissions and carbon sequestration when biomass from managed forests is used for energy to displace fossil fuels. The research shows that timing of GHG mitigation benefits will vary between different locations, due to variation in environmental and socio-economic factors. Moreover, the report proposes that even if some bioenergy systems may induce net carbon emission in their establishment, such a carbon cost should be viewed as an investment in establishment of a renewable energy system for a future with lower net emissions.

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Modeling energy conservation and CO_2 mitigation in the European building stock

In the European Union (EU), the building sector accounts for 35-40% of the total final energy use and associated CO_2 emissions. Since the turnover of building stock is low in developed countries, the greatest challenge for reducing energy use in the EU building sector is to find effective strategies for retrofitting existing buildings.

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Expert workshops on environmental sustainability of forest bioenergy
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The role of Nordic hydropower to handle European wind power

Researchers at Chalmers have investigated the role of Nordic hydro-power to manage the variations from expanded European wind power generation in the near future. The results show that by 2020 Nordic hydropower acts as a redistributor of low cost electricity in Northern Europe, both geographically and in time, assuming transmission grid reinforcement in Northern Europe according to current plans.

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

Filip's column

The actual climate benefit from using biomass is a topic of controversy with many factors influencing the net carbon sequestration. This newsletter summarizes results by the Pathways researcher Göran Berndes and co-workers, including work carried out in the context of the IEA Bioenergy network. The work concludes that a medium to long term view is required to perceive the climate benefits from bioenergy systems. Thus, design of policy for forest-based bioenergy should balance near-term GHG targets with the long-term objectives and should also recognize the multiple drivers and effects of forest management.

I am happy to announce that the Pathways work on the effects and costs of application of energy conservation measures in the building sector will be presented in a new PhD thesis. On November 27, Érika Mata will defend her thesis "Modelling Energy Conservation and CO_2 Mitigation in the European Building Stock". The work is a co-operation between the Departments of Energy and Environment and Civil and Environmental Engineering at Chalmers. The work is unique in that it addresses entire building stocks of individual countries. This newsletter gives a brief overview of the results of the work.

Another "hot" topic is the role of Nordic hydropower to manage the variations from expanded European wind power generation in the near future. A work has just been completed in which it is shown that by year 2020 Nordic hydropower can act as a redistributor of low cost electricity in Northern Europe, both geographically and in time, assuming transmission grid reinforcement in Northern Europe according to current plans. Hopefully this work will contribute to clarifying the possibilities and challenges by expanding wind power in Europe.

A key topic in the Pathways project has been to map and analyse the global markets of fossil fuels. This, since the challenges imposed by the momentum of these markets on how the energy system can be transformed is often overlooked. This newsletter reports from a recent study which compared trends during last decades in the use of renewable and fossil energy for different countries. From the study we identify a "fossil-fuel curse" implying that countries with large domestic fossil fuel resources cannot be expected to make these resources left as stranded assets. This point to the great challenge of reducing carbon emissions globally and the need for clear and long term policy measures, which put a sufficiently high price on carbon emissions. I conclude that it should be of great importance to initiate research and policy work which address the geopolitics of the abundant resources of the fossil fuels, especially coal in a climate-change mitigation context. The latter was a topic in a debate article which we published in the largest Swedish newspaper Dagens Nyheter on October 9 ("DN debatt")[1]. I can only hope that the article will have some impact in the political sphere such as being an input to the work of the "The Global Commission on the Economy and Climate", initiated by the Swedish minister of Environment Lena Ek.

Cheers!
Filip Johnsson

Prof. Filip Johnsson
Project manager of the Pathways project

[1] *Dagens Nyheter October 9 , 2013. See http://www.dn.se/debatt/overflodet-av-fossilbranslen-ar-den-storsta-/ (in Swedish)*

Copenhagen, November 14

Consortium day for the NORDICCS project

On November 14, there was a consortium day in Copenhagen for the NORDICCS project. NORDICCS is a joint Nordic project for investigating the role of CCS in the Nordic countries, comprising work on the entire CCS chain; capture, transport and storage. The consortium meeting was held at the Geological Survey of Denmark and Greenland (GEUS). The latest results from the project activities were presented and discussed among the partners, such as recent updates of the Nordic CO_2 storage Atlas.

nordiccs CO2
Nordic CCS Competence Centre

See http://www.sintef.no/Projectweb/NORDICCS/ for information on the project.

Bioenergy from forests:
the timing of GHG benefits

Göran Berndes is one of the lead authors of a new report statement from the IEA Bioenergy network. The report addresses the issue of the timing of greenhouse gas (GHG) emissions and carbon sequestration when biomass from managed forests is used for energy to displace fossil fuels. The research shows that timing of GHG mitigation benefits will vary between different locations, due to variation in environmental and socio-economic factors. Moreover, the report proposes that even if some bioenergy systems may induce net carbon emission in their establishment, such a carbon cost should be viewed as an investment in establishment of a renewable energy system for a future with lower net emissions. A medium to long term view is required to perceive the benefits. Design of policy for forest-based bioenergy should balance near-term GHG targets with the long-term objectives and should also recognize the multiple drivers and effects of forest management.

Many countries have introduced incentives for bioenergy as a component of their climate change policies. As a result the bioenergy industry has grown and substantial volumes of biomass from existing forests are used for heat and electricity in many countries. The biomass is typically obtained from a forest estate managed for multiple purposes, including production of pulp and saw logs. It is rarely questioned that long-rotation forest management with some level of biomass extraction for energy can be maintained on sustainable basis. Neither is there any disagreement on a principal level that the CO_2 emitted when forest biomass is used for energy was earlier sequestered from the atmosphere and will be sequestered again if the forest bioenergy system is managed sustainably.

Concerns over the benefits

However, the difference in timing between emission and sequestration of forest carbon that is observed on a forest stand level has caused concerns over the climate mitigation benefits. Claims have been made that some forest-based systems are associated with upfront losses in biospheric carbon (sometimes referred to as ”forest carbon debt”) which may delay climate change mitigation benefits beyond the target time period for climate policy. The debate about the climate change benefits of forest based bioenergy has fuelled demands that the use of forest biomass for energy is reconsidered.

A report aimed at policy makers

Pathways researcher Göran Berndes engaged with colleagues within the IEA Bioenergy network to produce a statement report that addresses the issue of the timing of GHG emissions and carbon sequestration when biomass from managed forests is used for energy to displace fossil fuels. The report, which is aimed at policy advisors and policy makers, explains the essence of the timing debate and proposes a perspective that considers the broader context of forest management, energy system transition, and the role of bioenergy in climate change mitigation. The authors contend that some studies have exaggerated the upfront carbon losses of forest-based bioenergy, due to narrow perspectives and simplistic views of forest management and the bioenergy industry. They explain that the calculation of climate change effects of bioenergy yields different results depending on the assumptions and scope of the study.

One key message in the report is that in order to fully understand the climate change effects of bioenergy from existing forests, it is important to consider the entire forest landscape and the wide range of conditions within which forest bioenergy systems operate, long term as well as short term effects and climate objectives, and the interactions between human actions and forest growth.

The critical questions for policymakers are: will changes in forest carbon stocks at landscape scale, resulting from bioenergy incentives, affect the GHG mitigation benefits of bioenergy, and the timing of such benefits?

Benefits depend on location

Principally different situations that exist in forests are discussed and illustrated in the report (see also Figure 1 below). It is shown that the net GHG benefits from implementing forest bioenergy schemes depend on sitespecific forest conditions and on how forest silviculture and harvesting regimes change in response to bioenergy demand, and how this in turn influences forest carbon stocks. Thus, the answers to the question about timing of GHG mitigation benefits will vary between different locations, due to variation in environmental and socio-economic factors: the change in forest management and harvesting regimes due to bioenergy demand depends on forest type, climate, forest ownership and the character and product portfolio of the associated forest industry; the forest carbon stock response to changes in forest management and harvesting in turn depends on the characteristics of the forest ecosystem; and - finally - the character of existing energy systems determines the fossil fuel displacement - and thus the GHG savings - achieved from bioenergy use. For example, displacing coal achieves greater GHG savings than displacing natural gas, because coal is a more GHG-intensive fuel.

The report further proposes that, ***rather than concentrating on the exact timing of emissions and sequestration, it is more relevant to focus on assessing the contribution that bioenergy from existing forests may make to the establishment of renewable energy systems that can provide a GHG-friendly energy supply into the future.*** While some bioenergy systems may induce net carbon emission in their establishment, this does not necessarily mean that they should not be encouraged. What matters is the size of these net carbon emissions - or carbon costs - and the drawback of such a carbon cost needs to be weighed against the benefits of expanding bioenergy. A carbon cost should be viewed as an investment in establishment of a renewable energy system for a future with lower net emissions. A medium to long term view is required to perceive the benefits.

Multiple objectives must be considered

Decisions on forest management must reflect multiple objectives, covering environmental and socio-economic goals. The overarching priority of forest management is obviously to preserve the forests as a renewable resource, i.e., to ensure that the productivity of the forest system is maintained or improved. Decision-makers should be cognisant that bioenergy provides renewable energy and therefore offers a beneficial alternative to fossil fuels. In contrast, forest management to sequester carbon, without mitigation through avoided fossil fuel emissions, has declining mitigation value over time because carbon sequestration diminishes as forests approach maturity, is vulnerable to future reversal through fires, storms and insect attack, and it does not offer a beneficial alternative to fossil fuels.

Design of policy for forest-based bioenergy should balance near-term GHG targets with the long-term objective to limit the increase in global temperature to 2°C, and should be based on a holistic perspective recognizing the multiple drivers and effects of forest management. Otherwise, there is a risk that policies will fail to promote outcomes that simultaneously address production and conservation objectives. Policy should be devised to promote the optimal use of land and biomass resources to meet needs for food, materials and energy.

Reference: *Cowie, A., Berndes, G., Smith, T. (2013). On the Timing of Greenhouse Gas Mitigation Benefits of Forest-Based Bioenergy. IEA Bioenergy: ExCo:2013:04. Available for download at www.ieabioenergy.com/*

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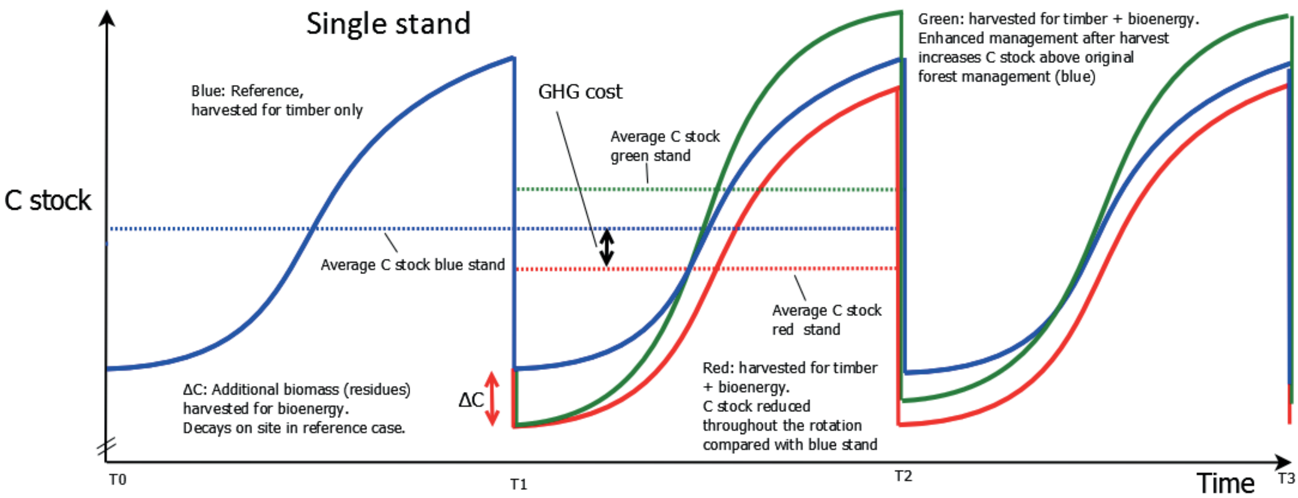

Figure 1. *The figure illustrate the carbon stock (sum of carbon in trees, soil and litter) of an individual stand, over successive rotations. The blue curve shows the reference scenario, a forest harvested for timber only. The other curves show two alternative scenarios, in which harvest residues (branches and tops), usually left in the forest, are removed for bioenergy at harvest, at time T1 and each successive harvest. The concept of "GHG cost" is illustrated in the red curve: the average carbon stocks are lower compared with the blue stand, due to removal of harvest residues, and, possibly, flow-on effects on soil carbon stocks and forest growth rate. The green curve illustrates how enhanced forest management can reduce the GHG cost.*

Expert workshops on:

Environmental sustainability of forest bioenergy

Forest based bioenergy is by many countries seen as an appealing alternative to fossil fuels as a means to reduce GHG emissions. However, the increasing demand for bioenergy raises concerns over the potential environmental impacts and the sustainability of forest biomass production for bioenergy. New standards, criteria and indicators targeting bioenergy products are, therefore, being discussed and developed. The European Union (EU) is a prime market for bioenergy products such as wood pellets and wood chips. The EU has in its Renewable Energy Directive (EU RED) outlined mandatory sustainability criteria for biofuels, and has also presented recommended sustainability criteria for solid biomass and biogas used within EU for electricity, heating and cooling.

IEA Bioenergy has, together with collaborating partners, organized two workshops to discuss aspects related to the sustainability of forest bioenergy in North America. This region is an important producer of forest biomass for bioenergy. The Pathways researcher Göran Berndes was involved in organizing both workshops as part of his engagement in IEA Bioenergy. The workshops gathered many European, Canadian and American experts involved in bioenergy research, industry and policy development.

The first workshop (held in Quebec in October 2012) had a Canadian focus. Canada has large forest resources and will likely play an important role in the increasing international trade of solid biomass. In Canada, forest management activities mainly takes place in forest landscapes inherited from nature, or that have only experienced very little direct influence by human interventions. Forest management guidelines and certificate systems have therefore been developed with aim to preserve the features of natural forests and to simulate the natural disturbance pattern. However, the Canadian approach may not easily align with overarching sustainability standards such as the EU RED. The aim of the EU RED is to apply for all types of biomes, including tropical and subtropical forests, whose management is very different to those found in Canada.

The workshop provided possibilities to discuss these issues related to environmental sustainability of bioenergy forests and the policy developments taking place on both sides of the Atlantic. From the discussions it was highlighted that new scientific knowledge and technology, as well as lessons learnt from past experiences from the "first generation" of. biofuels, must be incorporated when developing policy and industry aiming at increasing the share of solid biofuels. Furthermore, the definition and use of primary forest as a sustainable criterion was debated, and the importance of accounting for the GHG balance of forest bioenergy in policy and in certification system was brought forward (see also p 3 in this Newsletter). A final aspect stressed was that sustainability regulations for biomass should be relevant and not create unnecessary complications for actors on the bioenergy market in different countries.

A second workshop was held in Savannah (USA) in October 2013. This workshop followed-up the previous event with intention to advance the dialogue on sustainability standards and criteria for forest-based bioenergy. The event also provided opportunities to learn more about forest management practices in the Southeastern states of the US.

The strategic discussion paper "*The science-policy interface on the environmental sustainability of forest bioenergy*" summarizes the workshop in Quebec and is available from www.ieabioenergy.com

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The role of Nordic hydropower to handle European wind power

Lisa Göransson and Joel Goop have investigated the role of Nordic hydropower to manage the variations from expanded European wind power generation in the near future. The results show that by 2020 Nordic hydropower acts as a redistributor of low cost electricity in Northern Europe, both geographically and in time, assuming transmission grid reinforcement in Northern Europe according to current plans. This implies that further expansion of renewable electricity in the Nordic countries could be facilitated, but also that electricity from peak load units could be replaced by electricity from base load units.

The EU renewable energy action plans include large investments in wind power capacity in Europe in the near future. However, the current electricity generation systems in continental Europe and in the UK are dominated by thermal generation which is typically expensive to operate with respect to compensating for the variability in wind power generation. Access to Nordic hydropower could potentially facilitate continued operation of thermal base load. Recent research within the Pathways project has therefore assessed the role of Nordic hydropower in managing variations in electricity generation in Europe in the year 2020, given a high penetration of wind power. Specific focus is on the timing and volume of the trade between different regions, taking load flow constraints and thermal cycling into account.

Transmission reinforcements in place

In this study it is assumed that the transmission grid is expanded according to HVDC reinforcements currently planned in northern Europe, i.e. additional connections from Norway to Denmark (700MW), Germany (1 400MW) and the UK (1 400MW), as well as the transmission corridors in Germany (a total of 10 000MW) and in UK (2 000MW) are realized by 2020. The scenario also stipulates that each EU member state attain, at least, a renewable power generation corresponding to the renewable action plan. The Swedish wind power generation is expanded to reach the planning target of 30TWh/year, while Nordic hydropower and Norwegian wind power are assumed to remain at current levels

The European electricity generation system by 2020 is derived from the investment model ELIN and further analyzed using the cost-minimizing dispatch model EPOD to determine how variations in wind power generation and load can be managed (for a more detailed description of the models, see Newsletter #2/2013).

Nordic hydropower redistributes electricity

The modeling results indicate particularly high concentrations of wind power in northern UK, northern Germany and Denmark. With the new HVDC connections in place Norway and Sweden have good connections to most European regions with high wind and solar power penetration levels.

Figure 1 gives yearly net export in year 2020 for the regions investigated. It should be noted that Figure 1 gives the net result over the year, *i.e.* regions will both export and import electricity. Hydropower plays a central role when matching generation with load in the wind-thermal

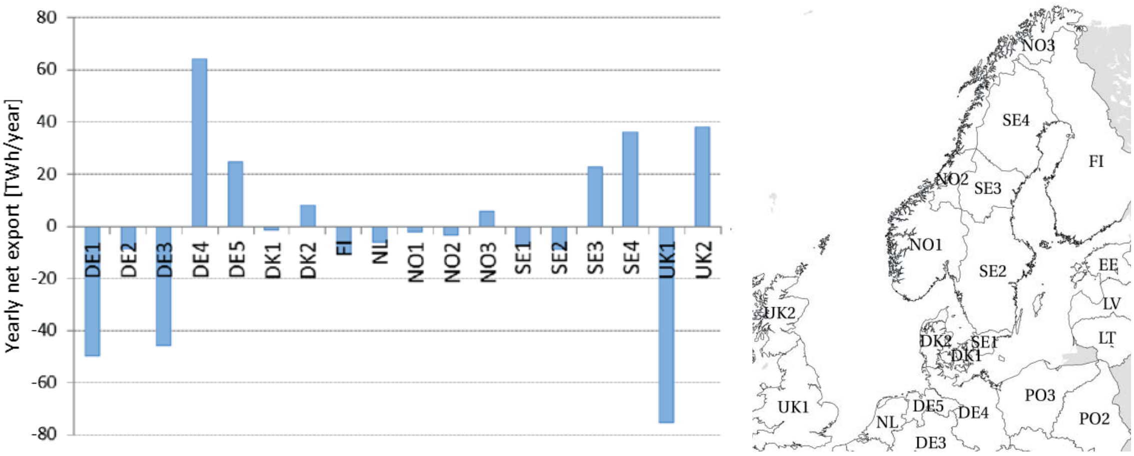

__Figure 1.__ The left panel shows yearly net export in year 2020 as obtained from the EPOD modeling for the regions investigated. The map in the right panel provides the abbreviation of the regions; DE1 (Southern Germany) and DE2 (Southwestern Germany) are, however, not shown in the figure.

systems and realizing the electricity redistribution given by Figure 1. For example, in year 2020 Norway exports 6.5 TWh/year to Germany, 2.7 TWh/year to the Netherlands and 8.6 TWh/year to the UK under normal-year conditions for hydropower. The Danish system supplies Norway with 8.5 TWh/year of electricity. Out of these, about 3.6 TWh/year has Swedish origin. Thus, Nordic hydropower acts as a redistributor of electricity in northern Europe, both geographically and in time. In this way, 17 TWh/year of Swedish and Danish electricity from hours with good wind conditions is redistributed by Norway to peak load hours in the UK and central Europe. It can also be seen that 7.1 TWh/year of peak load in Denmark, the Netherlands, Germany and the UK is redistributed by Norway to low load hours in these countries.

For further information:

LISA GÖRANSSON and JOEL GOOP,
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The geopolitics of renewable energy and abundance of fossil fuels

To what extent can technologies from renewable energy sources (RES) be expected to substitute fossil fuels so that the actual use of fossil fuels is reduced? This is the focus of recent Pathways research where, in particular, the change in fuel mix in primary energy consumption and in electricity generation over the last decade between regions with large and little domestic fossil-fuel resources is compared. It is concluded that in the developing countries rich in domestic fossil fuels, there is only moderate or no increase in primary energy from RES while large increases in primary energy consumption from fossil fuels. A possible "fossil-fuel curse" is identified, implying that countries with large domestic fossil fuel resources cannot be expected to make these resources stranded assets.

State-of-the-art research indicates that 50% to 70% reductions in GHG emissions by 2050 are required to limit the global temperature increase to 2ºC. This obviously represents a great challenge from the technical and political points of view. In order to mitigate climate change, investment in renewable energy technologies (hydropower and non-hydro renewable energy, NHRES) is often considered a key option. Hydropower has in recent decades seen a strong growth in developing regions, like China and India. It can, however, be considered an established technology with limited potential to further expand in developed regions, such as the EU and the US. Thus, in a future perspective, large scale diffusion of NHRES technologies (replacing fossil-based technologies) is considered a key to decarbonize the energy system.

Will renewables reduce fossil fuel use?

In the recent decade there has been a strong expansion in NHRES technologies in several regions around the world, especially with respect to wind and solar power. Yet, the use of renewable energy is still small compared to the use of fossil fuels and the fossil fuels are abundant. If the main reasons for expansion in NHRES technologies are to mitigate CO_2 emissions and increase security of supply, an obvious question is if these can be expected to actually reduce the use of fossil fuels rather than adding capacity or, along with fossil fuels, contribute to meet increasing demand. This is the subject of current research by Filip Johnsson and Jan Kjärstad where they have, in specific, investigated whether there are any examples of countries which have, up to now, replaced fossil fuels with the use of NHRES technologies (or with hydropower). Their survey covers key regions including such with large domestic resources in fossil fuels and those with little such resources, namely ; China, EU27, Germany, India, Japan, Norway, Russia and the United States (US). For each region, the economic value of national assets of fossil fuel resources is estimated and indicators specifying the annual fossil-fuel production as well as the indigenous fossil fuel supply (resources and 30% of reserves) in comparison with annual GDP are calculated. The developments in primary energy use and electricity generation over the last decades are analyzed and differences between regions are compared.

A growth of fossil fuel use in many regions

The results show that for the regions rich in fossil fuels (China, India, Norway, Russia and the US) the amount of electricity from NHRES is in the order of a few percent, even though the last decade has, in general, seen a strong growth in NHRES electricity (see Table 1). However, for most of these regions, the growth in fossil electricity generation was much larger than the growth in NHRES generation *in terms of growth in absolute number*. Only in the US the recent growth in generation from NHRES is similar to that in fossil in spite of that the US has large amounts of fossil fuel resources.

For EU including Germany, i.e. regions with small amounts of fossil fuels the growth in electricity from NHRES is significantly larger than in fossil fuel generation within the studied time frame. In fact, as can be seen from Table 1, there was a reduction in fossil generation in EU as well as in Germany in the period 2004 to 2010. However, during the same time period and in spite of having almost no domestic fossil fuel resources, Japan has increased electricity generation from fossil fuels around three times more than from NHRES. Thus, there has been continued increasing import dependency in Japan.

The "fossil-fuel curse"

For China, India, and Russia which all have large domestic fossil-fuel resources and a significant economic development, not only electricity generation, but also prime energy consumption from fossil fuels have increased more than from NHRES. In fact, for these countries, there was no increase in prime energy use from NHRES over the last decade (significant decrease in India).This points to that it is a great challenge to make renewable energy replace fossil fuels since leaving the fossil fuels in the ground will represent significant "stranded assets". Similar to the expression of "natural resource curse" we identify a possible "fossil-fuel curse", implying that countries with large fossil fuel resources cannot be expected to make these resources stranded assets. Thus, this represents a large threat to mitigate human induced global warming.

Table 1. *Electricity generation [TWh] from hydropower, non-hydro renewable energy (NHRES) technologies and fossil fuels.*

	Electricity generation [TWh]											
	1990			2004			2010			△ (2004-2010)		
	Fossil fuels	NHRES	Hydropower	Fossil fuels	NHRES	Hydropower	Fossil fuels	NHRES	Hydropower	Fossil fuels	NHRES	Hydropower
China	523	0	127	1 830	2	354	3 393	57	722	1 563	55	368
EU27	1 462	25.0	286	1 776	133	357	1 706	321	366	-70	188	9.0
Germany	372.4	4.9	17.5	385.1	43.0	19.6	368.8	92.7	20.5	-16.3	49.7	0.9
India	212.0	0	72.0	560.0	6.0	85.0	797.0	22.0	114.0	237.0	16.0	29.0
Japan	532.0	13.0	89.0	671.0	23.0	94.0	706.0	34.0	82.0	35	11.0	-12.0
Norway*	0.1	0.4	121.4	0.4	0.3	138.9	4.4	1.3	126.3	4.0	1.0	-12.6
Russia	798.0	0	166	604.0	2.0	176	696.0	4.0	166	92.0	4.0	-10.0
US	2 213	106	273	2 961	102	271	3 060	192	262	99	90	-9.0

** "2004 and 2010" values are from 2000 and 2009*

The theme of this work was published on "DN debatt" October 9, 2013. See http://www.dn.se/debatt/overflodet-av-fossilbranslen-ar-den-storsta-klimatfragan/

For further information:
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New PhD thesis

Modeling energy conservation and CO_2 mitigation in the European building stock

In the European Union (EU), the building sector accounts for 35-40% of the total final energy use and associated CO_2 emissions. Since the turnover of building stock is low in developed countries, the greatest challenge for reducing energy use in the EU building sector is to find effective strategies for retrofitting existing buildings. This challenge is the focus of Érika Mata's PhD thesis work – specifically she investigates energy conservation measures (ECM) in building stocks by developing and applying a methodology for national building stocks. The methodology is based on a bottom-up building-stock model, ECCABS, and a methodology for describing the building-stock. The model provides hourly net energy demand (for all end-uses) for buildings representing an entire building stock of a country or a region. The results are presented in terms of final energy demand, associated CO_2 emissions, and costs for implementing a portfolio of ECMs.

Describing building stocks using archetype buildings

As input to the model, *sample buildings* as well as *archetypes* can be applied to describe the building stock of a country. Sample buildings represent actual buildings where data regarding thermal characteristics is obtained through measurements. However, this requires significant efforts towards measuring and quantifying of parameters and this data is, therefore, seldom available on a national level. Archetype buildings are instead statistical composites providing an approximate description of the building stock, based on knowledge of the overall building characteristics of the region in combination with national statistics related to the building sector. In order to describe building-stocks through archetype buildings on a national level, a methodology has been developed within the PhD project. This methodology comprises the following main steps: (1) segmentation, in which the number of archetype buildings required to represent the entire stock is decided according to building type, construction year, heating system, and climate zone; (2) characterization, whereby each archetype is described in terms of its physical and technical characteristics; (3) quantification, whereby the number of buildings in the stock represented by each archetype building is determined. The archetype description has been developed and validated for the building stocks of France, Germany, Spain and UK, which account for half of the final energy use of the residential and non-residential buildings in the EU-27 countries.

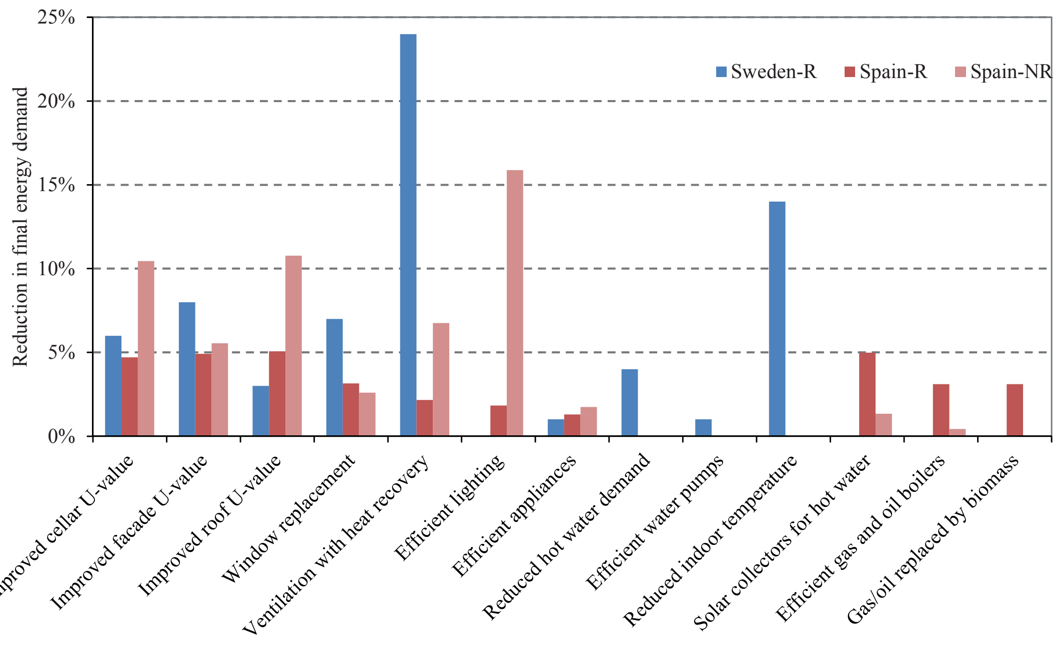

Figure 1. *Technical potential to reduce final energy demand for each investigated energy conservation measure (on an individual basis) in the Swedish residential (Sweden-R) building stock, and in the Spanish residential (Spain-R) and non-residential (Spain-NR) building stock.*

Up to 50% reduction of final energy demand

The ECCABS model has been applied to investigate the impact of various ECMs to the Swedish residential building stock and the Spanish residential and non-residential building stock. These building stocks represent Northern and Southern EU buildings, respectively. The model results show that the final energy demands of the Swedish and Spanish building stock could be reduced by 50% if all measures are implemented. Figure 1 summarizes the technical potential reductions (as % of the final energy demand in the baseline year) of applying the ECMs individually. In both countries, the different forms of envelope upgrade (improving the U-value of cellars, facades, and attics, and replacing windows) together conferred the largest potential for all buildings (5 to 10% reduction each). However, other ECMs with significant potentials differed between the two countries and subsectors. The results also indicate that the levels of CO_2 emissions from the Swedish residential buildings and the Spanish buildings could be reduced by 60%–70% (although emissions from the Swedish buildings are already very low in absolute numbers). If also considering the economic viability of the ECMs, techno-economical potentials of reducing energy demand by 20%–30% are identified for Sweden and Spain, corresponding to CO_2 emissions reductions of 40%–50%.

Need for strong policy measures

The results from the thesis also highlight that there is much to be gained if as many ECMs as possible are undertaken when a building is being retrofitted, not only from an economic point of view (as ECMs implemented simultaneously in packages are more cost efficient that individually implemented ECMs) but also for the opportunity taken. The market potentials estimated were substantially lower than the techno-economical potentials. Thus, if the techno-economic potentials identified in this work are to be implemented there is a need for strong policy measures to influence stakeholder action.

For further information:
ÉRIKA MATA, Chalmers University of Technology

Érika Mata will defend her PhD thesis "*Modelling Energy Conservation and CO_2 Mitigation in the European Building Stock*", November 27 at Chalmers University of Technology.

To receive a copy of the thesis, please contact Érika at mata@chalmers.se.