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LUND UNIVERSITY

Governance for a Low-Carbon Society

Combating climate change requires a major transition towards a sustainable energy future. What technologies and approaches to governance will make this transition a success?

SIEMENS

VATTENFALL

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Mr Allan Larsson, Chairman of Lund University, gives the Report on Governance for a Low Carbon Society to the representative of the Swedish Presidency of the Council of the European Union before the COP15 Summit in Copenhagen

Photograph: Mikael Risedal

Preface

The upcoming COP15 United Nations Summit on Climate Change has brought a lot of attention to the environmental challenges that our Planet will face in the near future. The developments in technology and productivity of the last century have not only radically changed our lives and increased our dependency on energy; they have also shown us the impact of our actions and lifestyle.

In recognition of the complexities of this issue and the vastness of the subject, Atomium Culture and Lund University have organised the writing of this Report and the High-Level Workshop on Governance for a Low-Carbon Society (HLW) to stimulate new insights and ideas from bringing together leading thinkers from university, industry, media and policy makers to discuss on the real issues and barriers of this debate.

This report and the HLW want to create a comprehensive, intersectorial and interdisciplinary forum in order to create a credible and realistic medium for the public at large to access and understand the complexities of the debate; to outline the challenges, the possible solutions and innovative ways of implementing these.

Climate change and the transition to a low-carbon society is a challenge that we all face. It cannot and should not be addressed by individual sectors and actors alone. Including society at large in these debates is a fundamental step towards a sustainable solution. An informed society is a society with a higher decision making capacity.

Lund University (LU) is a comprehensive and research intensive university with eight faculties, approximately 40,000 students and 5,700 employees. Climate, environment and energy is identified as one of seven priority areas in the LU Research and Education Strategy and coordinated under the LU Climate Initiative.

Atomium Culture brings together some of the most authoritative universities, newspapers and businesses in Europe in the first permanent platform for European excellence to promote the exchange and dissemination of the most forward looking new ideas: across borders, across sectors and to the public at large.

A strong belief in the importance of sustainable collaborations, open communication and inclusion brings these actors together to create a setting where all stakeholders share their knowledge in order to create a whole picture that is bigger and clearer than the sum of the individual contributions.

We want to thank all the people involved in this effort. Valuable contributions have been made by Shell, Siemens, Vattenfall, Bellona and EEA. The writing of the report was coordinated by Lars J. Nilsson (LU) and Erika Widegren (Atomium Culture) with written contributions from LU researchers Jamil Khan, Karin Ericsson, Annica Kronsell, Johannes Stripple, Roger Hildingsson, Lars Coenen, as well as Max Åhman (SEPA), Alex Bowen (LSE), Antonio Gomes Martins (UC), Carmen Navarro (UAM), Wolfgang Lucht (HU & PIK), Andrew Gouldson (ESRC). A special thank goes to the workshop participants who invested their time and effort in completing this report.

Mr Michelangelo Baracchi Bonvicini
President
Atomium Culture

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Vice Chancellor
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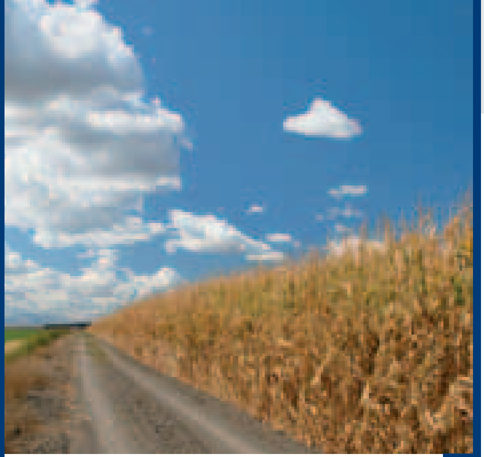

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Education, Information and Awareness:
Crucial Factors in Meeting the Challenge of Climate Change

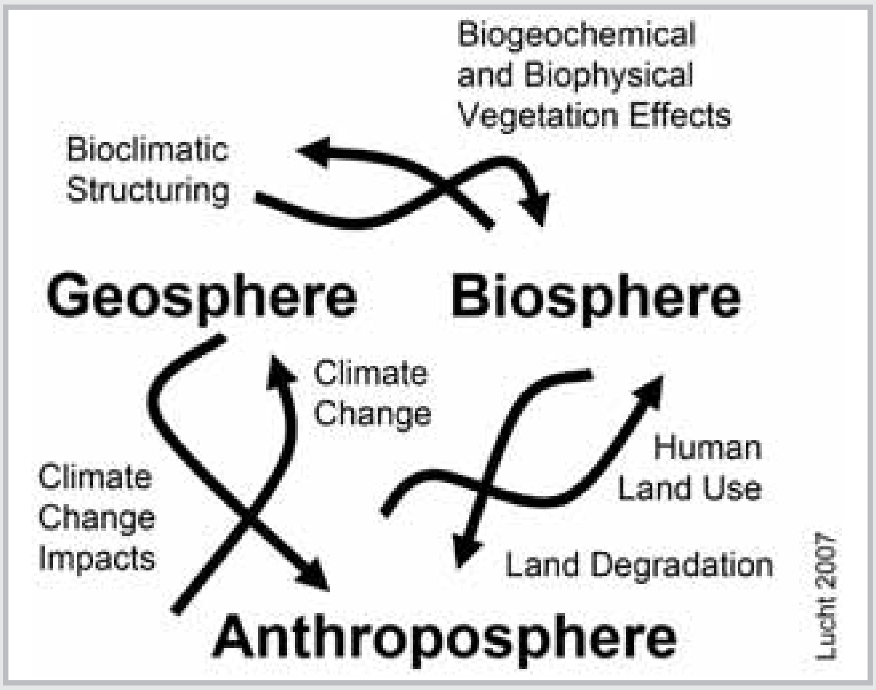
Preparing for the future is essential for societies, especially in a world where the environment is undergoing rapid change. Due to anthropogenic global warming, Earth's climate is entering a state it has not experienced in the last 3 million years. The world's biosphere is also entering a state without historical analogue, a consequence of widespread deforestation, land degradation and species loss. Against this background, it is not unreasonable to expect that the world's societies will equally undergo considerable transformative change as their regional and global environments are remodelled.

Fortunately, awareness of the Earth as an integrated system has made huge advances in the last few decades. Based on a scientific understanding of Earth as a system, the environmental changes that follow from the material interactions of the world's societies with atmosphere, land and oceans can now be understood and projected with increasing accuracy. This information and the awareness produced are crucial in the process of societal self-evolution that is now required to steer transformative politics into directions of improved sustainability. The required transformations cannot succeed if they are not based on good information, and if not supported by public understanding. Science and education are therefore among the most powerful tools available to societies when deciding about issues that will affect their future opportunities.

The main tools used in Earth system analysis are global Earth observation, computer modelling and communication through mass media. Comprehensive Earth observation provides the eyes and ears that allow to monitor environmental changes and understand the current and past states of the planet. Computer models build on what is known about Earth system processes and allow considered projections of possible outcomes of various scenarios of the unknown future. Mass communication from radio and television to the internet has made large sectors of the global public aware of the findings of this science, lending crucial though regionally differentiated public support to corrective actions.

Uncertainties remain in this process, but that should not come as a surprise, given the monumental complexity of the Earth system. However, dealing with incomplete knowledge is no obstacle in mainstream economic and political planning, where it does not keep anybody from making investment decisions and conducting strategic planning. Equally it should not deter now from taking action aimed at countering the threat of large and rapid environmental change in areas of utmost importance to the existence of current societies.

Contribution by Prof. Wolfgang Lucht, Chair, Research Domain "Climate Impacts and Vulnerability, Potsdam Institute of Climate Impact Research & Alexander von Humboldt Chair in Sustainability Science, Department of Geography, Humboldt University Berlin



Executive Summary

A speedy transition to low or zero carbon energy systems is necessary to stabilise concentrations of greenhouse gases at levels consistent with a 2 C target. It requires global cuts in emissions by *at least* 50 percent by mid-century and essentially zero emissions in industrialised countries. Such transitions appear feasible based on resource availability, existing and projected technologies, and associated costs, but require purposeful steering by states and other key actors in society.

This report, and the High Level Workshop for which it was prepared, is about the governance of transitions for a low-carbon society. Carrying out such transitions involves unprecedented challenges for political institutions and processes, and most likely requires new and innovative approaches to governance. The objective here is to anticipate and analyse such challenges, and explore possible ways forward.

For this purpose we use three building-blocks: (i) existing low-carbon future scenarios; (ii) analyses of issues associated with three key mitigation options, i.e., energy efficiency, renewable energy, and carbon capture and storage (CCS); and (iii) state-of-the-art understandings of challenges and opportunities associated with the governance of large-scale transitions. Key governance issues, specific to certain technologies as well as more general in nature, are identified.

How can high rates of energy efficiency improvement and double digit growth in renewable energy be sustained over the next 20-30 years? How can barriers to the demonstration and deployment of CCS technology at scale be approached? What can be the role of the state in the transitions? How can long-term goals be reconciled with short term priorities? These are some of the nine questions discussed in the High Level Workshop.

The debate between the representatives from university, industry, media and policy makers inspired cross cutting discussions on the governance approaches, including institutions and policies, that can enable and drive the transition. These covered many issues but four overarching themes are recurring. The first regards the importance of information, education and communication and the need for an appealing vision or narrative of a better and low carbon life and future. The second revolves around the topic of equity and rights within and between current and future generations; this debate also raises important questions concerning responsibility at all levels of society. The third regards the development of carbon pricing in a global market and the need to reinforce the underlying structure with mechanisms that create stability and dynamic consistency in prices and policy in the long term (for example, through a "central carbon bank"). Fourth, there is also a need for new and appropriate policies and institutions related to the specific mitigation options (energy efficiency, renewable energy, and carbon capture and storage) in order to maintain momentum in the transition but also to handle conflicts and unintended side-effects. Integration across different policy domains is important to ensure that a multitude of large and small barriers are addressed and a multitude of large and small enabling conditions are created. ■

Introduction

A speedy transition to low or zero carbon energy systems is necessary to reach the ambitious goals for reducing carbon emissions set for 2050. Governing such a transition without recession or upheaval presents a challenge to society which is unprecedented.

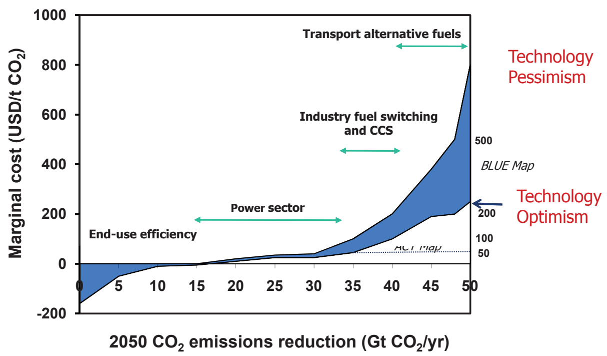
This report is about governing transitions toward a low-carbon society. Governance is a concept that is used to describe how societies, organisations and networks are collectively steered and governed. Different from government it emphasises steering enacted in cooperation and deliberation between public authorities and private actors. It includes energy and climate policies, and policy integration, but also the forms and rationalities of steering, e.g., by money, orders, or talk. A low-carbon society is one in which carbon emissions are below what is required for long-term stabilisation of greenhouse gases. Transition governance for a low-carbon society includes all purposeful mechanisms and measures aimed at steering social systems towards making the transition.

A growing scientific consensus has pointed to the need for stabilizing the concentration of greenhouse gases at levels below 450 ppm in order to stay below the 2 °C target. This requires global cuts in emissions by *at least* 50 percent by mid-century. For practical purposes, this means that industrialised countries, in a matter of 30-40 years, must transform their energy systems to essentially zero carbon emissions. Carrying out such transitions involves unprecedented challenges for political institutions and processes and most likely requires new and innovative approaches to governance.

The main objective of this report and the associated High Level Workshop is to anticipate, explore and analyse the governance challenges and opportunities involved in making such a transition. Our approach involves three building blocks that are elaborated in the following sections. The first is existing scenarios for low carbon futures and rates of change implied by transition pathways. The second are the specific implementation and governance issues associated with three key mitigation options, namely energy efficiency, renewable energy sources, and carbon capture and storage. We have decided not to address nuclear power, the fourth key mitigation option, in this report as it is not part of the international climate negotiations. The third building block is contemporary understandings of the fundamental challenges and opportunities associated with the governance of large-scale transitions.

Our point of departure is that low or zero net emissions are feasible based on what we know about the availability of resources, technologies and their current and projected costs. Reducing emissions also appears to be affordable and motivated from the point of view of economic efficiency. Mitigation costs are often estimated to represent a few - or even less than one - percentage points in terms of lower GDP. The present value of the benefits in terms of avoided damage costs is debated but would greatly exceed the mitigation costs according to many analysts.

Fig. 1: Costs of Emissions Reduction



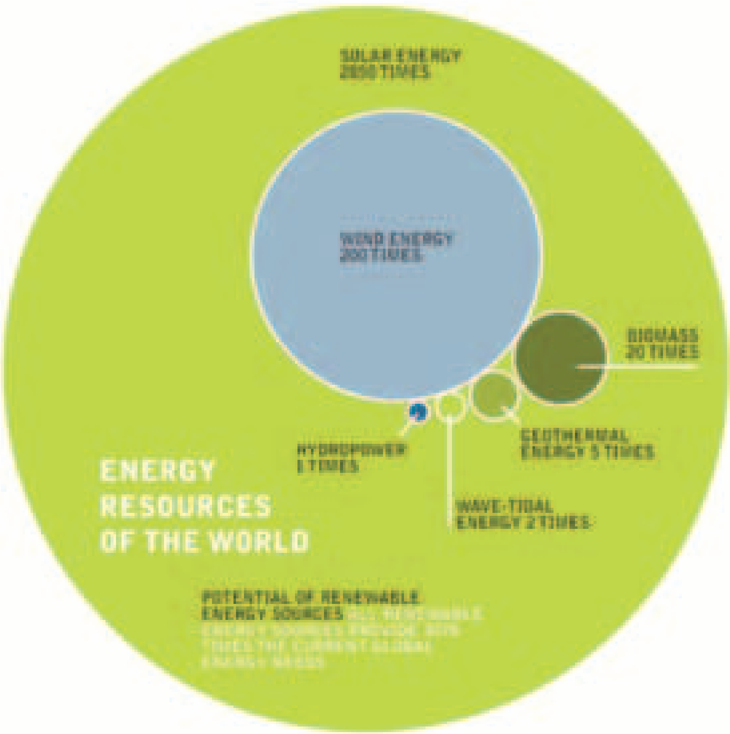
To bring emissions back to current levels by 2050 options with a cost up to USD 50/t are needed. Reducing emissions by 50% would require options with a cost up to USD 200/t, possibly even up to USD 500/t CO_2

Source: Energy Technology Perspectives, © OECD/IEA, 2008

The aim of this report is to raise, and enhance our understanding of, the pertinent issues that are entailed in governing transitions. Where will the critical goal conflicts and trade-offs appear? By what mechanisms can we effectively take society from the current situation of "carbon lock-in" to a "carbon lock-out"? What modes of governance are more likely to be useful in different technology and market contexts? How can effective climate policies be adopted and implemented without compromising the legitimacy of governance systems?

Stabilising or reducing atmospheric greenhouse gas concentrations requires the participation of all major emitters, including EU, USA and the BRIC countries (Brazil, Russia, India and China). This report, however, does not address current and contentious issues in the international negotiations concerning, for example, near term commitments, responsibilities and financing. Instead, it focuses on the implications for governance if a long-term objective of staying below 2 °C global warming is agreed. Our analysis is informed mainly by an industrialised country context but the governance challenges can be generalised for other regions. ■

Fig. 2: Availale Renewable Energy Sources compared to Needs.
Renewable and other energy resources do not constrain energy supply.



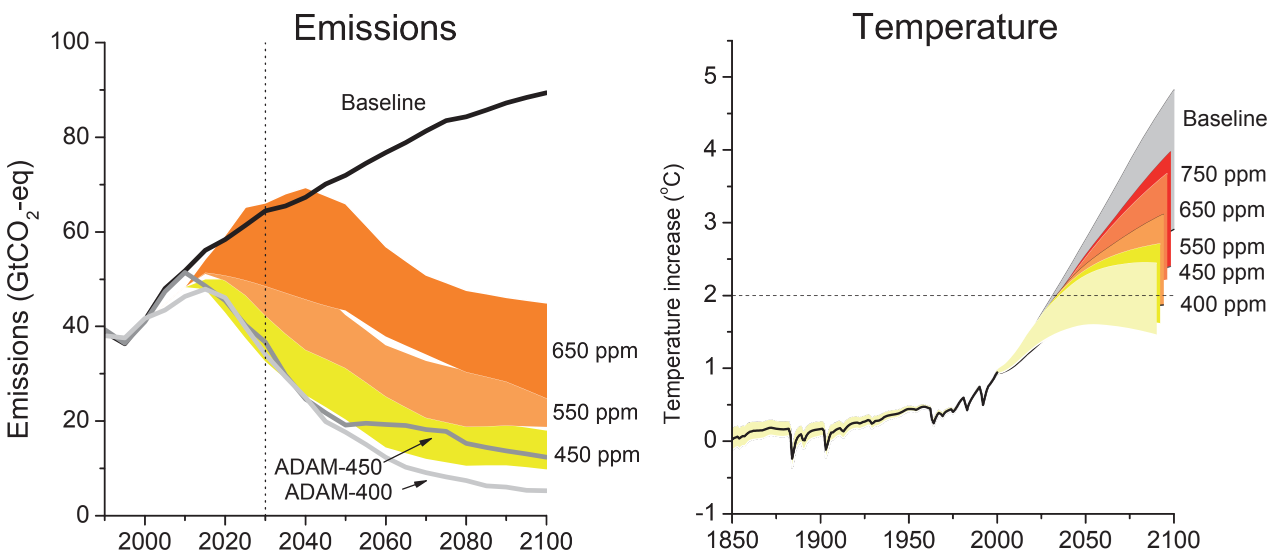
Low-Carbon Futures

Prevailing global energy trends are unsustainable. With a growing population, estimated to reach 9 billion by 2050, projected increases in global energy use and emissions will lead to rapid and irreversible climate change effects. Reversing the trends is possible and can lead to sustainable development benefits in addition to reduced carbon emissions.

Scenarios on low-carbon futures and energy transition pathways have in recent years recurred as a strategic element in climate and energy policy. The overall message from various scenarios and analyses is that radical emission reductions are urgently needed and technically feasible to achieve at reasonable economic costs to society. In other words, there is relatively broad consensus on *what* needs to be done. However, low-carbon scenarios are seldom explicit on *how* to make the transitions towrds low-carbon futures happen. Alas, the policy, governance and institutional challenges implied are largely underestimated or not addressed.

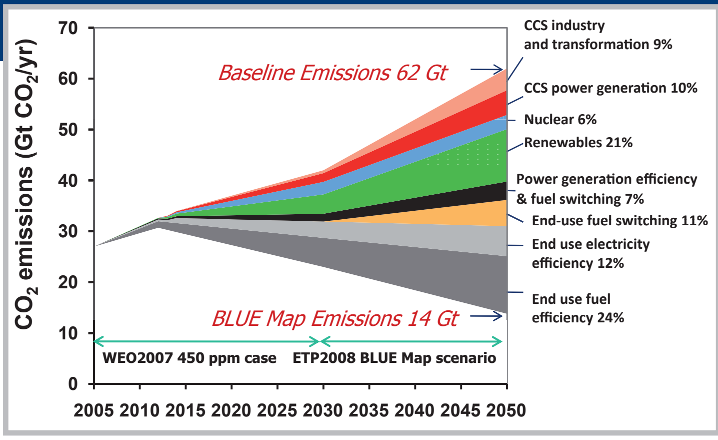
Most baseline scenarios yield a business-as-usual trajectory where global energy demand and greenhouse gas emissions are more than doubled by 2050, despite autonomous improvements in energy efficiency. This might put us on a trajectory towards a long-term concentration of greenhouse gases at levels above 900 ppm as we approach the end of this century, leading to rapid climate change and average global temperature increases of perhaps 6 °C. Long-term stabilization scenarios indicate that the concentration of greenhouse gases needs to be stabilized at levels below 450 ppm in order to have a 50 percent chance of staying below the 2 °C temperature target.

Fig. 3: Indication of emissions profiles and temperature outcomes of different stabilisation targets.



Source: ADAM-project and MAGICC calculations from Van Vuuren et al. (2008)

Fig. 4: IEAs BLUE roadmap scenario



Source: Energy Technology Perspectives, © OECD/IEA, 2008, figure 2.2, page 64

For this target, global emissions need to be *at least* halved by the mid-century, while emissions in advanced industrialized countries (i.e. OECD) are cut by 80-100% in 2050.

Transition pathways, or 'emission envelopes,' indicate the relative importance of various technologies and mitigation options that are available. In general, four types of energy-related mitigation options are emphasized; energy efficiency improvements; renewable energy sources; carbon capture and storage (CCS); and nuclear power. Energy efficiency improvements generally offer the greatest mitigation potential, however a broad mix of options are necessary to keep down the overall economic costs. While there are quite fundamental uncertainties regarding the future costs of specific options, mitigation tends to become more expensive if any option is not sufficiently deployed.

There are numerous scenarios in the literature. Scenarios modelled by the IEA provide a standard approach. While the World Energy Outlook reports forecast reference and alternative policy scenarios for 2030, the Energy Technology Perspectives report explores a range of least-cost options to drive an 'energy technology revolution' towards 2050. In this BLUE scenario (Fig. 4) energy efficiency accounts for 36%, renewable energy for 21%, CCS for 19% and nuclear power for 6% of the emissions reduction, while fossil fuel switching and efficiency improvements in power generation account for the remaining 18%.

Other scenarios, such as the Shell Blueprint scenario yields a similar view on an energy technology revolution to reverse the growth of emissions. The Energy (R)evolution scenario from Greenpeace indicates that a global 50 percent reduction of energy-related emissions is achievable even without CCS and despite a phase-out of nuclear power. Instead this scenario anticipates more ambitious energy efficiency measures, a greater utilisation of renewable energy for heat and power (over 70 percent share) and a key role for cogeneration and decentralised energy.

Most scenarios do not explicitly consider changes in lifestyle, behaviour or consumption patterns as a means to reduce emissions, although explicit lifestyle changes account for a significant share of the total mitigation potential in some scenarios (e.g., The Bellona Scenario). Purposeful changes in consumption away from carbon intensive goods and services, such as beef and air-travel, are important mitigation options but these are only available to a minority of the global population.

Estimates of marginal abatement costs go up to 200 USD/tCO_2 in, for example, the IEA BLUE scenario. Costs might be lower, but also substantially higher if technological progress turns out less successful than expected. There is also a range of options with low or negative costs. In particular, investments in energy efficiency and policies targeting end-use sectors (e.g., buildings, transport, and industry) are typically judged cost-effective and deemed critical to lower overall energy demand. Alas, what is cost-effective to society may not be perceived as cost-effective by individual actors in making decisions on which lamp, heating system, or window to install.

On the critical point about policy options, low-carbon scenarios are seldom specific, although it is obvious that a broad portfolio of general as well as targeted policies and instruments to induce technological and behavioural change is needed to make transitions happen. Policy is discussed as an exogenous issue in most scenarios. Effective and cost-efficient policy instruments are needed to provide economic, regulatory and other incentives for mitigation measures to be implemented. Policy coordination and integration across different sectors and policy domains is important in order to avoid conflicting policies and to smooth the transition. Governance approaches, including institutions and policies, that enable and drive the transition are also needed. Unless such enabling conditions are achieved, the actual level of deployment may be too low, the cost of mitigation too high, and public acceptance may erode.

Scenarios on low-carbon futures show us what needs to be done and reflect the current understanding of what can be done in terms of mitigation options. What needs to be established is *how* it can be done. ■

The Macroeconomic Implications of Transition to a Low-Carbon Society

If greenhouse gas emissions are allowed to continue to accumulate in the atmosphere, the climate change that they will cause will ultimately make economic growth impossible. Fortunately, economic studies suggest that the changes in the global economy necessary, although wide-ranging, need not be very costly. Recent research concludes that to give the world a 50:50 chance of keeping global temperature increases below 2°C need cost no more than 5% of GDP and possibly as little as 1% - even less if climate-change policies stimulate aggregate demand in a demand-constrained world economy like today's. And there could be benefits, on top of the avoided climate change impacts, from reduced local pollution and increased energy security.

However, economic policies must be well designed and implemented urgently if the costs are to be kept down and the 2°C ceiling avoided. First, firms and households must face a price for emitting greenhouse gases. Second, emissions reductions should be carried out in the countries and industry sectors where they are cheapest, which means that policies should be applied globally. Where the reductions are made should be separated from the question of who should pay for them. Third, policy-makers must get serious about tackling a range of 'market failures' that lead to inefficient use of energy, inadequate investment in R&D and excessive damage to the environment. That is more a matter of setting the appropriate incentives than spending public funds.

The transition to the low-carbon society will require a sharp fall in the energy intensity of production, part of which will be brought about by changing the mix of goods and services produced. Deforestation will have to be reversed. But the most important change will be in technologies. Renewable energy sources such as biofuels and wind, wave, solar and geothermal power will have to be deployed much more widely. But there is a danger that the abundance and cheapness of fossil fuels, especially coal, will ensure that they continue to be used for many years. India and China in particular are likely to keep using coal to fuel their extraordinary growth rates. That is why it is important that carbon capture and storage techniques are developed and deployed rapidly.

Contribution by Alex Bowen, Principal Research Fellow, Grantham Research Centre for Climate Change and the Environment, LSE

Energy Efficiency

Doing more with less, i.e., providing more energy services with less energy inputs, is a necessary component of the transition to a low-carbon society. The potentials for saving energy, while at the same time improving quality and comfort, are considerable.

Energy efficiency improvement is the mitigation option that accounts for the largest share of potential emission reductions according to most studies. It is also the least expensive mitigation option and many efficiency measures have a negative cost to society, i.e., they are motivated also in the absence of carbon taxes or other economic incentives. Energy efficiency improvements can be made by reducing losses in all parts of the value chain - from primary energy extraction to the delivery of a final energy service (e.g., lighting, motive power, or cooked food). But energy efficiency at the point of end-use typically offers the greatest potentials.

End-use technologies are still very far from the thermodynamic limits to energy efficiency (with the exception of a few basic industrial processes, e.g., fertilizer production). Technology development is also leading to new ideas and visions for what is possible and brings them closer to realisation. For example, thirty years ago we were looking for the most efficient heating systems for well insulated buildings. Today we are looking for and testing options for passive houses, zero-energy houses and buildings that will become net suppliers of energy - plus energy houses - through integrating solar technologies, energy storage, etc. in super-insulated buildings.

Many energy end-use efficiency measures have a negative cost to society and lower costs typically occur if efficiency measures are taken in conjunction with new investments. It is less expensive to build an energy efficient house right the first time than to make add-on energy efficiency measures to an existing house. Passive houses may be 5 to 20 percent more expensive to build but this extra investment is offset by significantly lower energy costs. Most energy efficiency measures involve such a trade-off between investment and operating costs when looking at the total life-cycle cost. However, the economic penalty for wasting or saving more energy than what appears optimal in this trade-off is typically small.

Accelerating energy efficiency through widespread deployment of existing energy efficiency options and development of advanced energy efficiency technologies are key to making the transition to a low carbon society. Low-carbon scenarios imply that we double, or triple, the historical 1 to 2 percent rate of autonomous improvements to future rates of 3 to 5 percent through energy efficiency policies. Such rates of improvement are technically possible and can result in a strong decoupling of economic growth and energy use (i.e., energy use decreases in absolute terms at the same time as more energy services are produced).

Over the past 5-10 years, the climate change issue and increasing concerns for energy security has resulted in a resurging interest in energy efficiency policy. China, for example, may now have the most ambitious energy efficiency policy in the world. The EU has a 20 percent savings target by 2020 and has adopted several directives to promote energy efficiency.

However, the governance of energy end-use efficiency requires attention to a plethora of barriers and challenges since energy use occurs in so many applications, across all sectors, and is influenced by so many decisions. In many cases the market is not sensitive to price signals and environmental taxes may therefore have little effect. For example, stand-by losses in appliances consume hundreds of terawatt-hours of electricity globally but the few watts

Zero Emissions Housing: Building the Future

Buildings should play a key role reducing energy dependence and CO_2 emissions. They account for about 40% of energy consumption in EU. More than 20% of the current energy consumption could be saved by 2020 using more ambitious standards in new and refurbished buildings.

Modern zero energy buildings (ZEB) and zero energy houses (ZEH) increase energy efficiency in two ways: strongly reducing energy consumption and on-site energy production. This can be achieved by combining climate-specific highly energy-efficient design, efficient construction and appliances, solar passive design, advanced control and management, and renewable energy systems so that it results in a net zero energy flow from the grid. A Zero Emissions Building or Zero Carbon Building is a building where the energy-use carbon emissions are balanced by the carbon emission avoided by on-site renewable energy generation.

Energy consumption can be lowered by using efficient appliances and eliminating phantom loads or standby loads. On-site energy generation typically means using renewable sources for generating both thermal and electric energy. In general, these buildings are connected to the grid from which they draw energy when needed and to which they export energy generated on site when there is a surplus. Zero energy or zero emissions buildings are designed, constructed and equipped to produce the energy they need. All the technologies used in such buildings are available off-the-shelf.

Passive solar techniques, efficient household appliances, smart metering and control, and on-site thermal and electric energy generation are the key tools for zero emissions housing.

Contribution by the initiative Energy for Sustainability, University of Coimbra, Portugal

in each appliance mean little to the individual consumer when deciding on which DVD-player or LCD-TV to purchase. Other actors, such as energy intensive industries, do respond and are sensitive to prices but they are also sheltered from price increases for just that reason. The problem being that higher taxes threaten competitiveness and run the risk of resulting in carbon leakage, in particular in the absence of international coordinated regulation.

As indicated above, there are very different technical, economic, organisational and institutional conditions associated with different energy end-uses and across different sectors. The applications range from TV set-top boxes to integrated steel mills. This has considerable implications for energy efficiency policy and governance. Getting the prices right is a necessary but not sufficient condition for harnessing the potentials for energy efficiency. Energy efficiency policy must also include minimum efficiency standards and regulation to eliminate sub-standard technologies and practices, as well as various instruments that help bring better technologies and practices to the market.

Energy end-use efficiency is not only about reducing energy demand but also about balancing energy demand by shifting loads to off-peak hours in power systems. With higher penetration of variable renewable electricity production it is expected that such load management will become increasingly important for grid operation and stability. Smart meters that facilitate two-directional flows of electricity and information, and remote control of end-uses (such as when to charge a plug-in electric vehicle) can allow for new approaches to system operation and lower cost to consumers. This requires planning and coordination that cannot be left to market forces alone. ■

Renewable Energy Sources, Smart Grids and Electricity

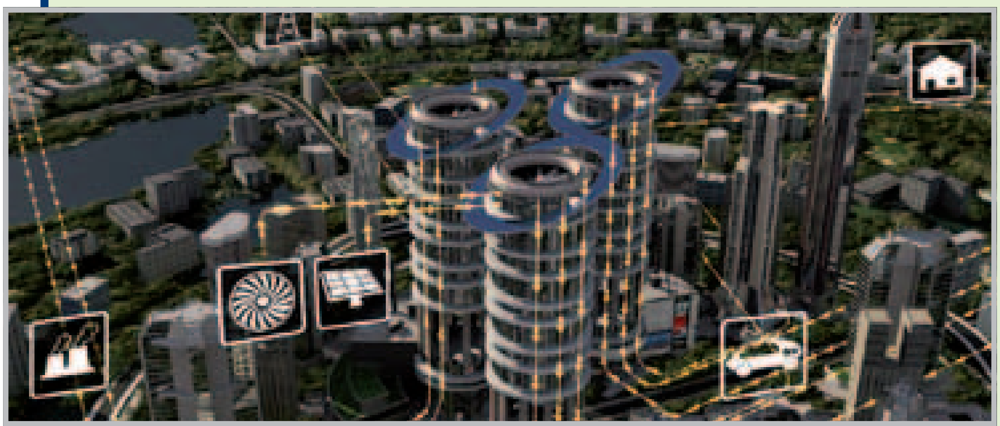
The growing use of small and medium-sized power generation plants using renewable energy sources such as wind and solar make the overall energy system far more complex and difficult to operate, since the renewable energy units don't produce a steady output of electricity. This requires a flexible and optimally managed and controlled network infrastructure. The new environment for energy creation and consumption, multiplying the number of actors "playing the game" require to rethink about our energy system.

Today energy grids operate with unidirectional flows. The new scenarios however require us to be able to sell surplus energy we produce and buy energy when we need. We need an efficient "market" for energy and a high degree of intelligence of the energy system where all kinds of infrastructures are connected along the entire energy chain (buildings, transportation, industry, e-cars etc.): smart-grids.

To achieve the necessary systemic optimization of the overall energy system, there will have to be a true paradigm shift in the power grid. Rather than operating with traditional unidirectional flows, bi-directional power flows and communication will be possible - and key to the system's efficient operation.

Electricity is the most flexible and efficient energy source we know and will be gaining momentum in the years to come. The increased use of electric appliances, such as electric cars, will further stress the need for an intelligent power infrastructure to harmonize the requirements of consumers.

For more detailed information about these technologies please see CD at the back of the report



There is ample and documented experience with various policy instruments but also a debate, and hesitance on the part of decision makers, concerning the extent to which government should interfere with the market and in what ways. The governance challenges associated with energy efficiency are many and diverse but four overarching issues are identified here:

- Who should have the mandate, jurisdiction and resources to govern energy efficiency? What types of organisations and institutions are more effective for realising the demonstrably large and low-cost mitigation potentials?

- Energy efficiency often requires coordination and steering across a complex web of actors (for example equipment suppliers, sub-suppliers, installers, builders, building owners, tenants and users in the case of building energy performance). What approaches to governance, at different levels from local to supranational, are more effective in various technology and sectoral contexts?

- Planning and regulation, if enforced, is very effective in several situations but may also conflict with prevailing liberal ideals about individualistic autonomy. How can potential barriers of this type be circumvented in the interest of the collective good? How can effective energy efficiency policy be made legitimate and reach broad acceptance and how are potential conflicts and opposition to be handled?

- Getting the prices right may be difficult politically, especially in the case of energy intensive industries due to concerns for competitiveness and carbon leakage. What types of instruments other than taxes can be used? Under what circumstances may border adjustment taxes become an option?

Electric drivetrains are 2 to 5 times more efficient than internal combustion engines. However, the overall Greenhouse Gas balance of Electric vehicles depends heavily on the CO_2 intensity of the electricity generation.

What is the role of transport?

Interview with the Vice President of the European Comission Mr Antonio Tajani

In contrast to other sectors, transport emissions are increasing and responsible for an increasing share of EU emissions. What will the role of this sector be in reducing carbon emissions in the coming years?

Decarbonising transport […] will not be an easy task.

In its Climate and Energy Package, the Commission has favoured a decentralised and flexible system based on the use of ETS for large industrial installations and aviation; and setting of national targets for the 'small emitters' sectors, that include road transport, agriculture, buildings (heating and cooling) and waste. Transport is also the only sector that has a sectoral mandatory target on the minimum use of renewable energy, which should reach at least 10% by 2020 as part of the 20% global target for the whole economy.

In addition, in the field of transport, the European Union has issued regulation to break the technological deadlock of oil dependency. New passenger cars have mandatory CO_2 performance targets, which will get progressively more stringent.

Finally, the Union is fostering R&D expenditures towards sustainable mobility technologies, for example through the 'European green cars initiative' and through joint technology initiatives such as the 'Fuel cells and hydrogen joint technology initiative' or the 'Clean sky' initiative which bring together EU-funded projects and major industrial stakeholders.

2. When it comes to responsibility, what is the different role of individuals, industry, local government, state and international cooperation? How is the European Commission tackling the issue of coordinating different actors in this process?

The success of the European Transport Policy depends to a large extent on how it is implemented and complemented by measures decided at other levels of government. Therefore consultation with stakeholders and policy coordination between different bodies and at different levels are and will be essential elements of the policy-making process. In particular, I would like to point at two areas in which the benefits of effective coordinated action, beyond what is currently done at EU level, are worth emphasising. These are interoperability and urban transport.

Many new technologies and regulatory practices will develop in the coming years. Coordination will be needed to ensure equipments' interoperability and to avoid the proliferation of different systems at national level, for example rules and standards for tolling, or access to congested areas.

The EU role in regulating urban transport is limited for subsidiarity reasons. At the same time, most transport starts and ends in cities. Cooperation at EU level can help urban authorities in making their transport systems more sustainable. There are a range of activities and fields where the EU can continue to promote and support demonstration projects and the exchange of best practices, notably through the seventh framework programme and cohesion policy programmes.

For full interview please see CD at the back of the report.

Renewable Energy

The future share of renewable energy in total energy supply is not limited by resources or technology. Research and development, as well as learning investments in technology demonstration and deployment make renewable energy increasingly competitive.

In 2007 renewable energy accounted for 12 percent of world total primary energy supply. Biomass is by far the largest renewable energy source, representing 9.3 percent of world total primary energy supply, mainly due to the widespread non-commercial use of firewood for cooking and heating in developing countries. Investments and market growth, however, ascribe to new, more sophisticated technologies, including for example solar cells, concentrating solar power, wind power and liquid biofuel production. Between 2004 and 2008, the solar cell capacity increased sixfold and the installed wind power capacity grew by 250 percent. Continued double digit annual growth for these and other renewable energy technologies will be needed in the next 30-40 years as part of the transition. Expectations are particularly high on solar energy, which makes an important contribution in most long-term energy scenarios.

Contrary to popular myth that renewable energy sources can only make a marginal contribution to energy supply, the actual resource and technical potentials for renewable energy technologies by far exceed their current diffusion. Most renewable sources, notably wind, geothermal, solar, and ocean energy, show very large and untapped potentials. Biomass potentials are also large but debated due to competing land-uses. Unexploited hydro resources are several times bigger than the currently installed capacity.

There are no technical limits to the level of integration of renewable energy into future energy systems, including the feed-in of variable electricity production such as wind and solar into power systems. Balancing of different power sources and end-use demand in smart grids, integration with other parts of the energy system, as well as expansion of (inter-)continental super-grids and deployment of storage technologies means that limits to the share of wind and solar power in the longer run are not possible to define and become mainly an economic issue.

Some renewable energy technologies are already cost-competitive with fossil-fuels, for example, solar water heating, wind power and hydro power in many locations, and many biomass applications. Other technologies, such as solar cells and off-shore wind are projected to be competitive by about 2020. There are also advanced technologies, such as artificial photosynthesis and algae based biofuels, for which future performance and costs are still uncertain.

The barriers to renewable energy differ between the specific technologies and consist of economic as well as non-economic barriers. The removal of economic barriers involves reducing costs for renewable energy technologies as well as placing an appropriate price on carbon emissions and other externalities associated with conventional energy resources. Cost reductions can be achieved through efforts in research, development and demonstration (RD&D) and technology learning from marketplace deployment. Technologies such as solar cells still require efforts in RD&D in order to improve performance and reduce costs. For other technologies such as the production of second generation biofuels, focus should be on bridging the "valley of death," i.e. the gap between R&D on one side and market deployment on the other. At this stage of development, financing of demonstration plants should be a priority. For other technologies close to commercialisation it may be more appropriate to focus on nurturing niche markets and up-scaling, a development that may be promoted through different economic incentives.

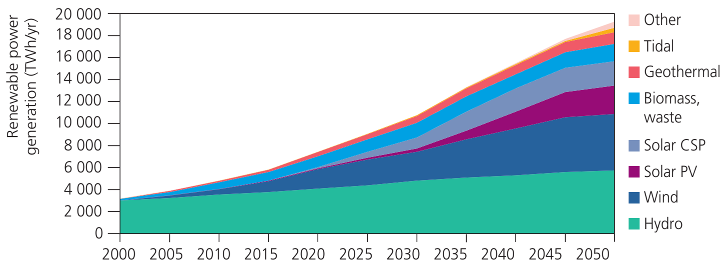
By 2009, at least 64 countries had some type of policy to promote renewable electricity production technologies. Experience shows that non-economic barriers can significantly hamper the effectiveness of economic support schemes. Removal of non-economic barriers, including for example administrative hurdles, obstacles to grid access, low social acceptance and lack of information and trained installers, is therefore essential for policy effectiveness and renewable energy market development. For example in the case of wind power, opposition from local stakeholders, and long permitting procedures have proved to be major hurdles to investments in many countries.

Land use is a particularly important issue in the case of biomass since dedicated biomass production requires productive land and thus competes with food and fibre production. The rapid expansion of maize, sugarcane and rape seed cultivation for production of liquid biofuels in recent years has, in this respect, raised concern about food prices and food security in low-income countries. However, there is also an untapped potential of agricultural and forestry residues, resources that do not compete for land. But when policies create a high willingness to pay for biomass this will affect the price of land, and thereby the price of food and fibre. The upside is that higher prices will stimulate investment and higher productivity in agriculture, and facilitate the phase-out of agricultural subsidies.

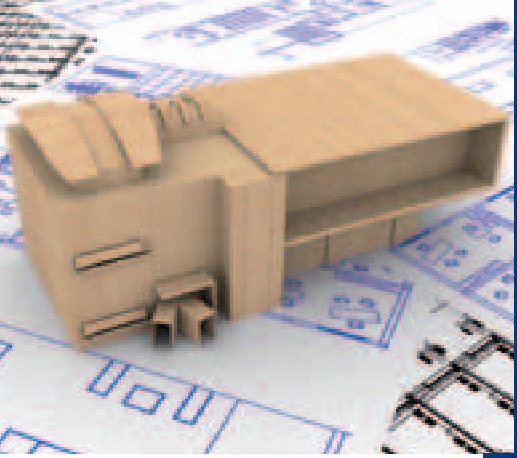
Investments in different infrastructures for carbon-free energy carriers such as electricity, hydrogen and district heating and cooling, will be essential for enabling the transition to a low-carbon society. For example, district heating facilitates the use of deep geothermal heat, as well as unrefined biomass and waste, which are economically unattractive or environmentally problematic to use in individual heating equipment (in this respect renewable energy is not different from other primary energy sources). Regardless of fuel, centralised conversion of the fuel to any of these energy carriers also enables the use of CCS technology. In the case of biomass conversion, the application of CCS offers negative carbon emissions.

In order to accommodate large amounts of intermittent sources such as wind and solar power, considerable power grid investments will be required to manage variations in production. Super grids that link geographically distant renewable resources with each other, and markets, is one approach. There is also a need for more intelligent power grids that can handle integration of electricity production from small-scale distributed generation such as solar cells and small wind turbines on rooftops. Super-grids and decentralised electricity production poses a challenge not only to power system operators, but it also challenges incumbent power producers and business models. ■

Growth of renewable power generation in the BLUE Map scenario, 2000-2050

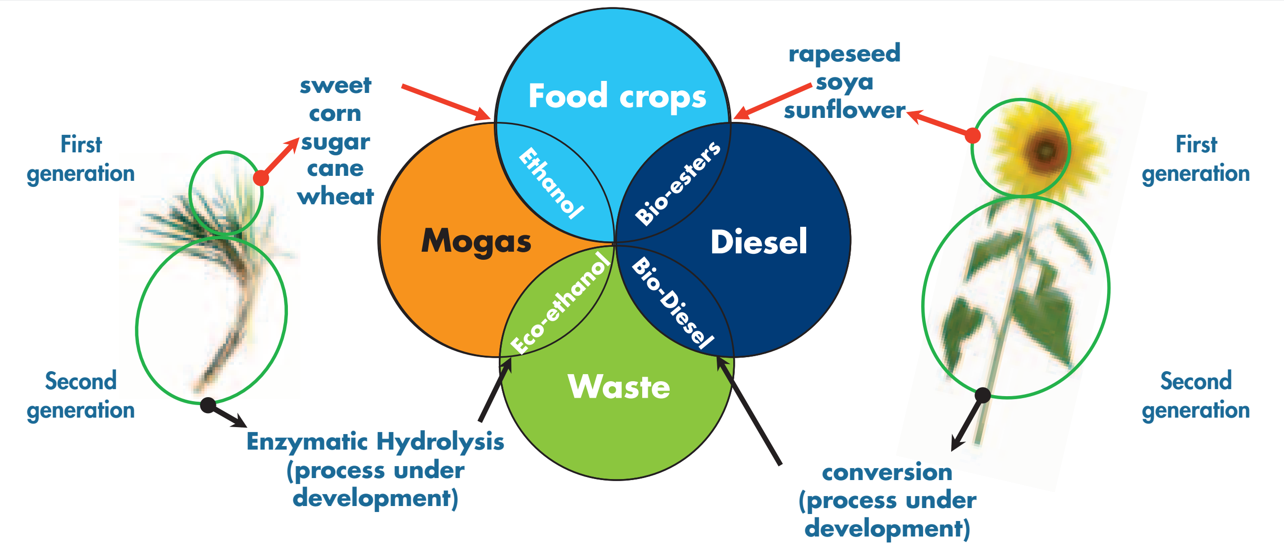


Source: IEA Blue Map Scenario



Biofuels

Biofuels have an advantage in being compatible with existing transport infrastructure. But they are also questioned with regard to their environmental and social sustainability. Indeed, the environmental performance of biofuels varies greatly depending on biomass feedstock, the type of land on which it is grown, agricultural practices, production process etc. This means that a specific biofuel such as ethanol can be either sustainable or unsustainable depending on how it is produced. Socio-economic aspects are manifold and include labour conditions, whether value adding conversion processes are retained locally, and effects of land-use competition including higher food prices. But rural development is also a key approach to poverty reduction. One possible means of preventing the production of unsustainable biofuels is to condition the support granted to these fuels based on their environmental performance. This strategy is now applied in the EU, which recently introduced a number of sustainability criteria for bio-liquids. Note, however, that such criteria are likely to have limited effect on relieving the pressure on food prices and natural ecosystems from a large-scale bioenergy expansion, as these negative effects are mainly dependent on the overall demand for agricultural land. Second generation biofuels based on non-food feedstock and by-products may reduce the pressure on food prices and enable "waste-to-value" innovation along the whole chain of products, e.g., chemicals, electric power, materials and carbon dioxide for storage. The graph illustrates these distinctions. However, the complexity of bioenergy systems and the close links to other policy domains present several governance challenges.



The governance challenges associated with renewable energy are relatively well known but they are likely to be accentuated under a transition to low carbon energy systems. Key governance challenges include:

- Substantially increased demand for biomass requires land-use management and other measures to address food security in low-income countries and ensure sustainable biomass production. What are the appropriate governance approaches to handle this?

- Considerable investments are needed in power grids but also other enabling energy infrastructures. It ranges from local heating systems to (inter-)continental super-grids. Who should plan and finance the development and expansion of these infrastructure investments?

- Removal of non-economic barriers such as long permitting procedures and limited grid access, trained installers and public awareness, is important and may be achieved through a broad portfolio of instruments.

- The removal of economic barriers to renewable energy technologies is essential. The key means to achieve this is to place an appropriate price on carbon emissions and other externalities. In addition, economic support policies promoting RD&D and increased market diffusion are required and need to be adjusted to the maturity of various technologies.

Geo-political implications of Energy Demand

Almost all activities in modern societies have a common element, the use of energy. Secure access to it is fundamental due to the way in which our communities are organized. Up to date, the use of energy is dominated by fossil fuels, i.e. oil, coal and gas. However the supplies of fossil fuels are limited and they generate CO_2 emissions and contribute to global warning. Despite investments in renewable energy and energy efficiency, consumption is on the rise.

Oil and gas trade are under a permanent risk of becoming politicized bringing negative effects for security of supply. This is not a theoretical probability. Supply disruptions characterized by political rationale have recently occurred in the relations between Russia and former-USSR states. This is not the only threat looming over these sources. The IEA has alerted about the probability of a gradually emerging oil supply gap as a consequence of lack of investments, growing energy consumption and insufficient production levels. At the same time, the international consensus on how to tackle environmental issues is limited and several states regard other national interests as a more important target than dealing with climate change. All in all, the structural components determining the rise of consumption of fossil fuels seem difficult to revert. A lack of perception of a common global interest, the prioritization of short term aspirations over the long run goals, neglect of good governance strategies and little room for multilateral solutions, are all factors determining the dynamics of the field.

In order to secure energy supply in the future, we need to decrease demand (energy efficiency), find alternative source (renewables) and anticipate the CO_2 emissions form fossil fuels -that will be used whether we like it or not- (CCS).

Contribution by Prof. Carmen Navarro, Universidad Autonoma de Madrid

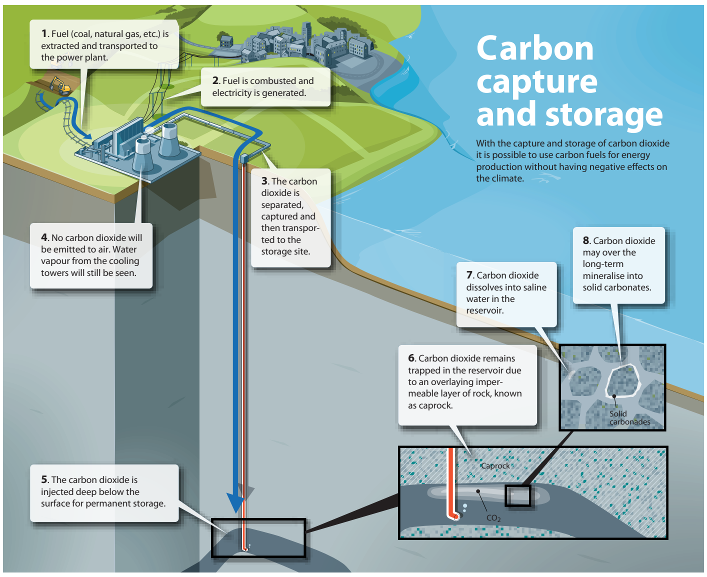
Carbon Capture and Storage

Carbon capture and storage technology has been used for more than 30 years. It offers a way of preventing CO_2 emissions from any large emission point, whether the CO_2 comes from fossil fuels, biomass or industrial process emissions.

Carbon capture and storage (CCS) has received increasing attention in the climate debate as a key element in attaining ambitious climate objectives. The potential for CCS is very large since the emissions from large stationary sources account for about half of the emissions from fossil fuel use. Its potential will increase if final energy use switches to electricity and, in the longer term, hydrogen.

The CCS technology system consists of the *capture* of CO_2 from the emission source, the *transport* of compressed CO_2 and eventually the *injection and storage* of CO_2 underground. Technologies for each of these three elements are already proven at large scale separately and in this sense the technology is already commercially available. For example, handling of CO_2 and transport in pipelines has existed for more than 30 years in the U.S. for enhanced oil recovery through injection into oil wells. However, no large scale fully integrated CCS system for power or industrial plants exists today. The storage capacity in geological formations (e.g., saline formations and depleted oil and gas fields) is at least 2000 Gton CO_2 and probably several times greater. Hence, storage capacity does not constitute a resource constraint at the current rate of fossil fuel use.

CCS has several key features that appear attractive in a climate restricted world. CCS can reduce the projected cost of attaining long term climate objectives - halving emissions in 2050 without CCS is likely to increase the mitigation costs significantly. CCS can allow for the continued use of strategic energy reserves, which is a crucial argument for several fossil fuel intensive countries. CCS can also



Source: A One Tonne Future © Vattenfall AB, 2009

"The equipment required for CO_2 injection has a relatively small footprint and is housed in the structure in the bottom right of the photo."

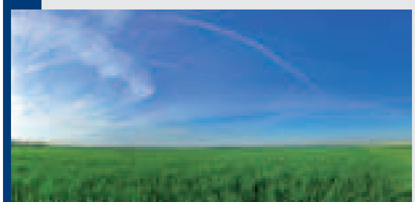
allow for negative emissions in the future with the use of biomass with CCS. This can lower mitigation cost further and provide an opportunity to correct earlier inaction by, in effect, scrubbing CO_2 from the atmosphere. CCS may also be the only viable solution for some major industrial applications such as process emission from cement and steel production.

Existing technologies can reduce CO_2 emissions by 70-80 percent compared to an equivalent power plant without CCS. Technologies being developed can reduce emissions by more than 95 percent. The production of a kWh of electricity with CCS requires about a quarter more primary energy input than the production of a kWh without CCS.

A challenge for CCS, as for many other mitigation options, has to do with the initial costs of the technology and making cost reductions through early deployment, demonstrations and learning. The EU and G8 have called for a large number of full-scale demonstration plants to prove feasibility and bringing down cost. The demonstration plants and the following first generation are needed not only for reducing costs and support capture technology development, but also for understanding and assessing future storage sites and for integrating complete systems. Niche markets for economically viable early deployment exist (notably enhanced oil recovery) but are limited.

A large-scale utilisation of CCS would make CO_2 one of the most transported goods in the world. The main mode of transport is via pipe-line. Transport and storage cost generally makes up a relatively modest part of the overall projected cost. Building a pipeline network at the scale needed may constitute a barrier for future development but using existing pipeline corridors is possible in many places. Planning and coordination is needed, often across national boundaries, in order to establish such networks. CO_2 pipelines exist today in the US and Canada where CO_2 is used for enhanced oil recovery.

The storage of CO_2 underground is one of the most contentious issues in public opinion concerning CCS. So far, CO_2 has been stored successfully in, for example, the Sleipner field outside Norway and in In Salah in Algeria. A better understanding of possible injections rates, permeability, and



Negative Emissions: the promise of CCS combined with biomass

The potential of CCS is not limited to cleaning fossil fuels. If sustainable biomass which does not compete with food production or nature conservation becomes available, biomass can be burnt using CCS. Trees and plants absorb CO_2 from the air during their growth, so this will extract CO_2 from the air and bury it underground where it came from.

Large-scale implementation of biomass with CCS is technically speaking a straight-forward concept. Replacing fossil fuels with biomass in large-scale plants, such as power plants or factories, is already happening on industrial scale.

For example, Nordjyllandsværket in Denmark is one of the candidates to be equipped with CCS in the next few years, within a program to co-fire biomass with coal in three power plants. It would remove 0.5 million tons of CO_2 from the atmosphere per year.

Contribution by Eivind Hoff, Director of Bellona Europa

CO2SINK

"Given the EU's ambition to reduce greenhouse gas emissions by up to 30% by 2020, the European power sector will need to drastically reduce the amounts of CO_2 resulting from the use of fossil fuels. The possibility of capture and geological storage of CO_2 (CCS) represents one of the options, with the potential to achieve substantial carbon dioxide reductions at acceptable cost levels in the coming decades."

European Commission press statement of 13 June 2007 on the launch by Commissioner Piebalgs of the Pilot CO2SINK Project.

The CO2SINK project, started in April 2004, aimed to be the first European project to inject CO_2 into an onshore saline aquifer. The primary objective was to advance understanding of the science and practice of storing CO_2 underground at an onshore location. It also aimed to build confidence towards future European CO_2 geological storage and provide experience to help develop the future regulatory regime.

The site is near the small town of Ketzin in Brandenburg Germany about 25 km west of Berlin. This is close to the GFZ German Research Centre for Geosciences the coordinator of the project and a world renowned centre of geological expertise.

CO_2 injection started in July 2008 and to date over 24,000 tons of CO_2 have been stored. An extensive array of site characterisation and monitoring techniques are deployed at the site which now offers a place where new methods can be tested by the scientific community.

Advanced techniques deployed at the site include down hole cross well electric resistance tomography, permanent passive seismic monitoring arrays and continuous fibre optic down-hole temperature measurements. Further experiments are expected to be added to the programme including the safe and permanent abandonment of the wells. Long term monitoring of the underground plume and measurements of well integrity are planned.

Plans are being developed to demonstrate the complete CCS chain by injecting some CO_2 from the new capture plant at Schwarze Pumpe.

leakage concerns in geological formations is needed for confidently scaling up storage. The world has enough readily available storage capacity for covering all major emitters but regional differences in knowledge and coverage exist.

A key challenge for CCS is to get the necessary public support and acceptance for developing this new infrastructure. The current debate stems from communities in the vicinity of planned transport pipelines or storage sites because of general questioning of the long term legitimacy and sustainability of CCS.

There is furthermore a strong fear that vague promises of CCS in the future will provide an alibi for "business as usual" building of new conventional coal-fired power plants. Public funding for CCS creates a risk that it diverts resources away from urgently needed renewable energy and energy efficiency mitigation options.

The introduction of CCS raises several and yet unanswered legal issues that need to be addressed as well. Eventually, government needs to take liability for storage sites as private project developers cannot and will not take liability indefinitely. Ownership of storage sites will have to be sorted out as several potential storage sites may not limit themselves geographically to one country. Pre-injection requirements for assessing and approving storage sites and the responsibility for monitoring need also to be solved. Third party access to both storage sites and transport infrastructure must be regulated if available and tested storage sites and pipe-lines are to be used effectively. Access to and right of way for building CO_2 pipe-lines can also delay or become a major barrier that needs to be addressed. ■

Swift policy efforts are necessary in order for CCS to make a significant contribution to emission reductions in the next 20 to 40 years. There are three evident governance challenges for CCS:

- Lack of public and political support may be the single most serious barrier to CCS and engaging in public deliberations about the pros and cons of CCS is a pressing need. What is the role of government and other actors in informing the public and creating legitimacy for CCS? Can independent knowledge brokers and institutions contribute to facilitate deliberation?

- Technology development and cost buy-down through commercial scale demonstrations, e.g., tens of plants worldwide by 2020, seem important for CCS to make a significant contribution to mitigation thereafter. Will available financing arrangements and public-private partnerships suffice, or will CCS development require other sets of sticks and carrots to incentivise investment?

- What type of legal and administrative frameworks are needed to govern CCS in order to handle risks, liabilities, permits, etc. at national as well as international levels since transport and storage may cross national boundaries?

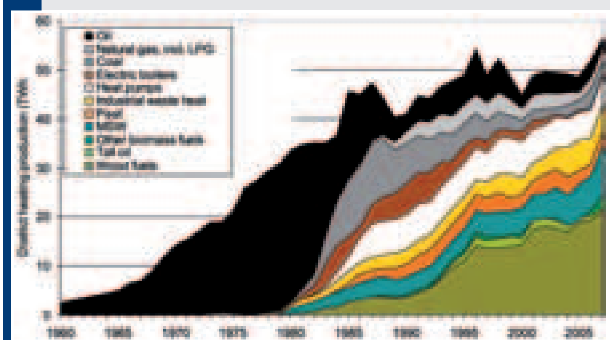
Transition Governance

Transitions happen all the time. They may be spontaneous, technology driven and to various extent governed by state actors. Anticipating and examining the governance challenges ahead can facilitate the low-carbon transition.

The mindset until recently has mainly been on how to reach Kyoto targets of a few percent reductions. Those targets can be reached through relatively marginal changes to current energy systems. The policy debate has been dominated by concerns for how such targets can be reached at lowest economic cost through, for example, international emissions trading. However, getting to near zero emissions by 2050 is a completely different task that implies a different mindset. Interestingly, there is a kind of liberation to think in terms of larger transitions. Eventually, fierce political debates and intellectual deadlocks that have characterised climate politics so far might give way in a different context and mindset.

On a positive note, history tells us that substantial socio-technical system and political change can be relatively quick. The transition towards a low carbon society requires fundamental changes in both our energy systems and in the ways we organize our societies to adapt to such large transformations. But, as shown in the previous sections these changes will not happen by themselves but require purposeful steering by states and other key actors in society. To be sure, there will be a range of goal conflicts, conflicting interests, distributional effects and unintended consequences that must be handled along the way.

The concept of governance is used throughout the social sciences to describe how societies, organizations and networks are collectively steered and governed. Governance is often used in opposition to government, which refers more narrowly to predominant steering by state institutions. In the context of this report, transition governance for a low-carbon society includes all purposeful mechanisms and measures aimed at steering social systems towards making the transition to low-carbon futures. While governance comprises everything from strict state regulation to voluntary



The role of policy:

Fuel shifts in Swedish district heating production

Swedish district heating illustrates the time scale involved and the role of policy in making transitions. The 1960-1985 expansion was driven in part by the need to improve urban air-quality. The second transformation from 1985 to the present was driven mainly by a carbon tax first introduced in 1991 and which is now equivalent to 100 €/ton CO_2,. Waste policy and various support schemes also provided incentives for the transition. Today, biomass and waste account for in total 61% of the production. About 51% of the district heat is produced in combined heat and power plants. The district heating systems also contribute to primary energy savings by accommodating industrial waste heat from a number of process industries. Swedish district heating production in 1960-2007, broken down into fuels and energy sources. The curves have not been corrected for outdoor temperature variations.

Transition Management

The Netherlands has been pioneering in developing and adopting a 'transition management' model to promote sustainable and low carbon futures. As a response to prior technology-push policy, this model was introduced to emphasize the dynamic interrelation between technological innovation and society. Long-term visions and pathways to system innovation are translated to practice by concentrating on consultation and exploration processes in which firms, research institutes, universities and governmental bodies are navigating and negotiating their way forward, gaining knowledge and experience along the way. Recognising that existing markets are often absent for emergent technologies, transition experiments have been set up to probe and experiment in niche markets along suggested transition paths for e.g., mobility, supply chains, and energy supply.

Despite considerable achievements, the transition management model has also been criticized for running the risk of neglecting the political difficulties and inertia in steering societal change. For instance, incumbents in fossil-fuel based systems are active stakeholders in the governance model for the Energy Transition program possibly watering out the potential contribution for radical disruptive innovation (and creative destruction) needed to achieve the original goal of system innovation. However, since the transition management approach is still rather new it is too early to make any conclusive statements.

measures by private and civil actors, the state remains the most important actor, especially when it comes to governing large-scale societal transformations.

Transition governance differs from 'day-to-day' governance since it implies the collective steering of fundamental and long-term transformations, cutting through numerous spheres of society. It involves embedded infrastructure and systems, and a variety of stakeholders, including future generations. It goes deep into all parts of the value chain and requires change at a massive scale. Transition governance differs from the related concept - transition management - that has developed primarily in the Netherlands. Transition governance is a broader concept that encompasses transition management, environmental policy integration, mechanisms for dynamic consistency (e.g., secure investment frameworks) and general approaches to steering. It focuses more on the existence of multiple interests and goals among a variety of actors, and highlights that processes of change are highly complex to steer, not the least due to institutional inertia. Still, transitions have to be governed somehow.

Two questions emerge as crucial in transition governance. The first one regards the nature of the problem at hand and how it is perceived by key stakeholders. The second question asks, how can change be achieved?

Turning to the first question, an important prerequisite for effective transition governance is that there is an acknowledgement of the nature and gravity of the problem among key stakeholders. In recent years we have witnessed a pronounced change in this regard, both in the international political community and international business. The leaders of the G8 countries in July 2009 announced the long-term target of 80 percent emissions reduction in rich countries by 2050 (50 percent reductions at the global level). In the business community there has been a gradual but steady shift in positions. Energy utilities and large industries that used to drag their feet now embrace ambitious goals, mirrored in corporate visions and roadmaps for decarbonisation. Among the general public there is an increased awareness of climate change. This may also lead to a greater willingness among the public to accept changes and stringent policies.

The second question concerns *how* change might be achieved and involves the *rationalities* of governance as it relates to the thinking behind steering. *Administrative rationality* adheres to rulemaking and regulation as the optimal form for governing. Indeed, regulation like performance standards or even bans (e.g. the EU ban on incadescent light bulbs), can be highly effective, but can in other cases be problematic. *Economic rationality* works on the premise of the price mechanism as the optimal way to steer behaviour in desired direction. *Deliberative rationality* emphasizes the need for inclusive policy processes, broad participation, communication and deliberation as ways establish new norms and make actors change their attitudes and behaviour. The question is if the best way to achieve change is through *orders, money* or *talk* and to what extent these different rationalities supplement each other in various situations.

State institutions will have a crucial role to play in transition governance since the large-scale societal transformations implied are hard to imagine without the active endorsement of governments around the world. State action is important on its own but more effectively in concert through global and regional agreements and institutions. However, one

should not be naïve about what governments can and are prepared to do. They are bound by internal and external structural factors that make it difficult for them to be the key change agents that they need to be. In addition, politics and governance decisions are not necessarily rational or always motivated by what is most effective or appropriate. Economic rationality can be preferred because it is consistent with market-liberal values and be used as a way to favour strong market actors. Deliberative rationality can be a way to create legitimacy, or used as a smokescreen, while leaving power in the hands of a few strong stakeholders.

Beyond the general problems of governance it is crucial to understand the challenges associated with specific technologies and systems. The previous sections described such challenges and indicated the importance of different rationalities. In addition, a multi-level perspective is crucial for technology innovation and diffusion. Technologies, markets, institutions and governance forms co-evolve and change when put into different contexts. Successful constellations are often based on a strategic fit with the context in which they are embedded. This means that certain technologies are more likely to develop in certain geographical and socio-technical contexts (e.g. biomass in Sweden and wind power in Denmark). It also implies that a successful strategy in one country or region cannot be directly translated into another context.

An important lesson from the study of large socio-technical systems is the role of path-dependency and lock-in effects. For example, natural gas based space heating systems in some countries and district heating systems in other countries each have their own transition history, or path, and now constitute the starting points for the future transition. The long term character of the transition means that attention must be paid to such path-dependencies as well as related capital asset cycles (Box 8.4 from Bellona). This can make the transition smoother, less expensive, and more legitimate.

It should also be recognised that what seems unsatisfactory in the short term might turn out promising in the long term and vice versa. A switch to natural gas will deliver short-term emission reductions but does not necessarily prepare the ground for deeper cuts in the future. The marginal near-term effect of electric vehicles may be increased carbon emissions but they harbour the promise of zero emissions in a future decarbonised electricity supply system. Hybrid electric vehicles improve fuel efficiency today but are also a stepping stone towards plug-in and battery electric vehicles through the development of electric power-trains (including FCEV with hydrogen) that create opportunities rather than lock-in situations.

A particular problem in climate governance is the dilemma between the need for long-term change and the political realities that favour short-term concerns. In this way decision makers can ascribe to ambitious long-term visions for tomorrow without committing to stringent, costly or unpopular measures today. One option for dealing with this problem is to create institutions that are at arms-length from day-to-day politics and that ensure some level of adherence to long-term goals. This might ensure dynamic consistency much in the same way as monetary policy and independent central banks to combat inflation and promote stable economic development. Could something similar be created for climate politics? Is it possible to create path-dependency towards an institutional carbon lock-out and a low-carbon society? ■

The UK Climate Change Act

The UK Climate Change Act - adopted in 2008 - includes a number of significant advances in climate policy. It changed the institutional architecture and it created legally binding mechanisms that should lock the country into a long-term transition towards a low carbon economy and society. This goal orientation has in turn started to trigger some very significant policy changes.

Institutionally, the Climate Change Act created an independent Committee on Climate Change to advise the government on the targets to be set and to monitor progress towards these. In its first review, this Committee advised that the UK should commit itself to a target of an 80% reduction in 1990 levels of greenhouse gas emissions by 2050. This advice was accepted and the UK became the first country to adopt such ambitious targets and to write them into law.

As well as setting long-term targets, the Climate Change Act also established a programme of legally binding 5 yearly carbon budgets. The first three of these have set targets for 2012, 2017 and 2022. The 2022 target is 34% reduction in 1990 levels of greenhouse gas emissions, but this could rise to 42% with significant international agreement in Copenhagen. Through such budgets, current and successive governments are obliged to show that they are making progress towards the longer-term target, and so they create a significant degree of goal orientation, transparency and accountability.

These factors have in turn unlocked a range of other changes. There have been hugely significant revisions in UK planning law and in energy policy to accelerate the deployment of low carbon technologies. And the Act has also created a trading scheme for energy efficiency that combines binding targets and economic incentives with league tables of performance for all large energy users in both the public and the private sectors. The early signs are that this 'complementary mix 'of policy signals is triggering rapid advances in the capacity of organisations to manage energy use, and the signs are that the reputational risks associated with the league tables will be a particularly significant driver of change. If successful, the scope of this scheme could easily be extended.

By Prof. Andrew Gouldson, Director - ESRC Centre for Climate Change Economics & Policy, Director of the Sustainability Research Institute at the University of Leeds

To conclude, transition governance towards a low-carbon future raises the following key issues:

- What portfolios of policies and measures need to be adopted and enacted in order to support and stimulate technological transformations towards a low-carbon society? What are appropriate rationalities of governance in various situations? To what extent could they benefit from each other and be combined?
- What institutional reforms are necessary to enable transitions, to create a carbon lock-out, and to make societies capable of handling and coping with associated governance challenges of conflicting goals and interests?
- How can effective transition governance be enacted while being inclusive of various views and perspectives? How can transition governance attract acceptance among affected actors and stakeholders?
- Who should have the power to make authoritative decisions and how should decision-making power be delegated in the context of multilevel governance: upwards (e.g., international), downwards (e.g., local), or sidewards (e.g., private)?
- How is it possible to ensure dynamic consistency with the long-term climate policy objectives? Can it be done through enabling stable frameworks? If so, how can such frameworks adapt to changing conditions and contexts?
- What is the role of government and other actors in information and education to increase knowledge and gain public acceptance for the variety of measures and policy instruments implied by a transition to a low carbon society?

Private-Public Partnerships: Megacities Challenges

Tomorrow's world will be shaped by megatrends such as urbanization and demographic change: they pose specific challenges to the way we use energy in cities, and to the level of greenhouse gases they emit.

By the year 2025, there will be some eight billion people living on our planet, or almost 20% more than today. Most of these people live in cities today already. Cities such as Paris, Bangkok, Mexico City, Buenos Aires, Seoul and Tokyo will be generating up to 50% of the gross domestic product of their respective nations. People in industrialized countries spend 95% of their lives inside buildings.

The governance challenges for the transition to a low-carbon society are enormous. The need to think in different ways and increase intersectorial collaborations is an important step. Public-private partnerships are necessary in order to transform our cities into "green-cities". Initiatives such as Megacities Challenges, where cities such as London, Munich and Vienna are becoming "green" with little additional cost to the city (the whole studies conducted for those three cities can be found on the conference CD), are a good example of public-private collaborations. Many technologies needed in cities in order to decrease energy consumption are available today, and have an significant role in decreasing not only the carbon foot-print of the city, but also in decreasing consumption and thus spending on energy.

Leveraging Education and Talent as strategic enabler for a low carbon society

Any effective pathway to a low carbon society needs a 'push' towards sound science based policy as well as a 'pull' of climate change aware citizens. In light of today's challenge we need both eco-innovations as well as more rapid implementation of new technologies in society. Behavioural change can be achieved through improved citizens' understanding of the reality we are in.

To succeed, society must pay more attention to communication and education and ensure that its most precious resource - Talent - is directed towards finding solutions for society's most pressing problems., such as climate change.

Encouraging students' interest in the development of eco-efficient and innovative technologies is one reason why the Shell-Eco-marathon is a good example. Started 25 years ago the Eco-Marathon is an energy efficiency competition bringing together each year some 2000 students from every corner of Europe, who challenge themselves and each other to run the longest on the minimum amount of energy possible. The prototypes run on gasoline and diesel, solar, fuel cells, and electric and hybrid motors. Awards are also given for innovation and this year a team from Stockholm University won special recognition for their creative parallel hybrid design.

The current European Eco-marathon record for a combustion engine entry was set in 2004 by the team from Lycée La Joliverie (France) at 3,410 km on the equivalent of a single litre of fuel. For prototype vehicles using fuel cells, the record is even more impressive. In 2005, the hydrogen-powered vehicle built by Swiss team ETH Zurich achieved a projected 3,836 km on the equivalent of a single litre of fuel. This is the equivalent of driving from Paris to Moscow!

This initiative won the Petroleum Economist Award for Best Youth Education project in September 2006 "for their innovative challenge geared towards encouraging youngsters to learn more about the energy industry through practical and fun projects. The Eco-marathon is aimed at promoting sustainable development and environmental protection alongside increasing awareness of cultural and individual diversity".

Engaged Citizens for a Sustainable Response

The availability of accurate information is central to democratic and effective governance. All too often, however, this process is seen as a one-way flow: from experts to the public. This is an enormous missed opportunity. Local people and organisations represent a huge potential source of information. Just as important, giving people the chance to contribute and comment confers ownership of the issues, empowerment and greater faith in 'official' data.

At the European Environment Agency (EEA) we recognise that our ultimate goal - protecting the environment that sustains us - is best served not by providing data to passive citizens but engaging them in two-way communication. We rely on dialogue with indigenous peoples, industry and local organisations to complement scientific monitoring and modelling. […]

Prof. Jacqueline McGlade, Executive Director, European Environment Agency

Key Issues for Making the Transition

This report has shown that there are numerous questions, issues and challenges associated with making the transition to a low-carbon society. Some of these are specific to certain technologies and some are more general in their nature. Some of them appear to represent particularly important challenges, sticky problems or contentious issues. This has lead us, based on the preceding sections, to formulate and select nine specific issues for further discussion and debate in the High Level Workshop. There are no conclusive answers to any of these questions but they need to be explicitly unpacked and addressed as part of the process of making the transition.

- *How can long-term goals be reconciled with short term priorities?* Whereas a long term goal is zero emissions there are also short term priorities related to economic efficiency and energy security. The transition will generate goal conflicts and conflicts of interest that constitute barriers to the implementation of policies commensurate with the long term goal. What are the institutional and policy mechanisms that can enhance dynamic consistency and create a "carbon lock-out"?

- *How can the transition to super-smart-grids be governed and what barriers will be encountered?* How can smart grids with distributed generation and intelligent load management be combined with intercontinental super grids in organisational and institutional terms?

- *What is the trade-off between efficiency and democracy, or between control and stakeholder engagement?* What is the nature of the trade-off, real or perceived, between taking effective, efficient and technically correct actions (based on evidence) versus the need to engage and include a range of stakeholders? What are the functions of stakeholder involvement and what are risks of limiting this?

- *What can be the role of the state in the transition?* It is clear that the state has an important role to play in the transition to a low-carbon society but the nature of that role is less clear. What are appropriate forms and rationalities of governance in various situations? How far can we go with voluntary and market based solutions? When is regulation necessary?

- *How can the rate of energy efficiency improvement be accelerated?* Energy efficiency policy has delivered important energy savings in the past 30 years but the results are far from the doubling of improvement rates that are implied by low-carbon scenarios. What institutional, organisational and policy changes are needed to make a step change in improvement rates?

- *What is the role of information, education and R&D in making the transition?* What are the implications for different levels in the educational system? What are the implications for R&D and innovation policy?

- *How can land-use in a low-carbon society be governed?* A low-carbon society implies high direct or indirect carbon prices which put pressure on land for bioenergy production. What institutions and policies are needed to ensure that the growth in bioenergy delivers very low net greenhouse gas emissions and is consistent with broader sustainable development goal?

- *By what mechanisms can public support for CCS be enhanced?* CCS is surrounded by important technical, economic and legal issues but lack of public support might become the biggest barrier to large scale deployment. How can decision processes be designed that allow for an open debate and exchange of information between different societal stakeholders? How can the public be informed about, and engaged in, the development of CCS and what is the role of different actors, including intermediary organisations and knowledge brokers?

- *What will be the role of leadership and pioneers in making the transition?* What are the pros (e.g., first mover advantage) and cons (e.g., lower competitiveness or growth) of being a pioneer and a leader? What are the tradeoffs?

High-Level Workshop outcomes

The High-Level Workshop delivered a set of significant observations and ideas focused on nine governance issues. The fruitful debates between representatives from university, industry, media and policy makers, inspired cross-cutting discussions. Below you will find the recommendations and thoughts agreed by the participants as key in the transition to a low-carbon society. These thoughts are exploratory and cover many issues, but there are five main overarching themes that are recurring.

· The first regards the importance of information, education and communication and the need for an appealing vision or narrative of a better and low carbon life and future.

· The second revolves around the topic of equity and rights within and between current and future generations; this debate also raises important questions concerning responsibility of all actors at all levels of society.

· The third issue regards the development of carbon pricing in a global market and the need to reinforce the underlying structure with mechanisms that create stability and dynamic consistency in prices and policy in the long term (for example, through a "central carbon bank").

· Fourth, there is also a need for new and appropriate policies and institutions related to the specific mitigation options (energy efficiency, renewable energy, and carbon capture and storage) in order to maintain momentum in the transition but also to handle conflicts and unintended side-effects.

- Lastly, integration across different policy domains is important to ensure that a multitude of large and small barriers are addressed and a multitude of large and small enabling conditions are created. ■

Key messages

In addition to the five recurring themes, the HLW delivered nine key messages related to the nine governance issues, as well as a more extended response on each issue.

- We need an appealing narrative with essential features of a low carbon future. This can then serve as a framework for all societal actors. For policy-makers and regulators the narrative can guide the development of instruments that enable short-term decision-making by society to be aligned with the long-term goals. For citizens the narrative can make the efforts that are required worthwhile.

- Super Smart Grids are necessary to facilitate large-scale integration of variable power sources, distributed generation and demand response options. For this purpose, transmission and distribution systems need major investments and institutional reforms.

- Governments should set up long term visions, provide directions, set targets and create opportunities and framework conditions for change. The state must also provide regulations and incentives for superior environmental performance. The efforts should aim to price CO_2, correct other market failures, stimulate innovative experiments and management, and promote green procurement and sustainable consumption.

- Knowledge as a key resource and learning as a strategic process to facilitate system change for an energy transition requires a multi-level, multi-actor, system-oriented policy mix, with transparency and accountability as attributes of both public and private activities. Permanent exchange of information among all the actors will provide opportunities for broad participation and partnership fostering policies will ensure greater stakeholder engagement in the transition to a low-carbon society.

- Realizing the full potential and multiple benefits of energy efficiency along the entire energy value chain requires new appropriate institutional and organizational arrangements for coordinating efforts by public and private stakeholders. Governments need to create enabling conditions through promoting information dissemination, awareness, strong legal frameworks and other incentive structures for removing risk aversion of common investors and fostering energy efficiency.

- Innovation and learning are central in achieving forms of transitions towards a low carbon society that have combined environmental, economic and social benefits. Successful co-evolution of technologies, markets and institutions poses new challenges to the way innovation policy is organised and implemented.

- Governing a large-scale expansion of bioenergy will require both demand side policies (e.g., certification) and supply side policies (e.g., comprehensive pricing of all greenhouse gases, biodiversity and water conservation measures, and increased land tenure security in developing countries) to assure that it occurs in a environmentally and socially acceptable way.

- Elected governments need to show leadership in establishing long term legally binding ambitious reduction targets. In order to make such politically difficult decisions stick they may be isolated from electoral politics e.g. by giving specialized and democratically appointed agencies the authority to enforce the targets.

- The advantages to have more leadership in low carbon business activities are tremendous for society but risky for the individual market actors. Leaders need to be supported by encouraging companies and citizens out of their comfort zone and creating an entrepreneurial spirit.

Issue 1

• *How can long-term goals be reconciled with short term priorities? Whereas a long term goal is zero emissions there are also short term priorities related to economic efficiency and energy security. The transition will generate goal conflicts and conflicts of interest that constitute barriers to the implementation of policies commensurate with the long term goal. What are the institutional and policy mechanisms that can enhance dynamic consistency and create a "carbon lock-out"?*

We need an appealing narrative with essential features of a low carbon future. This can then serve as a framework for all societal actors. For policy-makers and regulators the narrative can guide the development of instruments that enable short-term decision-making by society to be aligned with the long-term goals. For citizens the narrative can make the efforts that are required legitimate and worthwhile. Broad social support for present day efforts can be achieved only if the long-term future is sufficiently attractive and realistic. It is important to create a reliable and open dialogue on these issues.

Key themes for the narrative include: futurism, opportunity, personal responsibility and the chance to make a difference, and openness. An overall positivism is frequently associated with renewables but not with the challenge as a whole, and in particular not with energy efficiency and CCS. These should be woven into the political communication of all important policies.

Where possible the most legitimate actors should take the lead role in shaping the narrative, ideally in coalition, and on communication. Providing a broad socio-political context for change can allow businesses to take action under less suspicion of self-interest. Examples discussed included the UK government approach to new coal (setting a date for CCS) that helps avoid cynicism that CCS is a tool for preserving the status quo

In some cases there is no conflict between short-term costs and long-term benefits. In these cases we often still need education and information to make informed choices. In cases of conflict, we need policy instruments that reward choices and behaviours that are aligned with the long-term goals.

Since the Stern-report, we know that a positive narrative is possible, and reaching it can be achieved at acceptable costs to society as a whole. The details of the narrative should still emerge from engaging multiple stakeholders. It should be appealing to all, but often for different reasons. Only the combination of awareness, education, information, policies and regulation will deliver the consensus and the willingness of all stakeholders to move towards a low carbon future.

Issue 2

• *How can the transition to super-smart-grids be governed and what barriers will be encountered? How can smart grids with distributed generation and intelligent load management be combined with intercontinental super grids in organisational and institutional terms?*

Both long-distance and local smart grid solutions will require major investment schemes, raising the question of who will pay. There is a strong hesitance in investments even in existing grids, which currently are run down and lack capacity to ensure free cross-border trade.

To make progress in work on the standardization of codes and guidelines for grid operation and to agree on grid investment projects to be given priority, we can only endorse the development of independent bodies, such as ENTSO-E (European Network of Transmission System Operators - Electricity) and ACER (Agency for the Co-operation of Energy Regulators). National regulators, transmission system operators (TSOs) and EU institutions should raise long-distance transmission and smart grid solutions to the very top of their agenda in order to create a modern infrastructure for the future. Likewise, we recommend the set-up of a funding mechanism ensuring proper allocation of costs among those benefiting from the investment.

We recommend continued high focus on the separation of grid operations from competitive market operations in order to create true independent planners of energy infrastructure dedicated to finding solutions that would stimulate power production in locations rich in renewable resources and benefit transition to CO_2-free consumption.

We recognize that a step-wise introduction of smart-grid solutions should be carried out to create local control centres functioning as laboratories for further testing and learning about load management and distributed generation opportunities. Here, we urge innovative response from across Europe to take inspiration from frontrunner examples and countries.

We also note the widespread local opposition to new production facilities and overhead transmission lines and recommend investigation of new institutional solutions giving local communities not only a say in development but a stake in the new facilities, in the form of various compensation schemes or ownership shares.

Issue 3

- *What is the trade-off between efficiency and democracy, or between control and stakeholder engagement? What is the nature of the trade-off, real or perceived, between taking effective, efficient and technically correct actions (based on evidence) versus the need to engage and include a range of stakeholders? What are the functions of stakeholder involvement and what are risks of limiting this?*

The successful transition to a low carbon future requires a new notion of governance, not just government, as it involves the wider sense of steering and governing society, using markets, networks and state imperatives in new combinations. Governments maintain indispensible roles as regulators at global, national and local levels., but must also assume new, more proactive functions.

A safe and healthy Environment is a common good that must be defined as a basic human right, and connected to the preservation of the needs of future generations. A core imperative of the state should be to guarantee such extended rights and needs. We consider democracy as a superior value in itself; efficiency is an important operational concern; democracy and efficiency have to go together.

Governance also involves and actively engaging actors in society at global, national and local levels. Everyone is or should be made stakeholders in transition towards low carbon society.

Experiments and demonstrations are crucial to allow new ideas, technologies and social innovations to emerge. This will enable society to gain experience and build acceptance, as citizens become part of the new solutions; a positive learning process can develop. However, the governance approach must be contextualized, since the degree and effectiveness of bottom-up implementation strategies vary, reflecting local circumstances and stakeholder concerns.

Issue 4

- *What can be the role of the state in the transition? It is clear that the state has an important role to play in the transition to a low-carbon society but the nature of that role is less clear. What are appropriate forms and rationalities of governance in various situations? How far can we go with voluntary and market based solutions? When is regulation necessary?*

Many parallel and complementary efforts have to be made in order to allow such a transition, acknowledging that transitions and their governance is multi-level, multi-venue, and multi-timed.

States should set up long term visions, provide directions, set targets and create opportunities and framework conditions for change. The state must also provide regulations and incentives for superior environmental performance. The efforts should aim to price CO_2, correct other market failures and barriers, stimulate innovative experiments and management, and promote green procurement and sustainable consumption.

However, the state governments as we know them also shows inadequacies and may have to be redefined in some respects; it must assume a role as provider of governance infrastructure; a role of innovation facilitator, and a role of representing future generations in short term policies. Additionally the state has to overcome governance failures, such as a lacking coordination and integration between various government bodies. Here the press clearly has a role to play, engaging in the correction of failures while maintaining its crucial integrity.

A major governance failure is that Nation states seem to lack sufficient capacity or legitimacy to implement major transitions that are global in scale. There is a need for stronger international governance structures, in order to substantially limit global carbon emissions as soon as possible.

Transition to low carbon society provides opportunities for the European Union to gain political influence and enhance economic competitiveness. Governments should engage industries to seize the opportunities to become frontrunners in low carbon technologies, products and services, and thereby gain competitive advantages.

Issue 5

- *How can the rate of energy efficiency improvement be accelerated? Energy efficiency policy has delivered important energy savings in the past 30 years but the results are far from the doubling of improvement rates that are implied by low-carbon scenarios. What institutional, organisational and policy changes are needed to make a step change in improvement rates?*

Our energy needs are projected to double over the next two decades. Energy efficiency, across all sectors, is an instrument that delivers energy security, economic development and climate change goals. Only by continuously improving energy efficiency along the entire energy value chain will we be able to meet these goals.

There is a plethora of knowledge on market barriers, instruments to circumvent barriers and evaluation methods. This knowledge should be used systematically and integrate energy efficiency action plans. Policy mixes are essential as there is always the need for a set of measures to address barriers related to technology, behaviour, split incentives and other issues.

However, accumulated knowledge and assessments also demonstrate that the kind of instruments used so far will not lead to the level of transformation required for a low-carbon economy. Integrated approaches are needed in order to remove the risk aversion of the common investor and to leverage public and private investment. The 20-20-20 target set by the EC, consistent with the Lisbon agenda, needs to be binding.

Institutional structures can be reformed to better balance and coordinate public and private energy efficiency efforts. These institutions should consider short-term policies to capture immediate energy efficiency savings and also create strategies for long-term transitions.

Issue 6

- *What is the role of information, education and R&D in making the transition? What are the implications for different levels in the educational system? What are the implications for R&D and innovation policy?*

Market transformation to meet the targets for a low carbon society relies on creating, sharing and assimilating knowledge. There is a market failure for the generation and communication of new knowledge. Therefore the government could play a key enabling role in promoting a knowledge society in coordination with other stakeholders.

In the context of a knowledge society concerned with a carbon-free future, the importance of education, science & technology and innovation policy is highlighted. Transparency and accountability in public and private activities are crucial when driving change and facilitating learning. Information must permanently be exchanged with the public at large and also be available to public, private and civic actors. There should be opportunities for open participation throughout.

Investment in knowledge and learning for a carbon-free society requires public-private partnerships and broader stakeholder engagement. Government could thus induce increased investment, risk-taking and innovation by leveraging private funds and mobilizing civic action. This stresses the need for a systemic, joined-up approach where knowledge and learning are key parts of a broader mix of instruments and approaches.

Innovation and learning are central in achieving forms of transition towards a low-carbon society that have combined environmental, economic and social benefits. To create such outcomes, innovation policy needs to place greater emphasis on multi-level, multi-actor, system-oriented policy mix for social learning. A better coordination across instruments such as education, R&D, learning investments, public procurement, and institutions in the area of Intellectual Property Rights, is needed. This poses new challenges to the way that innovation policy is organized and implemented. Capacities to recognise, communicate and assimilate cases of good-practice need to be improved, and solutions need to be tailored to fit with the contexts in which they are applied.

Issue 7

- *How can land-use in a low-carbon society be governed? A low-carbon society implies high direct or indirect carbon prices which put pressure on land for bioenergy production. What institutions and policies are needed to ensure that the growth in bioenergy delivers very low net greenhouse gas emissions and is consistent with broader sustainable development goals?*

Effective land use management will need to employ policies both on the bioenergy demand and supply side.
Demand side measures like certification schemes have the potential to reduce land demand by assuring that the bioenergy options deployed are land and climate efficient, but this will not be enough to quench the enormous demand for land that will result from stringent climate policies, growing populations and increasing living standards.
On the supply side we need comprehensive pricing of the greenhouse gas (GHG) emissions from land use, land use change and forestry, including the non-CO_2 GHG from agriculture. This can be achieved either through pricing the GHG emissions directly—e.g., through a REDD (reduced emissions from deforestation and forest degradation) system—or, where technical abatement opportunities are low and heterogeneity and uncertainty in emissions are high, indirectly—e.g., through input taxes on nitrogen fertilizers or output taxes on meat consumption. To assure an efficient allocation of production of biomass between countries, and between the choice of producing food, fibre, or bioenergy, distortive policies (e.g., tariffs and specific bioenergy subsidies) should be avoided.
Also on the supply side, additional policies will be needed to create incentives beyond what a general GHG price and market forces would do: the demand for land for bioenergy production should be moderated through, inter alia, increasing yields of existing forests and energy crops, utilizing biomass residues from agriculture and forestry, and utilization of degraded marginal lands that are currently not cultivated. Also, increasing land tenure security in developing countries holds a great potential in fostering sustainable use of land resources, increasing agricultural yields and reducing pressure on natural forests.
Additional protection measures, e.g., conservation areas or payment for other ecosystem services than carbon retention, will also be needed for protecting endangered ecosystems, especially those with low-carbon content. These additional measures will need to be supported both in international fora, strengthening for instance the Convention on Biological Diversity (CBD) and Convention on Desertification , and through country-specific policies.

Finally, it is important to acknowledge that land use decisions include making complex trade-offs between climate benefits, biodiversity conservation, water use, etc, and one needs to account for these multiple policy objective in land-use planning at all levels, from international to local.

Issue 8

- *By what mechanisms can public support for CCS be enhanced? CCS is surrounded by important technical, economic and legal issues but lack of public support might become the biggest barrier to large scale deployment. How can decision processes be designed that allow for an open debate and exchange of information between different societal stakeholders? How can the public be informed about, and engaged in, the development of CCS and what is the role of different actors, including intermediary organisations and knowledge brokers?*

For enhancing public support for CCS it appears to help to provide clear context how CCS is needed in realizing a low carbon future and to acknowledge the local people as stakeholder and give them an interest

When we consider ways to enhance public support for CCS it is important to distinguish between the general public and the local people close to a potential site for CCS storage. Both need to be addressed.

It appears that support is higher if a clear context is provided showing the benefits of CCS as part of bigger picture to move towards a low carbon society. This involves reference to making ambitious targets realisable and to set clear dates when CCS will be a mandatory technology. It also helps not linking CCS only to coal fired power generation. Combining CCS with biomass fuelled plants has the promise of providing a net sink for CO_2 from the atmosphere and CCS in industry is one of the very few means to drastically reduce its CO_2 emissions. Energy companies are often not trusted by the public: their competence is trusted, but not their motives. Information from a distrusted source will be ignored or actually work as counterproductive. A consortium of experts from different backgrounds (e.g. NGO's, universities and energy companies) is more likely to be trusted.

On a local level you would need an open and transparent decision process, with stakeholders (also local public or their representatives) involved from the start and information at every step in the process. This is much easier if stakeholders have interest in the project. This might be realized by creating financial ownership, e.g. by leasing of the land. Offshore projects receive much more support than projects onshore. To increase public support it helps to first expand experience in offshore projects before realizing many onshore projects.

Issue 9

- *What will be the role of leadership and pioneers in making the transition? What are the pros (e.g., first mover advantage) and cons (e.g., lower competitiveness or growth) of being a pioneer and a leader? What are the tradeoffs?*

Both governments and businesses can be first movers towards a low carbon society. Business leaders and pioneers can have a tremendous impact in making the transition towards a low carbon society happen. They can prove it is feasible to shift towards less energy use, carbon free technologies, and make this an attractive case for many others. They are the ones that first overcome barriers in implementing new technologies and policies. Therefore they are facing risks but also rewards.

The number of entrepreneurs and pioneers in the field of low carbon services and technologies in Europe is too low. For individual entrepreneurs the risks are substantial while the profit margins are often low (e.g. in renewable electricity). Many companies and citizens can just stay in their comfort zone. They experience no reason to change their energy consumption pattern and investment behaviour and often they are even ignorant about their CO_2 emissions they cause. Further, an entrepreneurial spirit seems to be missing.

Two routes are needed to improve conditions for first movers. The first is to create the long term framework that is beneficial for entrepreneurs and enables many customers and businesses to move out of their comfort zone. This will create volume in new technologies and thus improve business opportunities. Having more binding targets and obligations will help. There is clearly a role for governments to set up such policy instruments and help reinvent business models to allow the first movers to make good business cases. The second route is to get more people become entrepreneurs by creating a spirit that is in favour of pioneers showing their successes in the media, paying more attention in higher education to sustainable entrepreneurship and creating favourable fiscal conditions for such entrepreneurs. ■

For more Information

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