Global Investments for Climate and Energy Security

A Cross-Sector Perspective

ECF Background Paper 1

European Climate Forum - Mission

ECF initiates and performs high-class research about climate change in close interaction with stakeholders. We provide a pluralistic communication platform in the emerging global field of governments, local authorities, businesses, and social movements. This field lies beyond the traditional linkage between academic institutions and the nation state hosting them. It requires a capability to learn from each other in situations where consensus is impossible, perhaps not even desirable. As a key requisite for addressing the climate challenge in this spirit, ECF contributes to a new economic theory that will enhance our capability to manage climate risks.

European Climate Forum e.V.
P.O. Box 600648
14406 Potsdam
Germany

info@european-climate-forum.net
www. european-climate-forum.net

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Editors: Antonella Battaglini, Antonio Ruiz de Elvira, Martin Welp

Project Management: Giulia Carboni

Design: Steffi Retzar

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Preface

Climate change is real. Its impacts can be detected already today and will become far more serious if effective mitigation and adaptation measures are not undertaken. However, there is no credible plan - neither from politics nor from business – on how to reach this target. What is clear, though, is that the issue of climate change must be addressed not only by science but also by businesses.

This publication is a collection of ideas for credible mechanisms and policies capable of channeling sufficiently large investment flows towards clean technologies and emission reduction. In occasion of the ECF general assembly 2007, experts from different scientific disciplines, the business sector and the political world have provided short contributions and proposed suggestions for long-term sustainability and climate security. These contributions are now collected in this volume in which authors have tried to identify measures which stimulate the economy and turn challenges, posed by climate change, into opportunities.

The ECF Background Papers 2008 cover a broad spectrum of options – from technology to consumption patterns and policy interventions necessary to prevent dangerous climate change while maintaining a healthy global economic growth.
This publication is meant to be the first of a long series.

Climate change : Can Expected Rewards Alone Drive Mitigation Efforts?

Knut H. Alfsen and Gunnar S. Eskeland

- CICERO

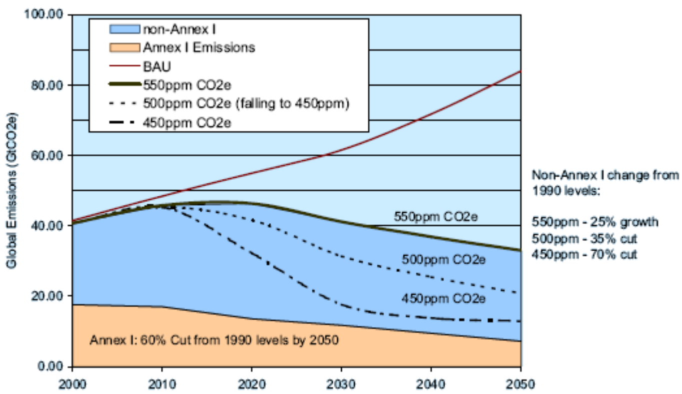
The challenge of climate change

2007 and 2008 mark interesting and challenging years for climate policy. 2007 ave us the fourth assessment report from the Intergovernmental Panel of Climate Change (IPCC, 2007), in which Working Group I affirms that climate change is

- happening,
- manmade,
- worrying, and
- worthy of serious mitigation action.

Just as importantly, with 2008 commences the Kyoto protocol's first commitment period, 2008-2012. It is now patently clear that the present climate regime – the Kyoto protocol – in itself will do little to curb greenhouse gas emissions, and it may indeed fail to meet even its modest emission reduction goals. This is in stark contrast to what needs to be done. Already, the target of avoiding a temperature increase higher than 2 °C – adopted by the EU – is most probably beyond reach. The Stern review (Stern, 2007) estimates that stabilizing the greenhouse concentration level at 550 ppm CO2-equivalents should avoid the most dangerous climate changes, but warns that damages likely increase sharply at concentrations beyond this. Today's concentration is in the area of 450 ppm CO2-eq. Figure 1, from the Stern review, illustrates implications of a stabilization target of 550 ppm CO2-eq. and lower in terms of emissions from the rich and the poor world, respectively. As a rough approximation this involves removing all emissions of greenhouse gases from the industrialized world by the second half of the century!

Figure 1. Illustrations of emission paths compatible with different concentration stabilisation targets. From the Stern Review (Stern, 2007)



On the scale of the problem and the need for climate friendly technologies

While this approximation makes no claim to be accurate, it usefully illustrates that the scale of the task is such that mere modifications of our lifestyles and changes in our behaviour in a more climate friendly direction, is far from enough to meet the challenge. What is required is a wholesale change of technology, in particular in the energy and the transport sectors. And we need to do this with the greatest sense of urgency.

The reason for the urgency is that in the coming few decades, given current and expected economic growth in large countries like China and India, more urban infrastructure is going to be constructed than has ever been constructed so far in human history! And as if that is not enough, the same is likely to hold for power plants and automobiles. It goes without saying that how we build this infrastructure and other assets is going to have an enormous impact on future greenhouse gas emissions and the cost of reducing the greenhouse gas emissions in the decades to come.
For the rich world, one might argue that the future need for more power and new plants in energy intensive sectors is a modest one, since growth can mostly be in service sectors and

other activities that are not emission- or energy intensive. For this reason, and because of wealth, if costs of cutting emission factors in power and manufacturing sectors prove to be noticeable or high – as currently with renewables in electric power production – they are also affordable.

For lower-income developing countries, the opposite is the case. Current costs of cutting emissions are low – this is assumed and proven through the clean development mechanism (CDM) – but growth aspirations require massive development in sectors such as power production. In short, the only hope that countries like China and India will implement climate friendly technologies is that such technologies become relatively cheap and affordable. This requires research and development (R&D) on a grand scale. Both in order to find genuinely new solutions, but also to improve existing solutions to a point where they are affordable for developing countries. Once these solutions are available, one is confronted with the equally daunting task of securing implementation of climate friendly solutions. No matter how forceful and successful the R&D efforts, the climate friendly solutions likely will be more expensive than the fossil based solutions we have today. Thus, some sort of market implementation framework (cap-and-trade or greenhouse gas taxes) will have to be in place to secure use of the most climate friendly solution. The Kyoto protocol (and its extensions in the most optimistic forms) can perhaps be viewed as a small step in this direction. When it comes to provide incentives and financing of the necessary R&D, however, the Kyoto protocol and similar control policies are clearly inadequate. The reason is spelled out as follows.

Can expected rewards alone drive mitigation efforts?

Private investments in R&D are motivated by price expectations for products that embody the technology once it has been developed to a commercial stage. A well-known problem is that knowledge, including inventions embedded in technology, is a public good in the sense that its value easily is subject to spillovers. This means that knowledge investments can benefits others than the investor, with the consequence that investments in knowledge are lower than optimal. Society's mechanisms for dealing with these issues are many, and powerful. Most importantly, in the fairly basic and general end of knowledge creation, taxpayers finance both schooling and research at universities. Also, intellectual property rights such as patents are government created institutions that attempt to reserve a good portion of the returns to new technology for the originator (the inventor, or the investors bankrolling the inventor).

Assuming that these issues are taken care of, a remaining important problem stands in the way of creating the necessary believable signals in the case of R&D on climate friendly technology: Governments control – and will control – the final price of greenhouse gas emissions . They do this in various ways; by determining the number of quotas under a cap-and-trade regime or, more directly, by determining the tax level on greenhouse gas emissions. In either case, governments continuously balance the cost of greenhouse gas mitigation with the expected benefits of such actions. Facing these choices, they will be under political pressure from two sides, since some groups benefit from higher and some from lower prices of greenhouse gas emissions[1].

If (and this is a big if) the governments can induce private investors to take on the heavy up-front cost of developing new climate friendly technologies, it would do this by explicitly or implicitly promising a high price on greenhouse gas emissions in the future. As an example, the EU emission trading system presently encourages investments in technology development for years beyond 2012 only to the extent investors form expectations about future quota prices. Nevertheless, if government(s) have succeeded in establishing a belief about high future quota prices, the governments will have every incentive to lower that price once the new technologies are available. We thus have what is sometimes called a dynamic inconsistency[2] between private investment costs and the governmental control of the payback to investors (Montgomery and Smith, 2005). In brief, since governments will fail fully to deli-

1 The list of reasons why expected rewards are insufficient could be longer. It is a fact, for instance, that emission free technologies have equal global benefits if sold in countries like China and USA. It is also a fact, however, that investors may emphasize that successful technologies may not have a future market there, due to their current energy/mitigation policies.

2 This is related to a phenomenon observed by Nobel prize winners Finn Kydland and Edward Prescott (1977).

ver on high expected emission costs, expected emission costs cannot be very high.

The solution to this dilemma is simple, if unpleasant: Governments themselves must pay a good portion of the costs of the necessary R&D[3].

Doing this, governments should normally abstain from subsidising the running cost of climate friendly technologies. Instead, they should provide a framework, e.g. in the form of a cap-and-trade system or by introducing greenhouse gas taxes, such that the preferred technological solutions are profitable alternatives in the market.

On picking low hanging fruits

Technology development is expensive, and the argument is sometimes heard that one should wait and instead concentrate on 'picking the low hanging fruits', i.e. pursue the cheapest options for emission reductions first. Today, this is quite likely achieved by buying CDM quotas from developing countries.

The 'low hanging fruit' argument is weak for two reasons: The first reason is related to the urgency of the climate change problem as described above. If we wait too long in developing affordable solutions, it will become very much more expensive to reduce future emissions . Partly because technology development requires not only work-time but also calendar time – decades – but also because long-lived investments are being made in real assets every decade, so there is a value in new technology arriving early.

Secondly, it is a fact that we will have to pick all the fruits. Metaphorically speaking, to do this, we will need a ladder, and it takes time to build it. In order to be able to pick the high hanging fruits we need to start building our ladder now. An example of high-hanging fruit for which a ladder needs to be built is emissions from the transport sector. It is impossible to judge today what will eventually be the role played by the various low-carbon or carbon-free transportation technologies, but it is a safe bet that great technological advances will be needed.

The twin tasks of technology development and implementation/dissemination.

The twin tasks of i) developing, through R&D, new technologies and ii) getting them implemented thus require two instruments: Public funding of R&D on the one hand, and a 'right price' on greenhouse gas emissions, respectively. This duality should also ideally be reflected in international climate policy. Thus, in the post Kyoto (post 2012) period, a cap-and-trade regime like the one introduced by the Kyoto protocol, should be supplemented with a technology (R&D) based treaty for a 'coalition of the willing', incorporating a long time horizon (perhaps 20 year, or longer in some form). Financing and other measures included in the treaty should be verifiable, and a system with a central 'research council' might be preferable. Each party to the treaty could be assured to get a proportional share of the resources in the form of research contracts, testing facilities, etc., but the teams carrying out the research and development should be international in scope, securing access to knowledge and technology transfer between the parties to the treaty. The technology treaty should thus secure substantial long-term public funding for research, development and testing of key technologies according to the preferences and comparative advantages of each participating country. Taken together, such an R&D based treaty should have a fair chance of being self-enforcing and also be attractive to nations outside the core industrialised countries. This is because R&D cooperation will attract participants interested in a) gains that yield energy security and climate benefits; b) sharing in research contracts and technology cooperation, and c) increased competitiveness and trade access.

Having acknowledged that cap-and-trade, or the one instrument approach, will not sufficiently stimulate the far-reaching end of technology development, a number of detailed questions about how need to be answered. A first question is commanded by the fact that the private sector has a number of strengths in terms of providing technological gains, in particular in the more applied end. This implies that government institutions, including the international ones to be created, need to be careful in examining the many ways in which government and private sector can work together. The range of instruments will likely include those that learn from development of defence technologies, the more 'blind' R&D subsidies (through tax benefits, for instance), specific research

3 An alternative route to this conclusion is found by considering the hold-up problem, well described by Oliver Hart and John Moore. In a setting where one party has strategic advantage ex post because she can destroy a joint asset by walking away from her partner, she must be an equity owner, to be committed to its success. In our setting, since government has power to determine – in the future - the value of a technology, the government must have an equity stake in the technology. To private investors, this will much look like risk reduction/risk sharing, but it is even stronger: it can make it incentive compatible for the state to implement its plans.

contracts, prizes for the first to bring a product to the market (see Kremer, 2000), etc. Likely, one important avenue requires government involvement, but not necessarily government money, namely sector specific standards and targets. Both the US and Europe has mixed experience with standards for cars, but it seems likely that long term targets and standards for average emissions of greenhouse gases, say for urban buses as a class, and for private vehicles as a class, can play a role in setting the stage for longer term development.

Compared to the theoretical 'one instrument' world, technology oriented policies will involve calculated risks of picking winners, or of specifying targets too narrowly (maybe we do not need low emission buses, for instance). We believe these risks are important but real, and that they simply highlight how the challenge of climate policy involves some political responsibilities and necessary strategic commitment. To put this point in another way, we believe one problem with very neutral policy instruments like the textbook version of cap-and-trade is that they do not chart very clearly how, in practice, society can live with lower emissions. A real world political statement like 'buses will on average have lower emissions, and will play a greater role in our cities' carries more responsibility than neutral, flexible instruments, and tries to communicate how one can live with lower emissions.

Another set of difficult issues will relate to the potential trade-offs between rewarding investors (allowing a high price for technology) and rapid dissemination, which requires a low price to the buyers. To some extent, the dissemination argument is important, and rewards can be supported by government funds (as presently, with subsidies to solar power installations and wind power, for instance). But there is an additional question of developing countries needing to feel confident that they will not only have access to the technology but also benefit from it in terms of industrial development. Quite likely, solutions to these problems will involve important research and development centres situated in developing countries, combining efforts by universities and corporations from both industrialized and developing countries.

The complementarity between R&D and implementation strategies like cap-and-trade

Greater emphasis on R&D efforts is in no way a substitute to supporting emission reductions through cap-and-trade or emission taxes. Rather, the two approaches are logically complementary, i.e. mutually supportive.

A way to see this is as follows. First, let us think of countries in a cap-and-trade regime like the current European Trade System or the current Kyoto protocol. A question looming over investors (and others) is what will be the quotas (or the price on emission) in future periods, say 2013 to 2020. Any belief that the price will not be high is depressing investments in climate-friendly technology, and these beliefs consequently keep up the costs of emission reductions in those future periods. In the political process of setting goals for the future periods, estimates of emission reduction costs will be a factor, and thus these past beliefs will limit the stringency of future quotas. As it happens, R&D will, if successful, reduce future costs of emission reductions. Through its effect on future emission reduction costs, R&D programs will consequently raise the stringency over time attained by the cap-and-trade approach. In other words, cap-and-trade is strengthened by a R&D program or treaty.

A similar argument applies the other way. R&D efforts may be hard to make effective if not stimulated in part by expectations of a market for the products that are successful in the technical terms of reducing emissions. Expectations for such a market are created by implementation instruments such as cap-and-trade. In other words, R&D is strengthened by a program supporting cap-and-trade.

This argument has here been spelled out in one particular dimensions: namely that R&D strengthens the depth of emission reductions over time in cap-and-trade. But the argument applies in the same way to R&D strengthening a broader participation in the mitigation efforts globally. Since future mitigation costs are reduced by R&D efforts, more countries can with confidence join talks about future emission reductions when a forceful R&D treaty is in place.

This means that R&D and cap-and-trade should not be seen as competing or alternative solutions. They are complementary tools in addressing the climate challenge.

Conclusion

We have argued that an important part of the solution to the climate change problem is to recognize that public funds will have to carry a substantial part of the research and development costs of new climate friendly technologies. This is because promises of future rewards to private investors in technology development are not in themselves entirely convincing, in particular when the rewards are more or less directly controlled by governments. Thus, government support, in the form of direct subsidies to R&D and other means such as setting standards and goals for the future, are necessary supplements to a cap-and-trade regime.

References

- Alfsen, Knut H., and Gunnar S. Eskeland (2007): A broader palette: The role of technology in climate policy. Report to the Expert Group for Environmental Studies 2007:1, Ministry of Finance, Sweden.
- Hart, Oliver (1995): Firms, contracts and financial structure, Claredon lecture in economics, Oxford University Press, Oxford.
- IPCC (2007): Climate Change 2007: The Physical Science Basis. Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, http://www.ipcc.ch/SPM2feb07.pdf
- Kremer, Michael (2000): Creating Markets for New Vaccines Parts I and II, NBER Working Paper 7716 and 7717, May 2000.
- Kydland, Finn E., Edward C. and Prescott (1977): Rules Rather than Discretion: The inconsistency of Optimal Plans, Journal of Political Economy, Vol. 85, No. 3 (Jun., 1977), pp. 473-492.
- Montgomery, W. David, Anne E. Smith (2005): Price, Quantity, and Technology Strategies for Climate Change Policy. Forthcoming in: Michael Schlesinger, Haroon Kheshgi, Joel Smith, Francisco de la Chesnaye, John M. Reilly, Tom Wilson and Charles Kolstad (Eds., 2007): Human-Induced Climate Change. An Interdisciplinary Assessment, Cambridge University Press, Cambridge. ISBN-13: 9780521866033. See www.crai.com/.%5Cpubs%5Cpub_4141.pdf
- Stern, Nicholas (2007): The Economics of Climate Change. The Stern Review, Cambridge University Press, Cambridge, 712 pp.

The Non-Analogue State of the Climate System and the Functioning of Key Stabilizing Feedbacks

Hartmut Grassl

- Max Planck Institute for Meteorology

After the publication of the Summary for Policy-Makers (SPM) of Working Group I of the Intergovernmental Panel on Climate Change (IPCC, 2007) it is difficult to present an argument going beyond the strong underlining of an anthropogenic influence on global climate. The summary has already stimulated or at least accelerated decisions of political bodies, e.g. the Council of the European Union, which is well beyond the emission reduction commitments for industrialized countries within the enacted Kyoto-Protocol. My points listed below are only in parts contained in the text of IPCC (2007).

Point 1:

- The often cited goal of keeping the global mean temperature change below 2°C until 2100 with respect to the pre-industrial period, as accepted by the European Union, might still trigger the melting of the Greenland ice sheet in the coming decades and lead to a global mean sea level rise of up to 6 m in several meters in the centuries to come. In otherwords: we may lose coastal mega-cities in marshlands if no strong globally co-ordinated climate policy will be implemented within the next few decades.

Point 2:

- We do not know whether the negative (stabilizing) feedback that has kept the greenhouse effect of the atmosphere in narrow bounds (ca. ± 5°C) over many millions of years despite continental drift, changed solar output and drastic changes in atmospheric composition will still operate in the present non-analogue state of the climate system. In other words: the climate system might develop into a totally different state disrupting our civilization. We have accelerated atmospheric composition change by factors of 100 and more compared to changes occurring during glacial transitions.

I do not want to be misunderstood: I regard the SPM as proper collection of our knowledge, but point 1, albeit contained, is not highlighted in the text and point 2 on the lack of knowledge is not expressed. In the following I will give arguments why we have to take points 1 and 2 serious.

Discussion of Point 1

The changes of the Earth's orbital parameters in the next at least 30 millennia speak with high probability against the initiation of a new glaciation. Eccentricity will attain very low values, i.e., we approach a nearly circular orbit, and obliquity of the rotational axis of the Earth is shrinking, thus causing less intense annual cycles. Therefore, ice sheets reacting to anthropogenic forcing can come close to their equilibrium with respect to the enhanced greenhouse effect. In addition, the northern hemisphere will get more solar energy in some thousand years, as the date with smallest distance to the sun will be shifted from nowadays 4 January into the northern hemisphere summer half year. The Holocene or – as it is now called - the Anthropocene can last for additional 30 to 40 thousand years.

In an Earth system model study Vizcaino (2006) has shown that the anthropogenic disturbance caused by the burning of fossil fuels would not only lead to a global mean warming, but it would also last over millennia. The warming triggered the partial or full melting of the Greenland ice sheet for all IPCC SRES scenarios without climate protection measures (called A1B, A2) for two combinations of an atmospheric and oceanic model (ECHAM4 or ECHAM5 coupled to the Max Planck Institute Ocean Model (OM1)). In three out of five members of an ensemble of the A1B scenario the meridional overturning circulation (MOC) in the North Atlantic was stopped in hundreds of years from now and did not recover for two members of the ensemble. The collapse of the MOC led to a reduced sea level rise as larger parts of the southern Greenland ice sheet were not melting. While the Antarctic ice sheet grew in the ECHAM4/OM1 combination with comparatively low climate sensitivity, it also contributed to sea level rise for the ECHAM5/OM1 model combination after some millennia as climate sensitivity is somewhat higher in this set-up.

At the state of present knowledge we cannot rule out the melting of substantial parts of the Greenland ice sheet at a global mean warming of 2°C, which is equivalent to a 3 to 4°C warming in high northern latitudes. I turn this into a message for the mayors of coastal marshland mega-cities: Urge your countries to implement a stringent globally co-ordinated climate policy in order to provide a future for your city also in centuries.

Discussion of Point 2

While point 1 makes a stringent globally co-ordinated climate policy more urgent and questions the validity of a +2°C mean warming goal for preventing a sea level rise of meters, it still assumes that rapid anthropogenic climate change does not turn the climate system into a totally different state, as the most drastic rearrangement of circulation might be a strong weakening or a halt of the meridional overturning circulation in the North Atlantic for these model runs. All changes, as drastic as they might appear, would still see the key negative feedback working that has prevented the positive feedbacks of the water cycle to lead to a totally ice-covered world or a boiling ocean. From where do we derive the knowledge that this negative feedback, probably linked to cloud properties and thus planetary albedo, would still operate at a climate change rate that is faster by a factor up to 100 than during rapid natural climate change, e.g. the transition from an intense glacial into an interglacial like the Holocene? The answer is: we do not know the key processes leading to this negative feedback and hence we cannot know whether it will still help keeping the greenhouse effect within known boundaries.

Both positive feedbacks in the water cycle more than double the effect of long-lived greenhouse gases. A doubling of CO_2 at fixed water cycle parameters would only lead to about 1.2°C mean warming at the surface and in the lower atmosphere, while the most probable mean warming of 3°C for a doubled carbon dioxide concentration (given as the climate system sensitivity by IPCC (2007)) is the result of the two positive feedbacks of higher water vapour concentrations and the transformation of very bright surfaces such as (powder) snow and snow-covered land- and sea-ice, into rather dark natural surfaces such as sea water and (vegetated) soils. As water vapour concentrations grow strongly non-linearly with temperature, the potential for a run-away greenhouse effect exists, if this positive feedback would be the major feedback and the negative ones would be too weak or to slow.

Conclusion

The full threat of anthropogenic climate change is not yet realized in the climate policy debate. In other words: the European Climate Forum should lead a debate on the still existing fundamental uncertainties of physically-based climate research. Point 1 mentioned above is circling around the Greenland ice sheet as the 'wild card' in the climate system, while point 2 points to a principal lack of knowledge of a central stabilizing feedback in the climate system that has allowed life to thrive for many million years.

References

- Intergovernmental Panel on Climate Change (IPCC) (2007): Summary for Policy-Makers of
the Fourth Assessment Report of Working Group I (Climate Science), issued on 2 February
2007 by World Meteorological Organization (WMO), Geneva, Switzerland
- Vizcaino, M. (2006): Long-Term Interactions between Ice Sheets and Climate under
Anthropogenic Greenhouse Forcing. Simulations with Two Complex Earth System Models.
Max Planck Institute for Meteorology, Hamburg, Reports on Earth System Science, No. 30

The Role of Science in the Development of Climate Policy

Klaus Hasselmann

- Max Planck Institute for Meteorology

1. The Challenge

The recent reports of Sir Nicholas Stern and Working Group 1 of the UN Intergovernmental Panel on Climate Change (IPCC), together with the public response to Al Gore's Oscar-awarded climate film, the activities of numerous climate-concerned business councils, NGOs, and regional administrations on state and city levels, have brought the problem of climate change firmly to the top of the political agenda.

How can science support this positive development? Science has played a decisive role in informing the public and policy makers about the problem of climate change. Admittedly, this took some thirty years since the first warnings were clearly pronounced in a series of international conferences in the early 1970's. But with the creation of an official UN Intergovernmental Panel on Climate Change (IPCC) in the late 1980's, charged with the mandate of periodically summarizing the full range of peer-reviewed scientific inquiry, the public and political understanding and acceptance of the scientific background of the climate problem has rapidly increased.

This holds, however, only for the reviews of IPCC Working Group 1 on the Science of Climate Change. The impact of IPCC Working Groups 2 and 3 on impacts, vulnerability, adaptation and mitigation has been much more weaker. This is presumably due to the conscious decision of IPCC not to engage in the political debate, to avoid partisan policy recommendations and provide only impartial scientific analyses.

This is very evident in the Stern report, arguably the most forceful political document to date on climate change. While the report draws heavily on IPCC Working Group 1 in summarizing the science of climate change, in the absence of clear guidance from the diffuse summary of IPCC Working Groups 2 and 3, it was forced to arrive at its own conclusions regarding the necessary economic and political response. Thus in contrast to Stern's generally accepted summary of the scientific evidence, Stern's strong economic and political conclusions have been subjected to some criticism.

The contribution of science to climate policy could be greatly strengthened by two actions: (1) the creation of an independent UN Intergovernmental Panel on Climate Policy (IPCP) with the specific task of analyzing climate policy proposals, in close interaction with policy makers and stakeholders, and (2) the development of a new suite of integrated assessment (IA) designed specifically for analyzing the impacts of climate policy proposals from the diverse viewpoints of different countries and stakeholders.

It would be unwise to assign the first task to the existing IPCC Working Groups 2 and 3. An independent, politically detached scientific body providing an overview of all relevant scientific work bearing on climate policy will undoubtedly be required in the future as it has in the past. However, needed in parallel is an independent, internationally authorized body that can work closely with stakeholders and policy makers in providing non-partisan advice on the impact of proposed climate policies on the different parties of the UN Framework Convention on Climate Change (UNFCCC).

The second task is an important consequence of the first task if an IPCP is to effectively address the concerns of policy makers. Existing IA models have largely evolved from the mainstream of computable general equilibrium (CGE) models, designed for studying the equilibrium response of the market to changes in external conditions. They fail to address many of the primary concerns of policy makers, such as the impact of climate policies on the employment level, on energy security, on life-standard inequalities, migration pressure and other factors affecting national security and international co-existence. On a more technical level, the present models fail to capture the complex dynamics governing the non-equilibrium response of the multi-regional, multi-actor, coupled climate-socio-economic system to global climate change and climate mitigation measures.

It is unlikely that a single model will ever be able to represent all of these complex processes realistically. More promising is to develop a suite of models, with different models focusing on different processes. The model suite would need to be created as a homogeneous model ensemble, however, in order that the simulation results from individual models can be processed further in a post-simulation (meta-analysis) system designed to extract a comprehensive multi-criteria assessment of a given climate policy from the full set of model simulations.

To illustrate the interrelationship between economics, intergenerational and interregional equity, and international security and co-existence, the following two sections consider some of the problems facing policy makers striving to arrive at an international agreement on post-Kyoto climate policy.

2. The interrelationship between economics, intergenerational equity and climate policy.

Figure 1 shows, qualitatively: the projected business as usual (BAU) global emissions curve of the principal greenhouse gas CO_2 in the absence of an effective abatement policy; the emissions goal that must be attained during this century if a dangerous level of global warming is be averted (defined by the EU as maximally 2oC above the pre-industrial level); and the various renewable technologies that are available to close the wedge between the BAU curve and the emissions goal. All curves except the sustainable-emissions goal, whose general level (although not detailed form) is determined by the physics of the climate system, must be viewed as qualitative sketches only. They depend in detail on the growth of the global economic system, the rate of technological development, and the impact of the measures introduced to bring the emissions down to the sustainability goal, none of which can be predicted reliably.

The technologies are assumed to penetrate the market with time delays that increase with the costs of the technology. Thus energy efficiency, in the form of improved insulation of buildings, coupled heat-power generation, more efficient lighting, low-emission vehicles, etc, penetrates the market first, at net costs which in many cases are negative. This is followed by CO_2 sinks through reforestration, and biomass, wind, hydro and geothermal energy. All of these relative low cost options have only finite reduction capacity, however. In two or three decades, the achievable reductions saturate and are no longer able to compensate the inexorably rising BAU curve, which is driven by the increasing energy demands of the emerging and less developed countries aspiring to catch up with the developed world.

To maintain the necessary rate of emissions reduction beyond about 2030, widespread introduction of more expensive photovoltaic or solar thermal technology will be necessary. The technologies exist and represent an effectively inexhaustible energy source. However, the current costs are considerably higher than other renewable technologies, so that their widespread introduction at current prices would significantly increase the cost of energy. To avoid a prohibitive future energy-price hike, the price barrier will need to be eroded by timely subsidies supporting market infusion of solar technology, thereby reducing future costs through operational experience (learning by doing), and by enhanced investments in R&D (learning by researching). Alternatively, the steep price increase can be softened by expanding nuclear energy (a controversial option), applying wide scale carbon capture and storage (CCS, a still unproven technology), or banking on a breakthrough in hydrogen fusion (which most experts regard as unlikely).

To close the wedge between the BAU and sustainable emissions curve, policy makers have available four basic instruments: carbon taxes, tradable emission permits (cap and trade), subsidies and regulation.

Carbon tax and cap-and-trade both have the advantage of reducing emissions efficiently using market forces. A carbon tax is convenient for business through the known price penalty incurred by using fossil fuel, but it is inconvenient for the social planner, who cannot predict the resultant level of emission reduction reliably. A cap-and-trade system has the opposite properties: the social planer knows rather well the level of achieved emissions reduction, but business is unable to predict reliably the price penalty for using fossil fuel.

However, on the global level, a cap-and-trade system has a distinct advantage over a carbon tax. It is very difficult to harmonize different carbon taxes applied by different countries. The standard example is the Scandinavian countries, which have applied a carbon tax for several years, but have not yet succeeded, despite a long tradition of economic cooperation, in harmonizing their carbon taxes. In contrast, a cap-and-trade system, if applied to all CO_2 sources and traded globally, automatically creates the same price for all emission permits. Moreover (as discussed further in the next section), if the permits are auctioned and allocated fairly to all countries, the system has the potential for solving another dilemma of climate change mitigation: intergenerational and interregional equity.

For the following discussion it will therefore be assumed that the mitigation goal is achieved by distributing (either by free allocation or by auction, or a combination of both) a total number of emission permits corresponding to the sustainable global emissions curve shown in Figure 1.

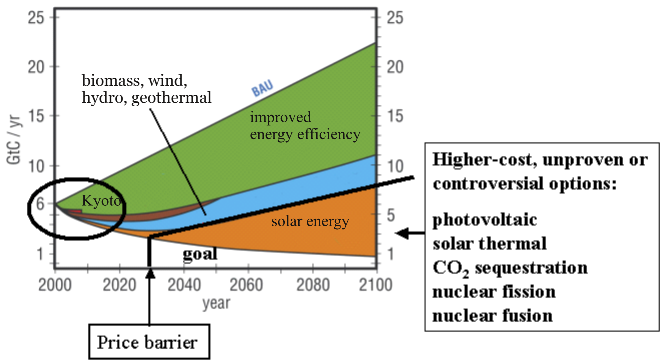


Figure 1. Technological options for filling the wedge between BAU emissions and the sustainable emissions goal

The third instrument, subsidies, is then applied to optimize the technological mix. The last climate policy instrument, direct regulation, can be regarded as a special case of capping emissions without the option of trade. This can be desirable where market forces have been found to be too weak, such as in energy efficiency for buildings, but will be disregarded here.
Having internalized the externality of climate change by introducing emission caps, it may be thought that the market would then automatically take care of the optimal realization of the necessary technological solutions. However, this is not the case. The market responds to the interests of individuals, in the present case, shareholders, not society as a whole. Shareholder value is governed by the optimal return on capital computed using high discount factors of the order of 5 to 10%. Society as a whole, however, in contrast to individuals, is responsive to the requirement of intergenerational equity: the fair distribution of the burden of averting dangerous climate change between the present and future generations. This implies a much lower social discount factor in the range from zero to a few percent. The disparity between the two discount rates can be "internalized" by government subsidies for renewable technologies, such as solar energy, which are still too far downstream to be competitive in the market in the near future (see Figure 1). Thus the erosion of the price barrier by government subsidies may be seen as a technique for minimizing the social costs of climate change mitigation.
Most estimates of the effective global costs of climate change mitigation, allowing for the reduction of future mitigation costs through learning by doing and learning by researching, lie in the range of 0% to 4% of world GDP. Figure 2 shows the impact of mitigation costs of 1% or 4% on the growth of world GDP over a period of 100 years, assuming an extremely modest reference annual GDP growth rate of only 1%. The resultant delay in economic growth is 1 or 4 years, respectively. Assuming a more robust reference growth rate, the delay is reduced accordingly. As an order of magnitude, the delay in growth over a period of a hundred years can be estimated as about one year.

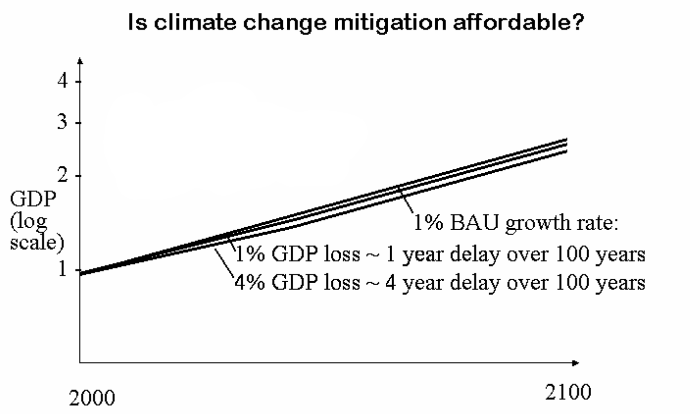


Figure 2. Impact of climate change mitigation on global GDP growth

Thus the issue of climate change mitigation is not whether it is affordable – as an insurance premium, it clearly is, given the uncertain but potentially very high risks of unabated climate change – but how to distribute the costs between different generations and regions.

3. Interrelationship between economics, interregional equity, international coexistence and security, and climate policy.

Figure 3 shows a breakdown of the global CO2 BAU emissions curve and the sustainability goal of Figure 1 in term of the per capita emissions for four typical regions representing the industrial countries (US, EU+Japan) and the emerging economies (China, India). A convergence and contraction scenario has been assumed in achieving the transition from the BAU curves to the sustainable per capita emissions curve: the industrial countries must reduce per capita emissions much faster than the emerging economies, whose per capita emissions are initially allowed to grow, all emission curves finally converging, however, into the sustainable asymptote. The least developed countries (not shown) need accept still smaller emission restrictions.
As long as the per capita emissions of the developing economies are significantly smaller than those of the developed countries, it cannot be expected that the developing countries will be willing to impose emission restrictions without some form of compensation from the developed countries. Thus the convergence and contraction scenario of Figure 3 assumes a flow of investments and know-how from industrial countries to the emerging economies is taking place. How can this transfer be achieved?

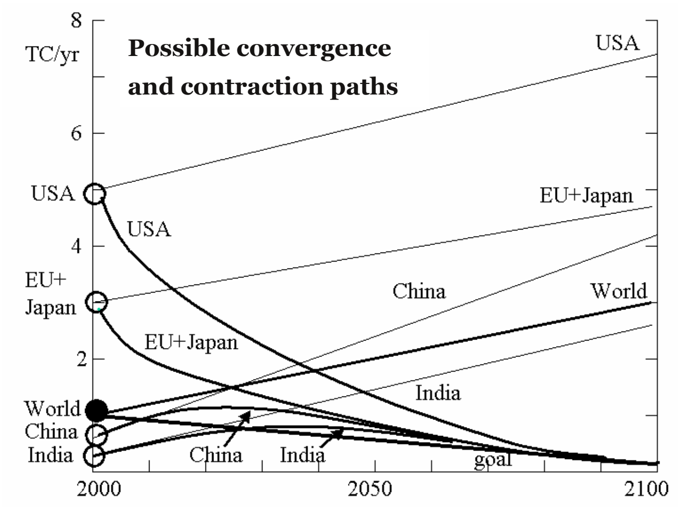


Figure 3. Per capita CO2 emissions for industrial nations and emerging economies corresponding to the global emission paths of Figure 1 (schematic).

The conceptually most straightforward and fairest transfer method is to incorporate in a global cap-and-trade system the fundamental human rights principle: every person has the right to the same amount of CO_2 emissions. This implies that every country receives a number of emission permits proportional to the population of the country. International permit trading then transfers permits from low per-capita emission countries to high per-capita emission countries, generating a corresponding flow of investments in the reverse direction. If the system is carefully designed and managed, both flows support the transition towards a global, sustainable low-carbon system. Details of the possible implementation of such a Global Climate Certificate System (GCSS) was presented by Lutz Wicke and discussed at last year's ECF Annual Conference. A basic attraction of the scheme is that it appeals to the aspirations of both developed and developing countries, and a binding global emission cap is ensured, independent of the resulting regional distribution of emissions.

Finally, the interrelationship between economics, interregional equity and climate policy is directly coupled to international coexistence and security. The elementary implications of interregional equity for the structure of a future international cap-and-trade system will be evident to all parties of the UNFCCC. Countries with high per capita emissions that try to ignore these implications will lose the moral high ground, clearly visible to all parties, with corresponding negative impacts on the country's international standing and influence. The international backlash, already apparent during the Kyoto period, can be expected to become more pronounced in the post-Kyoto period, as the urgency of the climate problem receives wider international attention.

The basic challenge of climate policy is to devise a global post-Kyoto climate agreement that, within the limited time frame of a few decades set by the finite inertia of the climate system, is able to transform the present non-sustainable, inequitable distribution of strongly differing per capita CO_2 emissions into a sustainable, equitable distribution. Present efforts to achieve this transition represent a highly fragmented patchwork of activities within the developed world of various citizen groups, NGO's and business councils, of the regulations of individual regional and city administrations, and of the efforts of the countries participating in the Kyoto protocol, spearheaded by the EU experiment in emissions trading, with its supporting transfer mechanisms JI and CDM. The net impact on climate change of all of these activities combined is generally recognized as negligible, but the experience gained from these first steps is nevertheless valuable.

It is therefore encouraging that an important second step towards establishing a more effective international climate policy regime in the post-Kyoto period has been made by the EU in its recent commitment to reduce CO_2 emissions by 20% relative to 1990 by the year 2020, together with an increase in the contribution from renewables to 20%. The unilateral EU commitment was combined with an offer to increase the reductions from 20% to 30% if the US and China were willing to make similar commitments. However, since investments in energy technology bind capital for thirty years or longer, climate policy commitments, or at least intentions, should be defined over significantly longer periods – extending, ideally, out a stabilization limit of about 20% of present emissions towards the end of this century.

Scientists can support the difficult political process of finding a constructive compromise between the divergent interests and perceptions of the different UNFCCC parties engaged in the post-Kyoto negotiations by developing and applying appropriate multi-actor, dynamical modeling tools for analyzing the implications of such policy proposals from the different viewpoints of the various actors involved. The impact of such analyses would clearly be greatly enhanced if they were presented not as the results of individual scientists, but as the consensus view of an internationally authorized UN Intergovernmental Panel on Climate Policy.

Climate Policy: from Rent-Seeking to Innovation

Carlo Jaeger

- Potsdam Institute for Climate Impact Research (PIK)

Climate Policy and European Identity

Friday, March 9, 2007, the EU reached what many see as a historic climate policy agreement. The British commentator Will Hutton wrote in The Observer: "The EU's landmark deal on carbon controls must be the model for a new Kyoto agreement." And: "German Chancellor Angela Merkel, emerging as a European politician in the great tradition of Adenauer, Brandt, Delors, Mitterand and Kohl, has used the current German presidency of the EU to mastermind an epic commitment on tackling climate change and energy security." And he adds: "For pro-Europeans like me, there has been little to cheer about over the last 10 years. But, extraordinarily, the EU is recovering its sense of purpose."

Another commentator, Gideon Rachman of The Financial Times, picked up that picture with an ironic twist: "the EU finds a new purpose in the battle against global warming; ordinary Europeans are inspired by this noble cause and rally to the European flag; the rest of the world follows Europe's example and the planet is saved." Before this background, he cautioned that "the EU has developed an unfortunate habit of proclaiming grandiose targets that turn out to be unattainable and then are gradually shelved or defined out of existence."

European integration can only succeed if it is tied to the commitment that Europe has a mission in today's world that it is able to offer a way towards a multilateral world order in which the U.S. can play a leading role without having to fall into the trap of unilateralism (Soros, 2006). Currently, climate policy is the area where that commitment has the greatest plausibility. That also means that here the danger of failure is particularly serious. Already in 1998, political analyst A. Michaelowa stated: "The EU has been a leader in the international climate negotiations from the beginning. Nevertheless, it has not been able to implement strong policies and measures to actually reduce emissions." Given the stakes involved both in terms of climate policy and of credibility of the European project, careful analysis of this situation and effective action to improve it are certainly warranted.

The climate rent

It is widely understood that avoiding dangerous climate change will require the establishment of a price for carbon emissions. A large amount of studies and debates focuses on how the cost that a carbon price brings to some economic agents can work as an incentive towards reducing those emissions. However, if a price is a cost to some, it is by necessity an income to some others. This income is the climate rent.

To fix ideas, suppose there are two technologies to produce commercial energy (heat, electricity, etc.). Under given circumstances, one does so at 2 Eurocent per kwh, the other at 3 €c (the figures are chosen so as to roughly match orders of magnitude in today's Europe). The former technology, however, generates CO_2 emissions of about 650g per kwh, while the latter generates no such emissions. Without further restrictions, the first technology will serve the market. Suppose the market size is about 7*1013 kwh, so that total CO_2 emissions per year are about 4.5 gt. Now establish a market for emissions permits with a volume of, say, 4 gigatons. Then the price of permits will increase up to the level where the second technology becomes competitive. With the given cost differential, this happens at a level of 1 €c per 650 g of emissions, corresponding to about 15 € per ton of CO_2. Energy prices will increase from 2 to 3 Eurocents per kwhr, and for energy consumers permits will induce additional costs in the order of 4 gt * 15 € per ton and year = 60 billion € per year. For whoever owns the permits in the first place, those 60 billion € are an additional income: the climate rent.

If a specific firm is able to capture a share of that rent, its stock will gain in value. From then on the rate of return per value of stock will be again comparable to that of other businesses, of course yielding higher total profits than before. These gains are covered by consumers who pay more for direct and indirect energy use without owning the relevant stock.

If the total amount of permits available consistently decreases over time, changes in expectations, technologies, and tastes are likely to reduce the total amount of emissions, while the price of permits is likely to increase for several decades. Beyond that time horizon, new patterns of energy use will have emerged, and permit prices may as well fall again.

Of course, this mechanism is not restricted to the European emissions trading scheme. It arises whenever a government or group of governments takes action to reduce greenhouse gas emissions, be it by emissions permits, taxes, or other measures. In all those cases, powerful lobbies will engage in rent-seeking (Tullock, 1987). For many companies, there may be a higher return from investing in political lobbying than in aggressive innovation. This mechanism goes a long way towards explaining the challenge the EU is faced with when trying to reach its ambitious climate policy goals.

The importance of auctioning permits

To focus the skills and competences of business on innovation rather than on lobbying, four steps are essential. First, property rights for emissions must firmly stay with public authorities. In the case of emissions trading, this requires a transition from grandfathering towards auctioning. This will be the lithmus test for European credibility on climate policy.

Second, a stable fraction of the climate rent that then goes to public authorities must be used to subsidize R&D activities aiming at reducing emissions (the other part of the climate rent should be used for adaptation and compensation in the face of climate risks and damages). Third, public authorities must resist the temptation of deciding what technologies are most promising for the purpose of reducing emissions. So far, no institution has matched the performance of markets at discovering the most effective technologies for given purposes, and attempts by public authorities to pick winning technologies in advance are an immediate invitation for rent-seeking by all businesses that feel able to claim that their technology holds special promise for the future.

Finally, R&D subsidies should be geographically focused so as to foster innovative regional clusters. Such clusters are much easier to identify than specific technologies, and they can make a difference in global emissions by developing technologies that are competitive at a global scale (Porter, 2000). Europe has the potential to foster such clusters on its own territory, and it can engage in close co-operation with countries that are willing to realize a similar potential for themselves. Along these lines, the EU's landmark deal on carbon controls can indeed become the basis for a multilateral agreement that will be a valuable successor of the Kyoto protocol.

References

- Hutton, W. (2007) How Europe Can Save the World. The Observer. March 11. Michaelowa, A. (1998) Impact of Interest Groups on EU Climate Policy. European Environment, 8, 152-160.
- Porter, M. E. (2000) Location, Competition, and Economic Development: Local Clusters in a Global Economy. Economic Development Quarterly,14,15-34.
- Rachman, G. (2007) Another European Commitment that May Vanish into Thin Air. The Financial Times. March 19.
- Soros, G. (2006) Europe as a Prototype for a Global Open Society. Talk delivered at the European Policy Centre in Brussels. www.soros.org/resources/articles_publications/articles/europe_20061120.
- Tullock, G. (1987) Rent Seeking, in: J. Eatwell, M. Milgate, P. Newman (eds) The New Palgrave, vol. 4.

Economic Impacts of Climate Change - Financial Implications

Claudia Kemfert

- German Institute of Economic Research (DIW)

Climate change harms the economy. Recent reports demonstrate not only that climate change will become more serious as it has been expected so far[1] and will bring economic damages[2]. It is foreseeable that this will cause irreversible long-term damage which will jeopardise the natural bases of life. The report by the Intergovernmental Panel of Climate Change (IPCC) summarises the main facts and consequences of climate change. In the 20th century the global surface temperature rose by 0.6° C (± 0.2°). The rise in the surface temperature in the northern hemisphere was greater during that period than in the previous 1000 years. 1990 was the warmest year globally in the 20th century, and 2002 was the warmest year since weather records began. The number of hot days has increased and the number of cold days has decreased. The anthropogenic (that is, caused by human activity) concentration of greenhouse gases, carbon dioxide (CO_2), methane (CH_4 and nitrous oxide (N_2O) has increased exponentially in the 20th century. Depending on assumptions on future developments, temperature increases of between 1° and 3.5° Celsius are to be expected in 2100. The concentration of carbon dioxide alone in the atmosphere has risen since weather records began by 31% (± 4%). CO_2 emission comes mainly from burning fossil fuels. As the emission of greenhouse gases increases and the temperatures rise the global sea level will also continue to rise. Again depending on the assumptions and scenarios on which the prognosis is based the figure is put at between 10 cm and 90 cm by the year 2100.

The number and severity of natural catastrophes, like flooding caused by extremely heavy rainfall, will continue at growing intensity, as will heat waves and storms. Table 1 shows the extreme weather events that are possible, how likely they are to occur and their possible impacts. Many regions in the world are already more affected by climate change than others, and this will also be the case in future. In North America worse storms and tornadoes are to be expected, while floods are more likely in Asia. In Europe as well as extreme heat waves and flooding the storms like tornados and hurricanes are also likely in future.

Extreme heat phenomena and rainfall have been a striking feature in Europe in recent years, especially Germany. In 2002 Middle and Eastern Europe suffered catastrophic floods. In the east and south of Germany, the southwest of the Czech Republic and Austria and Hungary the rivers Danube, Elbe, Moldau, Inn and Salzach burst their banks. The millennium flood hit Germany hard, causing damage amounting to about 9.2 billion euros[4].

In 2003 the whole of Europe suffered from an extreme heat wave. The economic damage of such catastrophes include those who died of heat stroke (particularly in France), increased ill-health from the greater risk of disease, as well as harvest losses, disruptions to energy provision and more forest fires[5]. Altogether it is estimated that the heat wave in 2003 caused damage of between 10 and 17 billion euros in Europe[6].

Economic Impacts of Climate Change- all sectors are affected

The economic damage from extreme weather events has increased by the factor 15 in the last three decades[7]. The impacts of anthropogenic climate change are lower as they will become in

[1] IPCC, FAR, 2007
[2] Stern (2006)
[3] Today there are 150 gigatonnes (Gt) more of carbon dioxide emissions in the atmosphere than before industrialisation. The quantity is growing by 3% a year and in 2050 it will have reached 300 Gt if this growth rate continues unchanged.
[4] That is the figure for the damage given by the insurance industry. See Münchner Rück: 'Jahresrückblick Naturkatastrophen 2002', Munich 2002.
[5] High river water temperatures also bring the risk that nuclear reactors will not be adequately cooled. In 2003 this caused nuclear reactors in Germany and France to be closed.
[6] In a speech the British Prime Minister Tony Blair actually spoke of 26 000 dead and put the damage at 13.5 billion US dollars: Speech given to mark the tenth anniversary of the Prince of Wales' Business & the Environment Programme (abbreviated), London, 14 September 2004 (www.britischebotschaft.de/de/news/items/04091.4.htm, 4 October 2004).
[7] Münchner Rück (2006)

the future, as a major contribution of the damage increase measured by insurance companies result from the fact that the wealth of the society is increasing as well as the vulnerability. Because of increasing wealth and insurance density wealthy nations tend to move also to especially vulnerable regions, as for example Florida.

Different sectors are affected by climate change (Tol (2001), (2002), Tol et al. 2004, Nordhaus and Boyer 2000, Fankhauser 1994, Hope 2004, Pittini and Rahman 2004 and Schellnhuber et al. 2004, Kemfert (2002a), (2002b), (2007)). The agriculture and forestry sector suffers from extremely hot days during summer as forest fire will increase. Water scarcity could bring negative growth effects. Forest cultivation needs to be changed, as mixed forest are more resistant against climate change than monocultures. Especially agriculture and forestry have to increase expenditures for adaptation. Because of more intense rainfall some regions are more vulnerable to flooding which can cause damages to buildings and infrastructure. Together with the increase of extreme hot summer days, less cold winter temperature cause a reduction of ice glacier, especially in the Alp region (OECD 2007). This on the one hand cause adaptation costs to tourist branches of the Alp region as well as economic damages from declining tourism.

Extremely hot summer days will also shift tourist areas to less hot regions. As increase of more hot days in the years also reduce labor productivity and increase energy demand for cooling. Furthermore, less availability of cooling water for energy production increase energy costs. Extreme weather events like storms and hurricanes can destroy energy exploitation fields[8]. Energy costs will increase because conventional energy production may be reduced or substituted if not enough cooling water exist in high temperature periods. In addition, indirect energy cost increase because of supply disruptions. An increase of energy costs by 20 % will harm the economy by negative growth impacts of up to 0.5 % of GDP. The financial sector can suffer by different impacts. On the one hand, insurance companies face additional losses because of higher direct damages of climate change. On the other hand, firms listed on the stock exchange can be evaluated negatively if they contribute to climate change or cannot demonstrate a clear strategy for a sustainable development.

Position

- Economic impacts of climate change are large and can increase of up to 8 % of the global GDP;
- Economic damages occur from flooding, extreme heat and intense winds. Insurance companies will suffer as well the agriculture sector, tourism and health;
- Economic costs to change the energy system are high- if the economy does not invest immediately large amounts of R&D expenditures in innovative, CO_2 free technologies, economic costs will be high because of supply disruptions and energy price volatilities;
- Costs of adaptation increase with rising extreme climate events.

References

- Fankhauser, S. (1994): "The social costs of greenhouse gas emissions: An expected value approach." In Energy Journal 15(2):157-184.
- Intergovernmental Panel of Climate Change (IPCC) (2007): Climate Change 2007, Fourth Assessment Report, Scientific Basis, Cambridge University Press, Cambridge 2007.
- Kemfert, C. (2002a): An Integrated Assessment Model of Economy-Energy-Climate – The model WIAGEM. In: Integrated Assessment, Vol. 3, Nr. 4, 2002, S. 281-299.
- Kemfert, C. (2002b): Global Economic Implications of alternative Climate Policy Strategies. In: Environmental Science and Policy, Nr. 5, 2002, S. 367-384.
- Pittini, M. and M. Rahman (2004). The social cost of carbon: Key issues arising from a UK review. in The Benefits of Climate Change Policies. OECD. Paris.
- Stern, N.: The Stern Review (2006): The Economics of Climate Change, Cambridge University Press.
- OECD (2007): Climate Change in the European Alps: Adapting Winter Tourism and Natural Hazards Management. Paris.
- Tol, R.S.J. (2001). "New Estimates of the Damage Costs of Climate Change, Part I: Benchmark Estimates". Environmental and Resource Economics.
- Tol, R. S. J. (2002). Estimates of the Damage Costs of Climate Change, Part II: Dynamic estimates. Environmental and Resource Economics 21: 135-160.
- Tol, R., T. Downing, O. Kuik and J. Smith (2004). "Distributional aspects of climate change impacts." Global Environmental Change: Special Edition on the Benefits of Climate Policy Part A, 14(3): 259-272.
- Nordhaus, W. and J. Boyer (2000). Roll the Dice Again: Economic Modeling of Climate Change. Cambridge, MA: MIT Press.

[8] In Summer 2006, hurricane „Katrina“ destroyed oil platforms in the Golf of Mexico. The Gulf region is especially vulnerable to climate change. The oil price increased because of supply disruption of up to 80 $ per barrel.

- Schnellnhuber, J., R. Warren, A. Haxeltine and L. Naylor (2004). Integrated Assessment of Benefits of Climate Policy. in The Benefits of Climate Change Policies. OECD. Paris.
- M. Zebisch, T. Grothmann, D. Schröter, C. Hasse, U. Fritsch und W. Cramer: Klimawandel in Deutschland - Vulnerabilität und Anpassungsstrategien klimasensitiver Systeme, Climate Change 08/05/, 2005, ISSN 1611-8855, S. 122-136.
- Umweltbundesamt: Anpassung an Klimaänderungen in Deutschland - Regionale Szenarien und nationale Aufgaben, Dessau, Oktober 2006.
- Umweltbundesamt: Neue Ergebnisse zu regionalen Klimaänderungen - Das statistische Regionalisierungsmodell WETTREG, Dessau, Januar 2007.
- KLIWA: Klimaänderungen und Konsequenzen für die Wasserwirtschaft. KLIWA Berichte, Heft 4, 2004, http://www.kliwa.de/, zugegriffen am 15.2.2007.
- P. Martens, R.S. Kovats, S. Nijhof, P. de Vries, M.T.J. Livermoore, D.J. Bradley, J. Cox and A.J. McMichael: Climate change and future populations at risk of malaria. Global Environmental Change, 9, 1999, S89-S107.
- WWF: Kosten des Klimawandels. Frankfurt/Main 2007.

Figure 1: Examples of Extreme Climate Events and potential impacts (source: IPCC)

extreme climate event	**probability**	**impacts**
higher maximal temperatures hot days and and heat waves	very high	increase of deaths and serious deseases of elderly people, especially in poor regions; increase of heat stress of animals; silt of ourist areas; increase of risk of crop losses; reduction of energy security; increase of energy demand for cooling
less colder days and reduction of cold waves	very high	reduced death probabilities because of less cold days; reduced risks of crop losses; increase of "tropical" deseases circulation; greater spread of pests; reduced energy demand for heating
more extreme rainfall	very high	rise in damage from floods landslides and avalanches; more soil erosion; higher expenditures by the state on compensation payments; higher risks for insurance companies
rise of summer dry periods and the risk of droughts	high	loer harvest yields; rise in damage to buildings from changes in ground conditions and contraction; reduction in water resources and poorer quality of water; greater risks of forest fire
rise in the strength of hurricanes increase of medium and rainfall (in some regions)	high	greater risk to human life; greater risk for deseases and epidemics; increased coastal erosion and more damage to buildings and infrastructure near to coasts; increase of damage to the ecosystem on coasts
more floods and droughts from the El Nino effect	high	lower agricultural productivity in areas liable to drought and flooding; rise in damage in Central Asia; fewer water resources in drought regions
greater fluctuation in Monsoon rainfalls in Asia	high	more flooding and droughts
greater severity of storms in equatorial regions	low	greater risk to life and health; greater loss of welfare and more damage to infrastructure; more damage in coastal areas

Climate Change Mitigation by Geo-engineering, Potential Side Effects, and the Need for an Extended Legal Framework: the Case of Ocean Iron Fertilization

Mark G. Lawrence[1], Rosemary Rayfuse[2], Kristina Gjerde[3]

It is well established from long-term measurements that carbon dioxide (CO_2) concentrations in the atmosphere are increasing, and this can be attributed largely to the combustion of fossil fuels such as coal and oil. It is also now widely accepted by the scientific community that the balance of evidence points towards this as a primary cause of observed climate changes over the past few decades, according to the recently published fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC).

CO_2 has two main effects on the environment. First, it affects the atmosphere by acting as a greenhouse gas, trapping infrared radiation and warming the lower atmosphere and Earth's surface. Feedbacks in the atmosphere are believed to enhance this effect by leading to an increase in the evaporation of water from the warmer Earth's surface. This in turn increases the amount of water vapor, which is also a greenhouse gas. A wide variety of other effects are expected to result from this warming, including more frequent extreme weather events, more rapid glacier melting, increased input of fresh water into the seas, sea level rise, etc., many of which have already been observed to be occurring.

Second, CO_2 has direct effects on land and marine ecosystems. CO_2 is a key ingredient of photosynthesis, and increased CO_2 is likely to lead to changes in plant growth and speciation. CO_2 also influences ocean acidity, and increased CO_2 is expected to lead to substantial ocean acidification, with accompanying effects on the marine ecology. This is especially the case for marine animals with calcareous shells or structures, such as plankton, krill, corals and mollusks, resulting in impaired growth and dissolving skeletons.

Many different initiatives have been undertaken to counteract the increase in CO_2 and its consequences for climate and ecosystems. These range from various national efforts, for instance encouraging increased use of renewable energy sources, to concerted international efforts such as carbon credit trading under the Kyoto Protocol. Furthermore, a myriad of so-called “geoengineering” techniques have been proposed by the scientific community and the private sector for either removing CO_2 from the atmosphere or somehow counteracting its effects.

This position paper first presents a framework for helping to organize further consideration of these various mitigation possibilities, then focuses in on the issue of whether the current legal framework is sufficient for regulating these efforts, considering particularly the example of ocean iron fertilization. The focus here is on presenting a broad overview at a level that should be understandable to the educated lay public. The interested reader is referred to a more detailed discussion of the scientific and legal aspects of ocean iron fertilization which we have recently published [1].

It is possible to sort the majority of the proposed mitigation efforts into a hierarchy of four basic categories:

1) reducing CO_2 emissions by:

a. providing incentives to reduce total energy consumption (e.g., use of public transit);

b. improving the efficiency of existing fossil fuel combustion engines and power plants;

c. increasing the use of alternate forms of energy production (wind, solar, hydroelectric, nuclear, etc.);

2) removing CO_2 from exhaust directly at the source (e.g., in smokestacks);

3) removing CO_2 from the global atmosphere in a variety of ways, including:

a. chemical and physical sequestration, such as conversion to carbonates, or injection of gaseous CO_2 into underground facilities (including oil wells) or the deep ocean;

b. sequestration by terrestrial biomass (e.g., trees or soils);

c. sequestration by increasing the activity of marine bio

1 Max Planck Institute for Chemistry, Research Group Leader, Department of Atmospheric Chemistry, Mainz
2 Professor of International Law, Faculty of Law, University of New South Wales, Sydney, Australia
3 High Seas Policy Advisor, Global Marine Program, IUCN—The World Conservation Union

mass and thus enhancing the sedimentation of dead organic material to the deep oceans;

4) counteracting the anticipated warming effects of CO_2 by cooling the Earth in a variety of ways, such as

a. injecting sulfur dioxide into the stratosphere to create sulfate particles which reflect sunlight;

b. injecting other reflective nano-particles into the stratosphere;

c. setting up a large solar reflector or an array of these in orbit around the Earth or at the Lagrange point between the sun and Earth.

It seems that the first type of mitigation listed above (perhaps in combination with the second type) is likely to represent the best long-term perspective for reducing anthropogenic climate change. However, international progress on this front has proven to be slow. Given that the amount of CO_2 in the atmosphere is likely to continue to increase over the coming decades, many are looking to the third and forth types of options, i.e., geo-engineering solutions.

Many different issues need to be considered in deciding which of these geo-engineering solutions should be allowed, and what types of economic support should be provided for carrying them out. Some of these issues include:

- How effective are they in removing CO_2 or counteracting its effects? How well can this effectiveness be quantified? Are the mitigating effects long-term, or short-lived? Is the required mitigation effort one-time, or continuous?
- What are the costs of this mitigation? Should these be borne nationally, internationally, or by the private sector, for instance through carbon credits trading?
- What kinds of side affects might accompany the geo-engineering efforts? Can these be monitored effectively?
- What kinds of international rules are in place for regulating proposed geo-engineering activities?

A great deal of literature has begun to appear on these issues in the past several years, but there is still much to sort out. The rest of this position paper focuses in on one specific example of geo-engineering within this context, summarizes some of the key knowledge about it at present, and poses the question whether the international legal framework for regulating it is sufficient at the present time.

One of the many proposed geo-engineering techniques, which has received substantial attention for more than a decade, is the fertilization of phytoplankton (algae) in the oceans using iron. This causes blooms to grow, which draw down CO_2 from the atmosphere for photosynthesis, and convert it to biomass. Some of this biomass will sediment to the deep oceans, either as whole or fragmentary phytoplankton after they die, or as fecal pellets after they are eaten and digested. The potential for this was first realized in the late 1980s based on the research of John Martin, who was trying to understand if there could be a connection between the biosphere and the onset of ice ages. Since his research, there have been about ten large-scale scientific open-ocean fertilization experiments. These have provided a mixed picture of the effectiveness of carbon drawdown and sequestration into the deep ocean. However, a few points have become generally clear:

1) adding soluble iron to patches of the ocean does indeed lead to explosive formation of plankton blooms, which last for varying periods (about a month for a single fertilization);

2) only a small fraction (probably less than 1%) of the carbon which is drawn down from the atmosphere ends up sedimenting down through the ocean mixed layer and into the deep ocean;

3) quantifying the amount of actual deep-ocean sequestration is extremely difficult and highly uncertain;

4) the plankton blooms are accompanied by substantial side effects on the local environment.

The effectiveness and actual costs of iron fertilization are still strongly debated, and it is likely that some scientists would disagree with point #3, claiming that the sequestration can be accounted for accurately by using ocean models. Ocean iron fertilization appears to some to hold enough economic promise that small enterprises have been formed which are speculating on using it to sequester CO_2, which can then be sold for a profit as carbon credits under the Kyoto Protocol. On the other hand, some eminent scientists have concluded already that ocean iron fertilization is likely to be too inefficient to really be an effective mitigation technique [2].

Is it sensible to further consider the effectiveness of the technique in terms of costs and CO_2 removal without first considering whether the side effects (point #4) would possibly or even likely outweigh the benefits? We would assert that it is not. Consider if this approach were applied to testing new pharmaceutical drugs: first determine whether the drugs can be produced for a reasonable price and will at least cure the disease which is being targeted, then go ahead and sell them and let the people who buy them determine for themselves if they have any side effects (dizziness, rashes, partial paralysis, or even death). Since it is now realized that some of the side effects of proposed geo-engineering measures could have serious environmental consequences, leading to economic loss and loss of habitats and even human lives, it is important that we treat geo-engineering with a similar care to testing new drugs. Certainly drugs can be applied, even when they have significant side effects, if it is clear that the positive effects will outweigh the side effects in most cases – chemotherapy is a good example of this. However, it would be irresponsible to market drugs without first undergoing careful, scientifically rigorous testing, and the same applies to geo-engineering. In some ways, the case is made even worse for geo-engineering, since our collective detailed medical knowledge exceeds our understanding of the earth system, and the potential for carrying out statistically robust tests is much greater for pharmaceuticals than for geo-engineering.

For the specific case of ocean iron fertilization, there is already substantial evidence from the scientific investigations that the side effects are likely to be considerable, and may easily outweigh the benefits from reducing CO_2. Attention was already drawn to this possibility over 5 years ago in short articles in Science [3, 4]. In these articles, it was made clear that there are a very wide range of substantial side effects which can be expected, both in the oceans, such as changes in marine ecology, and in the atmosphere, such as changes in emissions of climate-relevant gases. Since then, several scientific experiments on ocean iron fertilization have provided further support for our concerns. On the atmosphere and climate side, for example, nearly all of the predicted increases in trace gas emissions have been shown to actually occur, and several further changes which were not speculated on have also been observed. In particular, increases have been observed [5, 6] for:

- dimethylsulfide (DMS), which can affect clouds and their reflection of sunlight;
- isoprene, which is an ozone-precursor, and is also believed to affect clouds;
- halogen-containing organic compounds, which affect ozone destruction;
- N_2O, a greenhouse gas with a greenhouse warming potential much larger than that of CO_2 (this is particularly disconcerting, since further calculations [7] have shows that this would likely directly offset much of the benefit from a CO_2 reduction, but would still leave all the remaining side effects from ocean iron fertilization).

Furthermore, a few studies have shown that in addition to these effects, the absorption of solar radiation by plankton, which drives photosynthesis, can have a substantial warming effect on the ocean surface, corresponding to about 1 W/m^2 over the fertilized region, comparable to the radiative forcing from anthropogenically enhanced CO_2 [e.g., 4, 8].

Unfortunately, the legal framework for regulating this is not sufficiently comprehensive at the present time. For instance, Q. Schiermeier in Nature [9] indicates that "there is no legal framework to demand a full environmental-impact assessment. International maritime law covers issues such as the dumping of waste material at sea, but contains nothing to prohibit commercial ocean fertilization." Our detailed examination of the legal regime [1] shows the urgency of the extension of the international laws governing the sea to include regulation of fertilization (by iron or possibly other means). Fortunately, over the last year the London Convention has taken up serious discussion of this issue. However, to our knowledge no concerted steps have yet been made towards regulating ocean iron fertilization and its various side effects within the framework of carbon credit trading under either voluntary schemes or the Kyoto Protocol regime.

On the bigger picture, beyond this specific example for ocean iron fertilization, it is certainly sensible to carefully consider geo-engineering techniques, and eventually employ well-tested and well-understood measures to help mitigate climate change. However, it is imperative that a legal framework be developed for ensuring a thorough cost-benefit analysis, including the costs of expected side effects, before geo-engineering techniques are allowed to be applied on a renegade basis, which could end up resulting in small-scale or perhaps even large-scale environmental disasters which rival or outweigh the difficulties which are already anticipated from increasing CO_2.

Disclaimer:

The views expressed herein are based on our individual scientific and legal expertise and do not necessarily represent those of the Max Planck Institute for Chemistry, the University of New South Wales, or the IUCN.

[1] Rayfuse, R., Lawrence, M. G., Gjerde, K., Int. J. Mar. Coast. Law, 23, 297-326, doi: 10.1163/092735208X295846, 2008.
[2] Buesseler, K. Boyd, P.W., Science, 300, 67-68, 2003.
[3] Chisholm, S. W., Falkowski, P. G., Cullen, J. J., Science, 294, 309-310, 2001.
[4] Lawrence, M. G., Science, 297, 1993, 2002.
[5] Liss et al., Tellus, 57B, 269-271, 2005.
[6] Wingenter et al., Proc. Natl. Acad. Sci. USA, 101, 8537-8541, 2004.
[7] Jin, X., Gruber, N., Geophys. Res. Lett., 30, 2249, doi:10.1029/2003GL018458, 2003.
[8] Lefevre, N. , et al., Geophys. Res. Lett. 28, 1251–1254, 2001; Frouin, R., Iacobellis, S. F., J. Geophys. Res., 107, 4377, doi:10.1029/2001JD000562, 2002.
[9] Schiermeier, Q., Nature, 421, 109-110, 2003.

Investments in Reducing Forest Related Emissions: Integrating Climate, Development, and Biodiversity Protection Goals

Martin Welp

- University of Applied Sciences Eberswalde

1. Land use and forest related emissions

Climate change mitigation will require substantial cuts in greenhouse gas emissions and subsequently considerable changes in the global energy system. When and how a transition to carbon–reduced or carbon-free economies can be reached is subject to heated debates. Forest protection is, besides increasing energy efficiency and different technologies for producing climate friendly energy, a way to reduce global emissions.

Recent estimates published in the IPCC WGI Summary for policy makers (2007) indicate that land use change contributes to a considerable extent to greenhouse gas emissions. Of the annual CO2 emissions of 8 GtC (Gigatons of Carbon) about 1.6 (20%) are associated with land-use change, although the estimates have large uncertainties[1] . Part of this land use change is associated with global deforestation. The Stern report (2006) highlights non-energy emissions, such as avoiding deforestation as one of four major ways to cut Greenhouse-gas emissions. According to the report more than 18% are caused by deforestation, which is more than what the transport sector produces. Furthermore it suggests that action to prevent further deforestation would be relatively cheap compared with other types of mitigation, “if the right policies and institutional structures are put into place”.

2. Past efforts to halt deforestation

Already in the late 1970s and especially in the beginning of 1980s the destruction of forests, in particular tropical rainforests, received considerable public attention. At this point concerns about the climate effects were not as explicit as they are now. As a response to the threat to global biodiversity the international community took political action and started to invest in so called Tropical Forestry Action Plans (TFAPs). In some countries these were also called Forestry Master Plans. World Resources Institute, The World Bank, and UNDP prepared investment programmes for 56 countries (Liss 1999). This was implemented very much as a sectoral planning exercise. It was afterwards criticized that these plans did not take adequate account of deforestation's root causes (Sizer 1994). These include for example unclear tenure questions, poverty, inadequate economic incentives, and the lack of participation on community level. Thus TFAPs were not successful in halting deforestation. It was moreover criticized, that these plans did factually not take conservation issues seriously.

In the absence of a global forest convention and adequate international agreements, market based mechanisms, such as the Forest Stewardship Council (FSC) and other competing certification mechanisms have been further examples of efforts to halt unsustainable forest use. However, neither past policies, nor science has been successful in halting deforestation. Whitten et al. (2001) note critically that: “We are active for sure, but in the end we are failing to make a global difference”.

3. What kind of investments are needed now?

Clarifying ownership questions and enforcing clear property rights to forest land is a necessary precondition for sustainable management and one area where investments are needed. Land tenure is very much a question of national policies, and investments are needed in capacity building within forestry and related sectors, including awareness raising regarding different kinds of property regimes. International frameworks such as the United Nations Forum on Forests may play a supporting role in such efforts. The Stern Report mentions a number of ways to invest in forests, including: debt forgiveness in return for forest protection, using insurance markets to protect forest, and international finance to back national action.

Compensations from the international community to protect forests is a further way to stop deforestation. The Stern report

[1] There is, according to IPCC WGI, 5% likelihood that this value could be below 0,5 GtC and a 5% likelihood that the value could be above 2,7 GtC.

(1996) suggests that the opportunity costs in 8 countries responsible for 70% of the global emissions from land use could be about $5 billion annually (over time these costs may rise however). Countries such as Mexico and Costa-Rica have successfully included such compensatory payments in their forest protection programmes. Carbon markets may provide right incentives, and forests could be included in the second commit period of the Kyoto protocol in a more simple and transparent way.

Private investments in the forestry sector can play a positive role as well. If ownership questions are clear and the conditions for sustainable forestry are given; the owners (private owners, communities or private companies) are likely to have long term interest in the forests. Although managed (commercially used) forests do not store as much CO_2 as old growth forests or more natural forests, the forest cover is not removed permanently causing erosion changes in microclimate and the loss of the capacity to store carbon. Interest in wood biomass for energy may attract more private investments in future.

There are synergies between sustainable forestry and climate mitigation: timber can provide a substitute to energy intensive materials such as concrete in the building industry and wood biomass can replace fossil energy sources. No clear picture has emerged of the feasibility and scope of using biomass on a large scale for energy. In industrial countries wood biomass is used for heating, producing electrical power, and to a very small extent fuels for the transport sector (ethanol and methanol). In developing countries fuelwood is used for cooking in particular. One should keep in mind that worldwide fuelwood accounts for more than 50% of all roundwood consumption. With increasing fossil fuel prices the industrial use of wood for energy is becoming competitive. Whether wood for energy is a viable alternative depends on a range of factors, among others on the competing uses of wood. The overall demand for sawnwood, panels, pulp and paper and other forest products will continue to increase and thus the price trends for roundwood and wood fibre for these purposes play an important role.

Wood sources for energy vary greatly and include among others: forest round wood (including logging residues), wood from short rotation plantations, residues from pulp- and papermills and sawmills, as well wood residues from construction and demolition. Large-scale use of wood for energy would imply using residues effectively and, more importantly, intensifying the use of forests for energy. This can have positive effects on forests such as increased forest health through intensified silvicultural practices. On the other hand there are major environmental concerns, in particular impacts on biodiversity, landscapes and other services provided by forests, which limit the prospects for expanding the use of wood for energy. With respect to short rotation plantations the use of fertilizers and genetically modified seedlings increases the environmental risks. In this field investing in technological innovations and research on the impacts is needed.

4. Conclusions

Investing in the protection of forests has several economic and environmental benefits. Besides climate mitigation it is important in several other respects: environmental services, such as water balance and water quality, protecting biodiversity, and erosion control. Furthermore the sustainable use of forest resources serves development goals; providing livelihoods for rural population (European Forest Institute 2002).

One may rightly argue that past efforts such as Tropical Forestry Action Plans were not very successful. However efforts in the 1970s to reduce energy consumption, to increase the share of renewables were not very successful either. Energy consumption, as well as the rate of deforestation continued to grow. Investments of a different order of magnitude are needed in both areas. With respect to forests now that the climate is at stake, the impacts will not be remote: many of impacts of deforestation in the Amazon are not directly felt in developed nations, but the climate impacts will.

Investments in forests are likely to increase if they provide a source of income and livelihood on long time span. It is necessary to experiment and create institutions that help to protect the world's forest cover (community based forest management, compensations, technological innovations, etc.). The opportunity to have a considerable impact on greenhouse gas mitigation through protecting forests, with relatively modest investments should not be left unused. Besides energy related investments we need to address all other major sources of greenhouse gas emissions including forests.

References

- European Forest Institute (2002). Forests in Poverty Reduction Strategies: Capturing the Potential. Forests in Poverty Reduction Strategies: Capturing the Potential, Tuusula, Finland.
- IPCC (2007). Climate Change 2007: The Physical Science Basis. Summary for Policy Makers.
- Liss, B.-M. (1999). The Role of the Tropical Forests Action Programme and National Forest Programmes in Sustainable Forest Development. Formulation and Implementation of National Forest Programmes Volume I: Theoretical aspects. G. O. P. Glück, H. Schanz and K-R. Volz, EFI Proceedings 30.
- Tony Whitten, D. H., Kathy MacKinnon (2001). "Conservation Biology: a displacement Behaviour for Academia." Conservation Biology 15(1): 1-3.
- Sizer, N. (1994). Opportunities to save and sustainably use the world's forests through international cooperation, World Resources Institute: 28.
- Stern, N. et al (2006), Stern Review: The Economics of Climate Change, HM Treasury, London.

A SuperSmart Grid for Climate and Energy Security in Europe and Beyond

Antonella Battaglini, Johan Lilliestam

- Potsdam Institute for Climate Impact Research (PIK)

The energy future we are facing today, based on projections of current trends, is dirty, insecure and expensive. We know that new government policies can create an alternative energy future, which is clean, clever and competitive. Without additional measures, global energy demand increases by 53% between now and 2030 (EIA 2006:7). Over 70% of this increase comes from developing countries, led by China and India (EIA 2006:7). Under these circumstances, competition in securing energy sources is due to grow exponentially, with unforeseeable consequences also for Europe. Moreover, climate change is already happening with impacts occurring around the globe. If the current energy path is not modified, dangerous climate change will not be prevented (IPCC 2007). Strong policy actions are needed to move the world onto a more sustainable energy path, meet energy demand, and prevent dangerous climate change.

In Europe, the narrow national approach has to be overcome to meet Europe's climate commitments and secure future energy supply. To bring the international climate protection process forward, it is necessary that Europe speaks with one voice. A Europe wide energy policy is urgently required. This policy should strive for energy security and climate security. The ability of Europe to go beyond Member States' national interest is an essential step to become a reliable international partner.

To reach energy and climate security, a visionary approach is required. One such vision is to connect all EU Member States with a truly international electricity grid and eventually to extend this to Africa with its enormous potential for solar and wind power. This vision is not new, but it is only recently, with rising climate concerns and worries about the security of supply, that business and politicians have started to take notice of it. This paper discusses the need for Europe to build a pan-European SuperSmart Grid within the coming decades, say the next 30 years, as an essential component for guaranteeing energy supplies, meet the required emission reductions and prevent dangerous climate change.

The Grid

Whatever the energy sources of the future electricity production will be, it is already clear that the current grid in Europe is outdated and unable to satisfy the growing and changing electricity needs (e.g. Czisch 2001:52). We today need to imagine a grid capable of satisfying Europe's need in 100 years time.

The current European grid lacks the flexibility required by our modern societies to receive electricity from several different sources and transport it in different directions (e.g. DENA 2005:64ff). In other words, the grid we have today is not only an old grid but it is also not a SmartGrid. Massive investments are anyway needed in the coming years to keep the grid operating (EWEA 2005:6). We need to design a political framework to build it and have it operational within the next 10 years. Such a grid should allow the transport of energy over long distances, it should be flexible enough to handle different loads and allow feed-in from multi-sources, thus permitting a combination of centralized and decentralized energy production. The technology for a SuperGrid is already available and already tested. It was developed in the 1930s and the first commercial installation was realized already in 1951 in the former USSR between Moscow and Kashira. Today, many high voltage direct current (HVDC) lines are in place in different countries, for example a 1700 km long line between Kolwesi and Inga in D.R. Congo, a 2000 MW line between Les Mandarins, France, and Sellinge, UK, two Chinese 900 km long 3000 MW lines from the Three Gorges Dam to Zhengping and Huizho and the 600 MW line under the Baltic Sea between Sweden and Germany. These HVDC lines can transport electricity over thousands of kilometres with only negligible losses, some 3% per 1000 km in comparison to the usual AC transmission losses of 7,5% (Philips 2000; DLR 2006; Czisch 2005).

The dense population in Western and Central Europe is a major constraint for these regions to cover their energy needs with domestic renewable and carbon-neutral energy (Czisch

2004:2). The peripheral Member States have large potentials for an expansion of different renewable energies: wind power in the north and west, bio energy in the east and north, solar power in the south and hydro power in the mountainous regions in the middle and north (BMU 2006:5). While the conventional energy carriers, like coal and gas, can be moved great distances before getting utilized for electricity generation, the renewable energy sources, except bio energy, cannot be moved but must be exploited at the site where they are found. With a suitable infrastructure for transporting electricity from these regions to the consumption centres, the peripheral EU regions could become the European renewable power houses of the 21st century; substantially contribute to reduce green house gases emissions and lower dependence from energy imports (see Figure 1). Creating such inter-Member State infrastructure requires old thinking-patterns to be abandoned and replaced by a new pan-European energy paradigm. This is a matter that cannot wait: creating the framework needed for the SuperSmart Grid today can secure the energy and climate protection requirements Europe needs in the future.

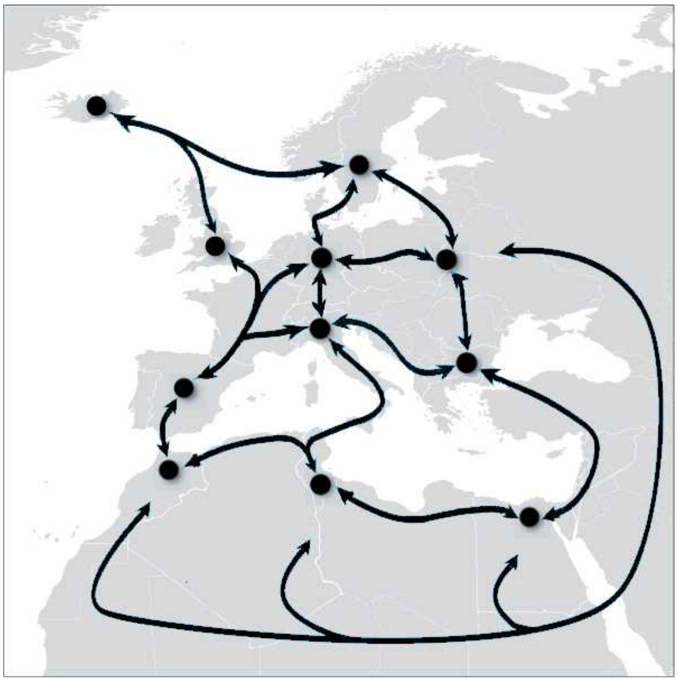


Figure 1: The vision of a pan-European HVDC SuperSmart Grid for renewable electricity with extensions to Northern Africa.

The Challenge

Discussions about building a grid which is not limited by bottlenecks and administrative barriers at national border have been carried out for long time and it is now clear that it is very likely that this will happen in any case, at least with an AC grid, but it will take too long time. To meet our energy and climate needs we are facing the task of designing a framework to have the grid covering all of Europe and beyond within the next 20 years. Today, the realization of a SuperSmart Grid faces two main challenges:

1. Creating a political framework for planning, constructing and operating the SuperSmart Grid,
2. Financing the construction of the SuperSmart Grid.

1. Framework

In the current political climate and energy framework, electricity imports from outside the EU and massive transmission of renewable electricity between Member States are not foreseen. With the Commission's proposal on a new Renewables Directive, this question has become more dynamic than ever, but still it remains to see what the final Directive says. And regardless of this, the European electricity market is still fragmented, and the current grid cannot handle the large-scale, long-distance bulk electricity transfer that is required. In order to solve these problems and stimulate large investments in renewable electricity generation capacity both within Europe and in North Africa as well as in an HVDC grid connecting the two regions, a stable and clearly defined political framework is needed. A clear, long-term Renewables Directive is one necessary step, as is a clear signal on how the future internal electricity market will look. For the second part, the experiences from the Scandinavian countries, which unified their power markets during the 1990s, can be used for lesson-drawing as a best-practice example.

We suggest as an initial step in continental Europe the realisation of a similar framework, including the option to build HVDC transmission lines, to be realised between Germany and Italy for lines extending to the Northern African coast. Germany is one of the most progressive countries in terms of climate policy and one of the most aggressive countries in terms of supporting expansions of renewable energy sources and the technology attached to it. Italy is one of the biggest importers of energy not only in Europe but worldwide. Moreover, Italy, as several other Member States, is struggling to meet its climate targets. Italy's geographical location elects it as an ideal bridge between continental Europe and the African coast with its huge potential for renewable energies. The economic potential for solar power in the coastal countries of Northern Africa is estimated to some 400 000 TWh/a (Greenpeace 2005:42) which can be compared with the EU25 electricity demand of 3100 TWh/a (European Commission 2005:36). The interest of Northern

African countries to become suppliers of electricity for Europe is straightforward and the implications for local economic development are manifold (see DLR 2005). Also Europe has a vested interest in developing the Northern African countries as a way to stabilize relations, influence migration patterns and develop new markets.

2. Financing

The key issue to financing the SuperSmart Grid is investment security (Helm 2005:7). Investors should have the confidence to recover their investments within a reasonable time frame. Policy has therefore the task to put in place legislations to ensure this and provide the long term perspective required.

In order to realise the SuperSmart Grid quickly, some financial help from public funds will be needed. A way to raise public funds for this operation could be to auction a share of the emission allowances (e.g. a 20% auctioning of combined Italian and German allowances would raise – at today's future price – some 2 billion €/year) and channel the funds into the realisation of the grid.

A task force should be put in place to address the following questions:

1. What are the key elements necessary in the framework to unable the construction and the operation of the grid in the first phase, where Germany, Italy and Northern Africa are connected (via Austria or Switzerland), and its extension/connection to new regions in the second phase?
2. How can investment risks and political risks with a SuperSmart Grid scheme with considerable electricity imports to Europe from North Africa be minimised?
2. What is the share and the amount of public and private funds needed to build the grid? How can public funds be raised?
3. Which are the pillars of the road map we need to follow to have a European wide grid in place within 20 years?

It is clear that the realisation of a grid which is Super and Smart and widely spread as depicted in figure 1, will require most likely over 50 years time. However in the coming two decades major steps forwards can be made in substituting the old European lines with new HVDC lines. In the short term, these nets will allow the creation of the strongly needed regional Super-Smart Grids; form the bases for inter-regional connections, and eventually realise the visionary Pan European Grid.

Europe's ability to move fast on this issue is the key for Europe to become a leader in innovations and carbon-neutral technology, thus enabling Europe to be the exporter of climate solutions.

References

- Czisch, G. (2001): Interkontinentale Stromverbünde – Perspektiven für eine regenerative Stromversorgung, in: FVS Themen 2001, p. 51-63, Forschungsverband Sonnenenergie, Berlin.
- Czisch, G. (2004): Least-Cost European/Transeuropean electricity supply entirely with renewable energies, Institut für Solare Energieversorgungstechnik, Kassel.
- Czisch, G. (2005): Szenarien zur zukünftigen Stromversorgung, Universität Kassel, Kassel.
- DENA (2005): Energiewirtschaftliche Planung für die Netzintegration von Windenergie in Deutschland an Land und Offshore bis zum Jahr 2020, Deutsche Energie-Agentur (DENA), Berlin.
- DLR (2005): Concentrating solar power for the Mediterranean region, German Aerospace Center (DLR), Berlin, Stuttgart.
- DLR (2006): Trans-Mediterranean interconnection for concentrating solar power, German Aerospace Center (DLR), Berlin, Stuttgart.
- EIA (2006): International Energy Outlook 2006, Energy Information Administration, Washington.
European Commission (2005): Energy & Transport in figures 2005, European Commission, DG Energy and Transport, Eurostat, Brussels.
- Greenpeace (2005): Exploiting the heat from the sun to combat climate change. Concentrated solar power – NOW!, Greenpeace International, Amsterdam.
- Helm, D. (2005): Securing supplies and meeting the challenge of climate change, New College, Oxford.
- IPCC (2007): Climate change 2007: The physical science basis. Summary for policymakers, International Panel on Climate Change, Geneva.
- Philips, G. (2000): Domestic energy use in the UK. Power conversion, transport and use, Powerwatch, http://www.powerwatch.org.uk/energy/graham.asp

Climate and Energy Perspectives

Lennart Bengtsson

- University of Reading and Max Planck Institute for Meteorology

1. Introduction

During the last 100 years the temperature of the Earth has increased by about 0.8 C. The warming is likely to accelerate. During the last 30 years the warming has been as high as 0.5 C in spite of two major volcanic eruptions that cooled the climate system during the same period. There is now a broad agreement that the main cause of the global warming is the increase of the greenhouse gases in the atmosphere (1). This has disturbed the Earth's heat balance leading to a reduction in the planetary heat radiation to space. Even if the emission of greenhouse gases would suddenly stop the warming will continue to add about another 0.5 C to the lower atmosphere. The main reason for the delayed warming is the inertia caused by the huge heat capacity of the oceans.

An analogue inertia exists in the world's energy systems. In spite of major efforts to reduce the emission of CO_2 and other greenhouse gases the direct radiative forcing effect on climate has increased by 22% since 1990 (2). The dominant part of this increase is due to higher emission of CO_2. A considerable increase has taken place during the very last years and the emission of CO_2 now amounts to ca 30 Gton/year or 1000 ton/sec. One reason for the recent rapid increase is the ongoing industrialization in China and in other countries outside the OECD. The recent projection by the International Energy Agency (IEA) (3) of the Total Primary Energy Supply (TPES) indicates a further increase by 48% from 130 PWh in 2004 to 192 PWh in 2030. 1 PWh is equal to 3.6 EJ (10^{18}Joule).

The proportion of fossil fuel of TPES is presently around 80%. This proportion has decreased by a few percent during the last 30 years mainly due to nuclear energy but is not expected to change noticeably in the near future. The IEA estimate of TPES is not necessarily on the high side and has in fact been somewhat upgraded compared to the previous IEA report in 2004. A part of this is due to the development in China where a previous TPES projection in 2002 was significantly underestimated. Another trend is the increasing use of coal for energy production presumably due to the increasing cost of natural gas and oil.

The consequences of this perspective for the climate are potentially severe. The combined inertia of the climate system and of the world's energy systems make it virtually impossible to avoid a CO_2 increase to some 450 ppm in 2030 and a further increase in global temperature of 1-1.5 C likely to be realized in the time frame 2030-2050. This follows broadly the SRES scenario A1B. It will be necessary to start to adapt to these changes, which now can be considered as unavoidable.

2. Adaptation to a warmer climate

Possible changes in extreme weather events for the next 25-50 years such as devastating cyclones have got considerable media and public attention but are not likely to be very much worse than at present. It is to be expected that the world community will be able to cope with this more or less in the same way as now. Certain extreme weather events such as tropical cyclones and excessive local rainstorms may be slightly more intense but damages and loss of life are more determined by other factors such as local environmental problems, poor preparations for extreme weather events and overpopulation in areas not suitable for a large population. In fact, more support for help for weather related damages in many parts of the world is urgently required in the present climate independent of any climate change. And because of the complexity of the system it will not be possible to determine whether a particular severe weather event is due to natural processes or to what degree it is affected by climate change.

Preparations for extreme heat waves in areas where they previously have been extremely rare such as in Central Europe in 2003 will probably be needed. However, it should be noted that the almost equally warm summer of 1947 in this respect passed unnoticed as at this time the population had another perspective of disasters as the World War II ended two years earlier. Even worse heat waves in US do not cause any severe problem due to the existence of air conditioning facilities. Have these been more common in Europe in 2003 many of the 35 000 people who died of heat exposure could have been saved.

Probably a larger concern should be devoted to changes in the atmospheric water cycle. One of the robust features of climate warming is the rapid increase in atmospheric water vapor as this increase follows the Clausius –Clapeyrons relation. However, the increase in precipitation is much slower as precipitation is controlled by evaporation, which in turn is driven by the surface heat balance. This leads to an increase in the residence time of water in the atmosphere also increasing the difference in precipitation between wet and dry areas (4). A consequence of this is that areas, which now have too little precipitation, are likely to have even less and in areas with high precipitation a further increase can be expected. An additional feature of climate change is a gradual pole-ward transition of the extra-tropical storm tracks. This expected change in climate is expected to create water problems in the Mediterranean region, in southern California, southern Australia and southern Africa due to a reduction in winter precipitation. Maybe Europe here should commence planning for large-scale transport of fresh water from northern to southern Europe. Alternatively more energy will be required for desalination plants.

3. Reducing other greenhouse gases

CO2 is not the only greenhouse gas in the atmosphere. Efforts should in any case be strengthened to further reduce other greenhouse gases such as methane, nitric oxide, tropospheric ozone and CFCs as well as heat absorbing aerosols such as soot or black carbon (5). All efforts need to be done to reduce or eliminate greenhouse gases with exceptionally long residence time in the atmosphere even if the present effect on climate warming is small. This includes sulfurhexafluorid, SF6.

4. Planning realistic energy systems for the future

Notwithstanding changes in the global energy systems which can only be done in a minor degree in the next two decades it will be urgently needed to make realistic plans now to have new energy systems ready to be put into use in some 15 to 20 years from now. It is important in my view that such plans are realistic and not driven by wishful thinking. The drive for a better life in the third world requires more energy and mainly in the form of electricity. (The TPES per capita in the Chinese Taipei is still more than three times that of China and the CO2 emission per capita is also more than a factor of three higher). Fossil fuel will likely continue to be the main energy system but needs to be complemented by nuclear energy. And we also need a functioning energy system sufficient for the world's population at a time when fossil fuel has been exhausted. The taboo against the use of nuclear energy must be lifted. It is quite unrealistic to believe that energy from wind, solar and bio-energy can fill the gap of fossil fuel on a global scale (6). The reason is the poor energy density and the fact the energy generation from these sources cannot easily be coordinated with the use of energy. Additional aspects are environmental damages due to excessive use of bio-energy and associated threat to biodiversity. The energy cost for producing ethanol from agricultural products can be almost as energy costly as the energy obtained from ethanol. Instead it may be more sensible to instead enhance the biological sink.

5. Priority given to CO_2 sequestration

Major efforts should be devoted to sequestration of CO_2. This could probably safest be done at the larger energy producing systems such as in association with major electrical power plants. But it could presumably also be accomplished elsewhere. Whether such systems are economically feasible and where they should be built should urgently be investigated.

6. Implementing energy conservation

What then are feasible mechanisms for encouraging a reduction in greenhouse gas emission in the atmosphere? The present system within EU with carbon emission permits for greenhouse gases has not yet been successful. The cost of the carbon emission permits fell from Euro 32 on 24 April 2006 to Euro 1.20 at 15 February 2007. Those who bought such permits have not made a very good investment. A possible reason is that too many emission permits were issued presumably because of concern for business. And it highlights what happens when long-term objectives such as concern about the future climate comes into conflict with short-term concern for business and jobs. In such cases it is no surprise that political leaders are forced to apply Realpolitik. And I am afraid that any well-meant scheme to reduce greenhouse gas emissions, however clever it may be labeled or presented, will not work when it is interpreted as a potential threat to the economy. What are needed are realistic technological solutions, which can do the job. And such solutions will require massive long-term investment that requires state support and guaranties; such an approach existed when the present installations for hydro- and nuclear electricity generations were built in the 20th century in many countries. It will also be necessary for the industry to take an overall responsibility and not just give priority to short-term profits and concern about the stock market. So I believe we need a close partnership between industry and governments to achieve this. And such initiatives are needed now as else there are severe risks that the world will face serious economical problems in the future due to lack of suitable energy or facing insurmountable environmental challenges or both.

Needless to say, there are many promising development that would significantly reduce the cost for the warming and cooling of homes and offices such as better insulation and the use of heat exchange systems. This will help reducing energy waste. This is progressing well but more factual information to the general public is required, including more economical incentives for more efficient use of energy. It is surprising, for example, that UK needs some 40% more energy for heating homes compared to Sweden. Energy can also be significantly reduced in the transport sector using more advanced engines, lighter cars and hybrid techniques. Here the European car industry has been much later in coming then that of Japan.

7. Geo-engineering ideas

Several such ideas have been proposed recently. To fill part of the space between the Earth and the sun with reflecting mirrors or regularly pump millions of tons of sulfur particles in the stratosphere to reflect solar radiation (7) does not seem very sensible, nor is it very practical. I consider such proposal unrealistic and potentially dangerous. Moreover, they will distract from sensible ways to solve the energy problem. The climate system is enormously complex and hardly predictable in its details so we will never know how the climate system will respond. Besides efforts to control climate by geo-engineering requires commitments over many hundred years. This is hardly politically credible (8)

8. Summary

A. As a considerable and an unstoppable climate change undoubtedly is underway on a time scale of some 25-40 years highest priority should be given to adaptation including adaptation to severe weather events in the present climate. Major considerations should be given to expected water problems in parts of the world where reduced precipitation is expected.

B. Urgent actions should be given to sequestration of CO_2 in order to reduce the CO_2 burden on the atmosphere.

C. Reduction of other greenhouse gases other than CO_2 including heat-absorbing aerosol such as black carbon

D. Replacement of inefficient heating systems and more energy efficient vehicles

E. Realistic energy systems are needed including nuclear energy. The nuclear energy taboo must be lifted and efforts to develop the 4th generation nuclear energy systems and fusion energy need to be accelerated. Here we need a new Manhattan type project.

References

- IPCC Report (2007).
- http://www.cmdl.noaa.gov/aggi/index.html, See figure 3.
- IEA (2006): Key World Energy Statistics.
- Held and Soden (2006): Journal of Climate.
- Hansen et al (2000): Natl. Acad. Sci.
- Bengtsson (2006): The Global Energy Problem, Energy and Environment, Vol. 17, No. 5.
- Crutzen (2006): Climate Change.
- Bengtsson (2006): Climate Change.

Canada's $100 Billion Oil Sands Investments: Can it Be Greened?

Matthew Bramley[1], Dan Woynillowicz[2]

- Pembina Institute

Abstract

Up to C$125 billion will be invested in developing Alberta's oil sands between 2006 and 2015. As a result, Canadian oil sands production could by 2020 be generating twice the amount of greenhouse gases (GHGs) as the total emissions of a country such as Sweden. The non-climate impacts of oil sands development are also large and serious. We describe and elaborate briefly on six potential policy levers that could make Alberta's oil sands investment more climate-friendly and/or redirect capital into more sustainable options:

- GHG emission reduction requirements, including a requirement for carbon neutral oil sands production
- requirements to use low-GHG technologies such as carbon capture and storage
- reform of royalty and tax regimes
- measures to address non-climate impacts
- demand reduction measures, such as regulated vehicle efficiency standards
- life-cycle fuel carbon content requirements, as recently announced by California.

1. Oil sands: the problem[3, 4]

The 174 billion barrels of recoverable crude bitumen in Alberta's oil sands make Canada's oil reserves second in size only to those of Saudi Arabia. The total size of Alberta's oil sands resource is estimated to be 1.7 trillion barrels.

A rapid acceleration is taking place in the extraction of bitumen and its upgrading into synthetic crude oil. Production of synthetic crude oil from Alberta bitumen already exceeds 1 million barrels per day and will reach 4.8 million barrels per day by 2020 if all publicly announced projects proceed as planned. Some energy analysts have projected production as high as 11 million barrels per day by mid-century.

The associated investments are enormous by any standards. Capital expenditures to construct all announced projects between 2006 and 2015 total about C$125 billion. The National Energy Board's "base case" estimates these expenditures to be about C$95 billion even when potential delays and cancellations are taken into account.[5]

Production of a barrel of synthetic crude oil results on average in more than three times more greenhouse gas (GHG) emissions than production of a barrel of conventional light or medium crude oil. This is because natural gas is combusted to heat the bitumen and separate it from the sand. Upgrading of the bitumen, which mostly takes place in Alberta, results in considerable additional GHG emissions, notably from hydrogen production.

Projections made by the Pembina Institute on the basis of all projects announced by December 2005 show GHG emissions from oil sands production (including upgrading occurring in Canada) rising from 25 megatonnes of carbon dioxide equivalent (Mt CO2
e) in 2003 to 84–94 Mt in 2012 and 113–142 Mt in 2 2020 – assuming that the GHG intensity of production does not fall much more rapidly than would be expected under business-as-usual conditions. This means that Canadian oil sands production could by 2020 be contributing twice as much to climate change as the total emissions of a country such as Sweden.

[1] Director, Climate Change (Ottawa-Gatineau), matthewb@pembina.org.
[2] Senior Policy Analyst (Calgary), danw@pembina.org.
3 Bramley, M. et al. (2005), The Climate Implications of Canada's Oil Sands Development, Pembina Institute, http://www.pembina.org/climate-change/pubs/doc.php?id=586.
4 Woynillowicz, D. et al. (2005), Oil Sands Fever: The Environmental Implications of Canada's Oil Sands Rush,
5 Pembina Institute, http://www.pembina.org/climate-change/pubs/doc.php?id=203.
National Energy Board (2006), Canada's Oil Sands, Opportunites and Challenges to 2015: An Update, p.11–12,http://www.neb.gc.ca/energy/EnergyReports/EMAOilSandsOpportunitiesChallenges2015_2006/EMAOilSandsOpportunities2015Canada2006_e

Beyond its impacts on the climate system, oil sands development consumes large amounts of fresh water[6]; creates enormous toxic tailings ponds and large volumes of harmful sludge; drastically alters the landscape, fragmenting and removing large areas of natural habitat, notably wetlands[7]; and produces large increases in air emissions of toxic and acidifying contaminants.

2. Policy levers

A variety of potential policy interventions by the federal and provincial governments could make Alberta's oil sands investment more climate-friendly and/or redirect capital into more sustainable options. Below we describe and elaborate briefly on six such potential policy levers.

2.1 GHG emission reduction requirements

The most obvious policy lever is the establishment of mandatory GHG emission reduction targets for oil sands facilities.

The government of Alberta took a first step in this direction in March 2007 by announcing a regulation that will require all established facilities with annual GHG emissions of at least 0.1 Mt to meet targets to limit their GHG intensity (emissions per unit of production) to 12% below average intensity for 2003–05, starting in July 2007. "New" facilities – those beginning operation in 1999 or later – will be exempt for their first three years of operation and then face targets that gradually increase to reach, in the ninth year of operation, 12% below the intensity measured in the third year. Targets can be met by making payments at a rate of C$15/tonne CO_2e into a "technology fund" and by purchasing offset credits from projects undertaken in Alberta. At this time, there is no requirement to demonstrate that offset projects go beyond business-as-usual.

The Pembina Institute has been highly critical of this regulation because it will allow GHG emissions (as opposed to GHG intensity) to continue to rise rapidly, because there is no guarantee of real emission reductions from the technology fund or offset credits, and because its loopholes create uncertainty for investors.

At the time of writing, the federal government is about two weeks away from announcing its own proposal to regulate GHG emissions from Canadian heavy industry sectors. The government has made clear that its targets will also be established in terms of GHG intensity, rather than actual emissions, but the level of the targets and other details, such as emissions trading, remain unknown. A leaked early version of the government's proposal included a target to reduce the GHG intensity of the oil sands sector to 40% below the 2000 level by 2020. But if all announced oil sands projects go ahead, this target could be met while actual emissions from the oil sands increase more than three-fold.[8]

The Pembina Institute has proposed instead that Canadian heavy industry should face targets for GHG emissions (not intensity) during 2008–12 set at Kyoto levels, i.e., 6% below 1990 emissions, and have access to foreign Kyoto-certified project-based credits as well as a guaranteed $30/tonne domestic compliance option. We believe our proposal is affordable because it would result in additional costs for oil sands producers on the order of only US$1 per barrel.[9] This means that producers would be required to make an additional investment in GHG reductions equal to only about 7% of their capital investment in new projects.[10]

We have also analyzed the opportunity for oil sands production to become fully carbon neutral (zero net GHG emissions) by 2020, using a combination of energy efficiency, fuel switching, carbon capture and storage (CCS – see box) and emissions trading. Estimated costs range from US$1.76 to US$13.65 per barrel. These estimates are conservative because CCS costs will decrease with future technology improvements, because they can be offset with revenues from enhanced oil recovery using captured CO_2, and because we included the possibility that offset prices in 2020 be as high as US$85/tonne.[11]

[6] Griffiths, M. et al. (2006), Troubled Waters, Troubling Trends, Pembina Institute, http://www.pembina.org/pubs/pub.php?id=612.

[7] Dyer, S. (2006), Death by a Thousand Cuts: The Impacts of In Situ Oil Sands Development on Alberta's Boreal Forest, Pembina Institute, http://www.pembina.org/pubs/pub.php?id=1262.

[8] Curry, B. (2007), "Climate draft allows spike in oil-sands emissions," Globe and Mail, February 26.

[9] Bramley, M. (2007), Fair Share, Green Share: A Proposal For Regulating Greenhouse Gases From Canadian Industry, Pembina Institute, http://www.pembina.org/climate-change/pubs/doc.php?id=1372.

[10] We estimate that if all announced projects proceed as planned, production will average 2.166 million barrels of synthetic crude per day during 2008–12. In the same scenario, annual capital investment in the oil sands will average C$12.5 billion annually during the same period (see Sec. 1). GHG reduction costs of US$1 per barrel therefore represent $1 \times 2.166 \div 1000 \times 365 \div (12.5 \times 0.85(\text{exchange rate})) = 7.4\%$ of capital investments.

[11] McCulloch, M. et al. (2006), Carbon Neutral 2020: A Leadership Opportunity in Canada's Oil Sands, Pembina Institute, http://www.pembina.org/climate-change/pubs/doc.php?id=1316.

To enable Canada to play its part in preventing dangerous climate change, the Pembina Institute has called on the governments of Canada and Alberta to require all existing and new oil sands operations to be carbon neutral by 2020, and we have called on oil sands producers to show leadership by pledging to become carbon neutral in advance of government requirements.

The Pembina Institute's position on carbon capture and storage[12]
We believe that Canada urgently needs to embark on a trajectory towards deep reductions in GHG emissions. The most important policy to achieve this is a system of mandatory, long-term limits on GHG emissions, particularly from industrial sources. Industry can deploy CCS to meet these limits – but only under certain conditions including the establishment of a strong regulatory framework to minimize the risk to people and the environment. Governments' priorities for public expenditures on GHG emission reductions should be sustainable energy initiatives (primarily low-impact renewable energy, energy efficiency and conservation), but it is acceptable to use a small percentage of the public funds devoted to GHG emission reductions to leverage much larger private investments in CCS.

2.2 Requirements to use low-GHG technologies

An alternative to the establishment of mandatory GHG emission reduction targets for oil sands facilities would be for regulators to include requirements to use low-GHG technologies such as CCS in facilities' operating licences. Environmental licences issued by Alberta Environment under the province's Environmental Protection and Enhancement Act can legally include technology-specific requirements, but in practice Alberta Environment has generally preferred to set technology-agnostic performance standards (such as emissions intensity targets).

A "carbon sequestration standard" that would require oil, gas and electricity producers to deploy CCS in gradually increasing amounts has been proposed in Canada[13], but up to now it has not, to our knowledge, been advocated by any of Canada's major environmental NGOs or seriously considered by federal or provincial governments.

There has recently been increasing discussion of the possibility of using nuclear energy as a replacement for natural gas in oil sands production – and as a way to reduce GHG emissions. The CEO of oil producer Husky Energy recently stated that "nuclear is the right long-term approach for oil sands" while Canada's Minister of Natural Resources has said "it's not a question of if, it's a question of when" nuclear energy will be used in the oil sands[14]. The Pembina Institute believes that nuclear energy's environmental, economic and reliability challenges, along with its unique security, accident and weapons proliferation risks, mean that it does not merit serious consideration.

In contrast, we believe that deep geothermal energy deserves serious investigation and consideration as a potential energy source for oil sands production.

2.3 Reform of royalty and tax regimes[15]

Alberta's oil sand producers currently enjoy an extraordinarily generous royalty regime. Producers initially pay a royalty equal to just 1% of gross revenue until all project costs have been recovered, at which point they pay a royalty of 25% of net revenue. This regime has resulted in royalty payments declining from C$3.39 per barrel in 1996 to just C$2.29 per barrel in 2005 during a period when oil prices and industry profits increased dramatically. Given that royalties are meant to be payments to citizens representing a fair value of the resource of which they are the owners, the Pembina Institute believes that royalty rates should be substantially increased.

On February 16, 2007, the government of Alberta announced a review "to examine the province's royalty and tax regime to ensure Albertans are receiving a fair share from energy development through royalties, taxes and fees."[16]

Oil sands producers, unlike conventional oil and gas producers, also currently enjoy a 100% Accelerated Capital Cost Allowance – a federal tax break that is worth between $5 million and $40 million for every $1 billion invested. The federal go-

13 Jaccard, M. et al. (2004), The Morning After: Optimal Greenhouse Gas Policies for Canada's Kyoto Obligations and Beyond, p.18, C.D. Howe Institute, http://www.cdhowe.org/pdf/commentary_197.pdf.
14 Seskus, T. (2007), "War of words begins over nuclear option," Calgary Herald, January 13.
15 Taylor, A. and M. Raynolds (2006), Thinking Like an Owner: Overhauling the Royalty and Tax Treatment of Alberta's Oil Sands, Pembina Institute, http://www.pembina.org/pubs/pub.php?id=1339.
16 Government of Alberta (2007), Expert panel to examine Alberta's royalty regime, news release, February 16.

vernment announced in its 2007 budget that this tax subsidy will be gradually eliminated starting in 2011.[17]

2.4 Measures to address non-climate impacts

As noted in Sec. 1, the non-climate impacts of oil sands development are large and serious. In June 2000 the Government of Alberta mandated a multi-stakeholder Cumulative Environmental Management Association (CEMA) to make recommendations on how best to manage cumulative impacts and protect the environment in the oil sands region. But by 2005, CEMA had met its targets for environmental management deliverables and recommendations on only approximately 25% of its workplan. Regulators have continued to approve oil sands projects before a regional management framework for environmental impacts has been established.

The Pembina Institute believes that further development of the oil sands should be conditional on the legal establishment of an ecologically representative interconnected network of protected areas and corridors, prescribed precautionary limits for water use and release, criteria air contaminants, watershed integrity and wildlife habitat, and a binding regional integrated management plan that maintains biodiversity and ensures the resilience of endangered species populations.

2.5 Demand reduction measures

Development of Alberta's oil sands is being driven by sustained demand for transportation fuels, particularly from the United States but also from Canada, where production of conventional oil is declining. A critical policy lever to curtail this demand is the tightening of regulated vehicle efficiency standards in the U.S. and their establishment in Canada. The government of Canada committed in October 2006 to set regulated automobile efficiency standards starting with model year 2011, but it has not specified the level at which the standards would be established. Average fuel consumption of personal vehicles is about 50% higher in North America than it is in Europe.[18]

Increased blending of biofuels into gasoline and diesel fuel, which is being driven by a range of government measures in both the U.S. and Canada, can also go some way to reduce demand for oil.

More generally, the Pembina Institute believes that further development of the oil sands should be conditional on implementation of a long-term national energy framework to guide Canada's transition to a sustainable and climate-friendly energy economy.

2.6 Life-cycle fuel carbon content requirements

On January 18, 2007, the Governor of California issued an Executive Order calling for a Low Carbon Fuel Standard (LCFS) to reduce the carbon intensity of the state's transportation fuels by at least 10% by 2020. The LCFS will apply to all refiners, blenders, producers or importers of transportation fuels, and "be measured on a full fuels cycle basis."[19]

California does not currently import any oil from Alberta's oil sands, but it could be an important future market if proposed pipelines to the Pacific coast are constructed. In addition, several other states have already reportedly indicated an intention to replicate California's LCFS. Although production accounts for only about 12–18% of the total GHG emissions from the life cycle of oil sands oil, the fact that the production of conventional oil is considerably less GHG-intensive (see Sec. 1) could potentially result in a significant disadvantage for the oil sands once a LCFS is in effect – unless oil sands producers take steps to substantially reduce their GHG intensity.

[17] See http://www.budget.gc.ca/2007/bp/bpc3e.html.
[18] An, F. and A. Sauer (2004), Comparison of Passenger Vehicle Fuel Economy and Greenhouse Gas Emission Standards Around The World, Pew Center on Global Climate Change.
[19] Executive Order S-01-07, http://gov.ca.gov/index.php?/executive-order/5172/.

Investments for Energy and Climate Security

Armin Haas

- Potsdam Institute for Climate Impact Research (PIK)

Energy and climate security are often perceived as contradictory goals. Regarding the energy system, the cheap and reliable supply of energy is the main focus of most discussions. In the usual discourse, climate security is perceived as an additional binding constraint imposed on the problem of optimising the energy system. As it is well known from operations research, imposing an additional binding constraint on an optimisation problem generally deteriorates the optimum.

In this paper, I argue that such a perspective is misleading. In market economies, entrepreneurial processes of innovation and diffusion enhance the wealth of nations. In the short run, entrepreneurial processes are indeed constrained by various limitations. In the long run, however, it lies in their very nature to shift the constraints and make societies richer.

Scarcity Commands

The famous debate between Julian Simon and the group around Dennis Meadows and Paul Ehrlich may serve as a good example. Basically, minerals are scarce resources. Only a finite volume is available, and only a very limited share of what exists on earth of a specific material is economically exploitable – at a specific point in time. In the 70s, Meadows and Ehrlich drew the conclusion that many materials will run out within a generation's time. Simon replied by highlighting the ability of market economies to allocate investments so as to roughly keep the availability of materials constant. The qualifier "roughly" hints at the fact that, in the short to medium run, various stochastic fluctuations can indeed lead to very bullish or bearish markets, i.e. to a situation in which materials are in rather short or long supply. In the longer run, these stochastic shocks smooth out and leave ground for the fundamental control dynamics of investments in market economies.

Adding a Constraint

In the discussion of climate security, the two degrees target is often perceived as an additionally imposed constraint that will cause a welfare loss. In this perspective, forcing economies from an otherwise economically optimal business-as-usual path makes nations worse off. Few people, however, are aware of what business-as-usual related to energy means. Business-as-usual means that, in the 30 years to come, about 15 trillion Euros will directly be invested in the world energy system. Another 15 trillion Euros will be invested in housing and transportation infrastructure. These huge investments will determine the energy use for most of the 21st century.

Joint Optimisation

The way in which these investments will be made will determine both the energy and the climate security of nations. The crucial point is to address energy and climate risks in a comprehensive approach. This is in no way a revolutionary insight. With the notable exception of climate risks, energy policy has most often used an integrative risk management approach. If, for example, the security of supply would have been the one and only goal of energy policy in Germany, the whole German energy system would have relied on domestic resources, i.e. hard coal, lignite, and renewables. It would have been possible to liquefy hard coal and lignite for transportation use as it has been done in WWII. The expenses for this strategy would have been so huge that the joint management of risks – economic, political, and military risks – ruled out this option. No one went for this strategy, not even during the cold war.

The joint consideration of several risks has been and will remain the core operation when managing the energy system. The inclusion of climate risks is, in this respect, no revolution, but just another adjustment in a world of changing risks.

The Investment Quest

The investment quest of German electric utilities gives an illustrative example for the risk management problem to tackle. In the years to come, a substantial share of power stations has to be replaced. When taking into account climate security but not energy risks, the obvious solution for fossilfuelled power stations is to go for natural gas, as it is the least carbon intensive fossil fuel. When, the other way around, taking into account just energy security and no climate risks, it is straightforward to go for hard coal and lignite since natural gas poses severe supply risks. It would not be wise to follow any of these extreme approaches. Addressing energy and climate security simultaneously is the challenging task to accomplish.

Between the Devil and the Deep Blue Sea

A well-acknowledged strategy when facing the devil and the deep blue sea is avoiding them both. The large-scale use of renewables for delivering electricity for Europe would, to some degree, avoid the need of choosing between two risky fossil options (cf. the position paper of Battaglini and Lilliestam "A SuperSmart Grid for climate and energy security in Europe and beyond" in this volume). Such a strategy would overcome both the long-settled structures of electricity supply in Europe and the long advocated small-only alternatives. It would, in contrast, open up European electricity markets, connect them with the vast renewable resource base in North Africa and push the development of peripheral European regions and North Africa. In the end, adding the climate constraint could turn out to force the system towards a path of greater wealth of nations.

Global Energy and Climate Security Through Clean Power from Deserts

Gerhard Knies

- Trans-Mediterranean Renewable Energy Cooperation (TREC)

Introduction

The present world energy supply system is facing 3 basic problems: limitation of fossil fuel resources, climate change by carbon dioxide emission, insecurity by nuclear weapon competence and radioactive materials. Therefore the strategic goal is: transition to unlimited resources, zero-emission fuels and no option for abuse.

Renewable energies, in particular solar energy as the most abundant form of energy on earth, are an alternative for a global energy supply:

Solar energy cannot be depleted by using it: it comes to earth at day as light, and leaves to outer space as heat radiation at day and night – whether we "use" it or not. It leaves no pollution behind and the biotope earth is in natural balance with it. It is not abused for military applications – otherwise solar energy technologies would have received support since long.

The most efficient places to harvest solar energy in large amounts are deserts. To be considered as a world-wide substitute for the fossil fuels there are 4 questions to be answered:

1. Is there enough solar energy in the deserts for the demands of a growing world population?
2. Can solar energy supply power as demands occur in time?
3. Can energy be transmitted from deserts to the regions of large demand of the world?
4. Is solar power from deserts economically viable?

1. How much solar energy is coming to the Earth's deserts?

The solar energy potential of the sun-belt deserts and desert-like regions can be estimated according to UNEP (www.unep.org/geo/gdoutlook/018.asp#fig12) as

desert space = 36 Million km²

and from the energy they receive annually from the sun. A reasonable average value for the energy of direct normal solar radiation is **2.2 TeraWatt-hour (TWh) /km²/year.**

This is as if a layer of oil of 24 cm depth is put onto the deserts, each year again. Slightly other values can be considered, but the conclusions do not change with such choices.

The energy received each year by 1 km² of desert is equivalent to the (thermal) energy contained in:

- 300 000 ton hard coal
- 1.5 Million barrel oil

The solar energy arriving annually at the 36 Million km² of desert areas is equivalent to

- 80 Million (Mega) TWh (thermal)
- 10,000 Billion (Giga) ton coal
- 50,000 Billion barrel oil
- 300,000 Exajoule

Since we do have the technologies to convert (at least) 11% of solar radiation into electricity, we can generate in deserts typically 0.24 TWh-electric /km²/year

2. Comparison to global demands

How the terrestrial fossil reserves, resources and their annual depletion/consumption compare to the annual solar yields is summarized in the table. According to site selection studies by DLR using satellite data the deserts in the MENA region would allow for production of electricity of 630,000 TWh/year, about 40 times the present world electricity demand. Collectors for the German total power consumption would require a square of 45km side length, i.e. the area of Berlin and Hamburg.

There are 4 particularly interesting messages:

1. The present global annual demand for primary energy arrives as solar energy in the deserts within 5.7 hours of sun shine.
2. The global annual demand of 55 Gtce expected for 2100 (WBGU) is arriving in 2 days.
3. The energy contained in the total known fossil reserves on Earth arrives in 47 days, and that in the expected total resources in 227 days in the deserts.
4. The total known and expected resources for nuclear energy are delivered as solar energy to the worlds deserts within 13 days.

In fact, deserts can be made to clean and over-abundant powerhouses for the world.

3. Can solar energy be supplied as demands occur in time?

Fossil fuels can be stored, and are available when demand occurs. Solar energy is delivered when the sun is shining. Sun shine itself cannot be stored, but it can readily be converted into high temperature heat which can be stored in thermal storage devices for hours and even for days, with insignificant losses.

This brings the technology of solar thermal power plants into a particularly attractive position: Equipped with simple and cheap thermal storage tanks they can produce solar power by demand, also at night. Large scale thermal energy storage is technically solved and commercially available.

During longer periods without direct sunshine steam can be generated by a supplementary fossil fuel heater. The solar thermal power plant provides firm capacity.

4. Can solar energy from deserts be transmitted to the high demand regions of the world?

Once solar energy has been converted into electricity, it can be transmitted as direct current at very high voltage (500 kV and higher) over thousands of kilometres with low losses of about 3% per 1000 kilometre. The HVDC (High Voltage Direct Current) transmission is a well established technology. Since large deserts are available in North and South America, North and South Africa, Western Asia, India, China and Australia, clean power from deserts can be delivered to more than 90% of world population.

5. Is solar power from deserts economically viable?

In a first step, concentrating solar collectors convert concentrated solar radiation into heat of about 300° Celsius and higher, up to about 1000°C. Steam from solar collectors for thermal power plants, as from 1 barrel of oil, can be as cheap as 30 and 50 $. This cost value can be brought down further by continued mass production of such collectors.

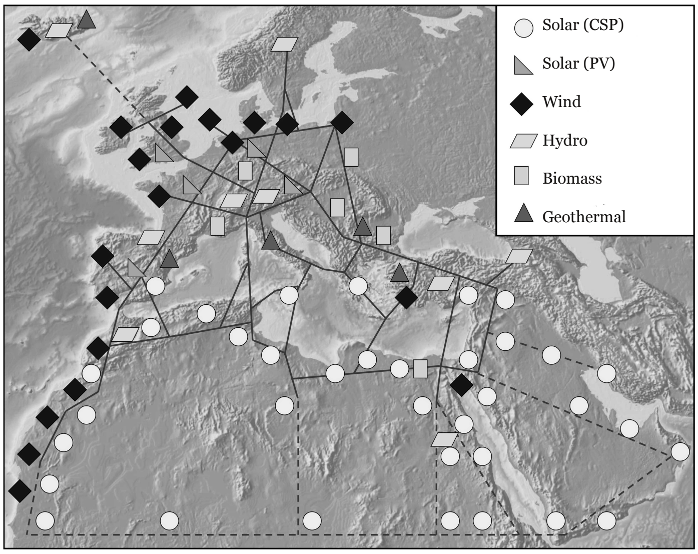
These costs vary with the available annual solar radiation, with collector technology and with capital costs. The bulk materials for solar steam generating collectors are glass and iron for which there will be no shortages. According to industrial learning curves we can expect within 2 decades:

power production costs of	4-6 c$/kWh
power transmission costs of	1-2 c$/kWh.

Coal and nuclear power plants can be phased out simultaneously.

Table: Fossil reserves, resources, consumption rates, depletion time (source: Federal Institute for Geosciences and Natural Resources, Hannover, 2004), and corresponding energy delivery times by solar radiation in deserts.

Fossil energy source In Giga tonnes coal equivalent 1 Gtce = 29 EJ = 8,140 TWh-thermal = 5 Billion bbl	Proven Reserve (expected additional Resources) Gtce	Annual Production/ consumption Gtce	Solar energy delivery time in the global deserts, corresponding to	
			Global reserves (Resources) In days	Annual fossil consumption In hours
Total	1.279 (6224)	13.1	47 (227)	5.7
Oil (conventional)	233 (118)	5.5	8.5 (4.3)	2.4
Oil (non-conv.)	96 (361)		3.5 (13.2)	
Natural gas (conv.)	196 (230)	3.0	7.2 (8.4)	1.3
Natural gas (non-conv.)	2 (1687)		0.1 (62)	
Coal (hard and lignite)	697 (3541)	4.1	25 (129)	1.8
Uranium, Thorium	56 (293)	0.5	2.0 (11)	0.2



With an EU-MENA grid as infrastructure for energy and climate security, solar power from deserts can become the least cost option for Europe.

6. Seawater desalination in cogeneration

In solar thermal power plants only 35% of the collected solar energy is converted into electricity. If combined with sea water another 50% of the collected energy, normally released as cooling heat, can be used for thermal desalination. This way up to 85% of the collected solar energy can be used, and with each TWh of power 40 Million m³ water can be desalinated in cogeneration.

Summary

1. The solar energy available in deserts is more than 700 times the present global primary energy consumption. This is far more than needed to replace fossil fuels.
2. Solar thermal power plants can store solar heat and generate solar power according to demand, also at night (secured capacity).
3. Technologies for power production and long-distance transmission to over 90% of world population are at hand.
4. In a solar energy co-operation technology-belt and sun-belt can achieve energy, water and climate security, and stable power production costs of 4 – 8 c$/kWh, within 2 decades.
5. Investments into solar technology will be beneficial for all future, while those into nuclear and fossil fuel technologies will become obsolete with the respective fuel expiration.
6. An Apollo-like program for bringing deserts into service for energy, water and climate security, as proposed by Prince El Hassan from Jordan at the Hannover Industrial Fair 2006, could be organized immediately.
7. TREC and The Club of Rome are calling for a conference DESERTEC to bring technology- and sun-belt countries to action.
8. Solar energy from deserts can give energy security to the world, and can stop the devastation of the Earth by fossil fuels green-house gas emissions.

Issues of Secure Energy Supply under Environmental Constraints

Wolfgang Kröger

- Swiss federal Institute of Technology Zurich (ETH) and International Risk Governance Council (IRGC)

Preamble

Security of energy supply[1] is an area of increasing visibility and acknowledged importance for maintaining national economy and welfare as well as global stability. It has become part of the political agenda at national and international level and of strategic decisions at corporate level – taking socio-political, technological and environmental (limit global temperature increase) constraints into account. The discussions often suffer from narrow focus and national interests and/or business perspectives, as well as from sectoral views, lack of realism and large uncertainties involved. There is a need of a more comprehensive (holistic) approach at international level which includes major stakeholders and the whole energy supply chain which encompass

- the provision of resources/fuels,
- the transport from producing to consuming countries or areas, either land-based or maritime,
- the infrastructures within consuming areas, e.g. for electricity supply: embracing power plants including front-end and back-end, high voltage transmission lines and local distribution.

Decisions we are making today including financial investments must reflect the whole spectrum of challenges and needs, respectively.

Some Facts (see also [1])

- Energy demand continues to rise in virtually all regions of the world. The IEA World Energy Outlook [2] foresees total world energy consumption in 2030 to be almost 60% higher than it was in 2002. This growth is expected to be mainly fossil fuel based with oil and gas taking the lion’s share of around one third each of the increase. Nuclear would play a marginal role in the expansion of world energy supplies, while renewables including hydro and traditional biomass contribute more than 10% towards meeting higher world energy demand.
- The primary energy use per capita shows large differences in the different regions, as energy use per capita in the US is twice as high as in the EU and Japan, and in China the ratio is 16 times lower again. The differences are projected to remain virtually unchanged in the future.
- The share of fossil fuels will basically remain unchanged or slightly increase to almost 80%. The import dependency of major consuming countries will continue to grow (e.g. for EU 25 from today 50% to reach 2/3 in 2030).
- Fossil fuel producing countries and large consuming areas are spatially separated: The biggest net import areas of oil and gas are the US, continental western European countries, and the Far East (Japan), while the Middle East nations (MENA), the Russian Federation, 2 Algeria/Nigeria and Mexico/Venezuela dominate the exports. Competition for limited primary energy sources by China and India has already become real and will further increase.
- LNG is regarded as an important export commodity for countries with large reserves of natural gas and for consuming economies, in particular the US, it is an instrument of diversification of primary energy.
- Continuous growth in energy demand, in particular electric power, and replacement of the fleet with an average age of 30 years within the next 10-15 years will lead to new installed capacities of 95-125 GW/a and huge investments (see Figure 1).

[1] Security of energy supply is assured when at any time the required resource/service of satisfactory quality is available at reasonable price within society/whole network.

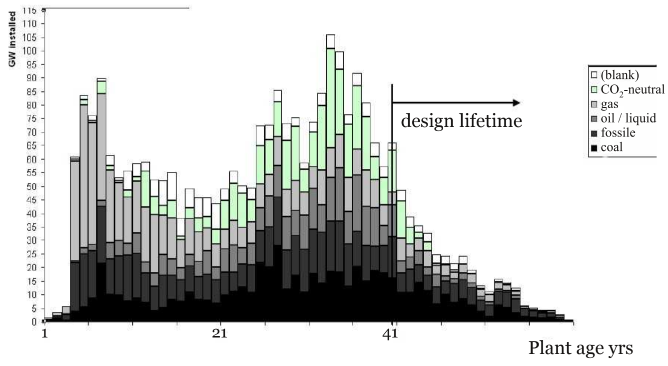


Figure 1: Global Installed Capacity versus Plant Age (source: ALSTOM)[2]

- Huge investments are needed (see Figure 2), about USD 800 billion a year, in the energy supply infrastructure worldwide over the decades to 2030. The electricity sector alone will need to spend a total of about USD 11 trillion. For the electricity sector as a whole 53% of the investment will be simply to replace existing and add future capacity. Almost half of the total energy investment will take place in so-called developing countries.

- In general new technologies with a potential to significantly decarbonizes or diversify our energy systems are not available within the next 10 to 15 years. Therefore, current and future more stringent CO2 regulations will hit or have to be mastered by today's technology.

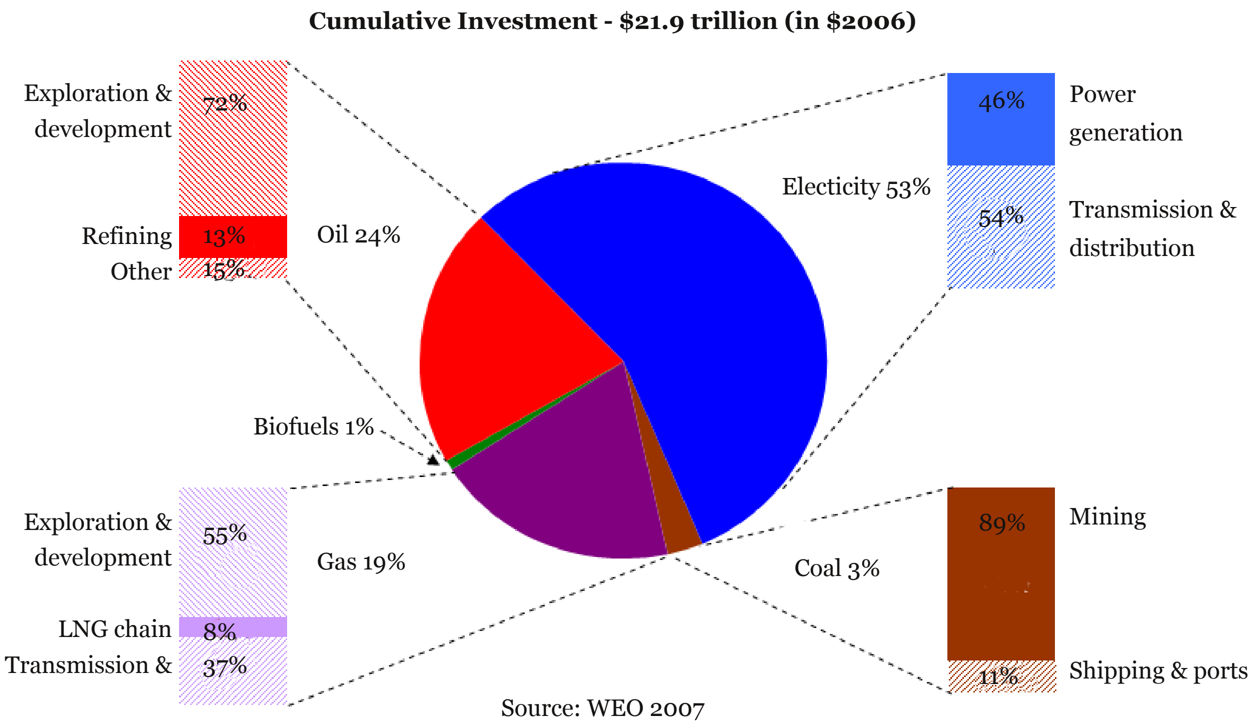
- For Europe the stability of operation of the UCTE-grid is essential. This synchronized network came into being by integration of smaller national systems, now serving 450 million people and providing 2400 TWh/a, out of which about 10% are transborder exchange at present. This system is now operated "more and more at its limits" [4], mainly due to market liberalization and related side-effects. Recent major blackouts legitimate the question whether the high degree of reliability experienced in the past can be further maintained without significant changes in technology and policy.

- "In today's liberalized energy markets – in which financing of energy projects is increasingly the role of the private sector – governments must act to create the right enabling conditions" [2].

How to Meet the Challenges

Strategies and policy options aiming to combat global temperature increase and achieve climate security must be embed-

Figure 2: World Wide Investment Needs in the Energy Sector 2006 - 2030 [3]. (The figures for electricity correspond to 693 billion € for EU25; they do not consider additional investment due to CO2 capture and sequestration.)



[2] The installed coal fired fleet in markets within the European Trading Scheme has an average age of about 30 years.

primary and final form (services) a transnational and trans-sectoral concern lacking adequate policies, mechanisms, and procedures to cope with the challenges such as

- aging fleets and narrow technology frame;
- growing constraints including competition and CO_2 regulation;
- huge investments needed as well as related financial schemes and adequate industrial capacity building;
- new forms of public-private partnerships and alliances which need to be developed;
- limited resources and increasing geo-political threats;
- lack of transborder mechanisms to predict and respond to energy related emergencies.

A governance process should be launched which helps to frame the problem and to set objectives, to decide on responsibility and priorities and which will include all major actors, e.g. from policy making at national and international level, industries including financial services, science and technology assessment, civil society including labor and end-user organizations. The risk governance framework proposed by IRGC [5] may be used to develop an integrative, structured and transparent approach.

References

[1] W. Kröger, Issues of Energy Supply, Proceedings Latsis Symposium 2006, Zurich

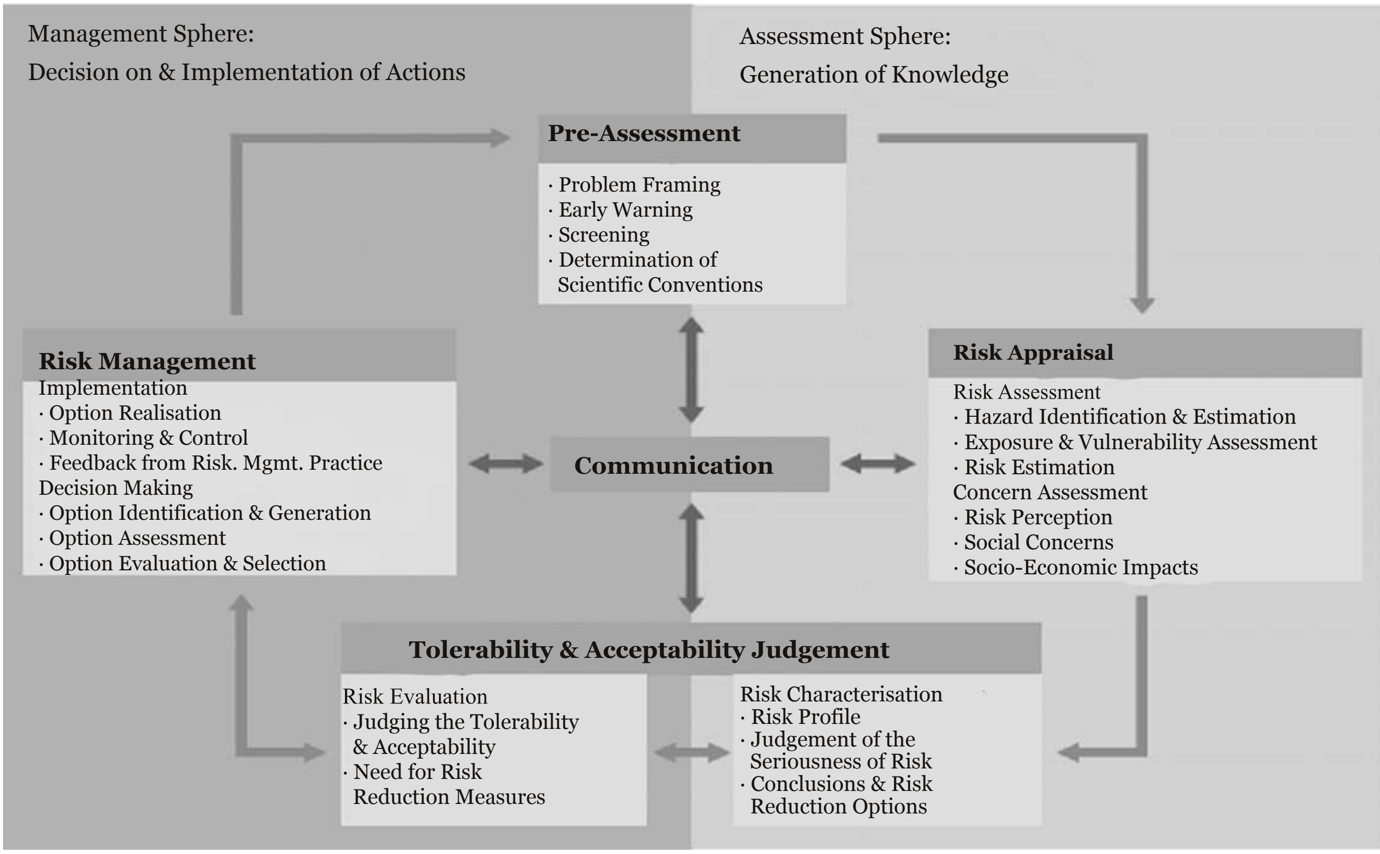
[2] International Energy Agency, 30 Key Energy Trends in the IEA and Worldwide, Paris, 2005

[3] International Energy Agency, World Energy Outlook 2007, Paris, 2008

[4] UCTE, Final report on system disturbance on 4 Nov. 2006, Paris, 2007

[5] O. Renn: Risk Governance – Towards an Integrative Approach, White Paper 1, International Risk Governance Council Geneva, 2005

Figure 3: IRGC Risk Governance Framework [5]



Ocean Wave Energy

Hans Christian Soerensen

- The Wave Dragon Group

1. The market potential for ocean wave energy

Electricity and hydrogen production based on ocean wave energy is expected to reach the same price level as offshore wind energy in the next decade. The market for ocean wave energy is enormous and an industry of comparable size to that of wind energy is expected to be established (ref: The Carbon Trust, Marine Energy Challenge). The huge potential shows that 10 to 50 percent of the world electricity consumption could be supplied by wave energy (ref: World Energy Conference and IPCC). In the IPCC scoping report the following figures are stated:

The theoretical global resource for ocean energy is estimated to be in the order of:

- 8,000 - 80,000 TWh/year for wave energy;
- 800 TWh/year for tidal current energy;
- 2,000 TWh/year for osmotic energy;
- 10,000 TWh/year for ocean thermal energy

This has to be compared to the Worlds electricity consumption of 16,000 TWh/year

2. The advantages of ocean wave energy

In comparison with wind energy wave energy can be predicted very precisely 6 hours ahead. Furthermore wave energy is feasible to utilise in large quantities along the west coast of several industrialised countries like Western Europe, US, Australia, New Zealand, Chile and South Africa.

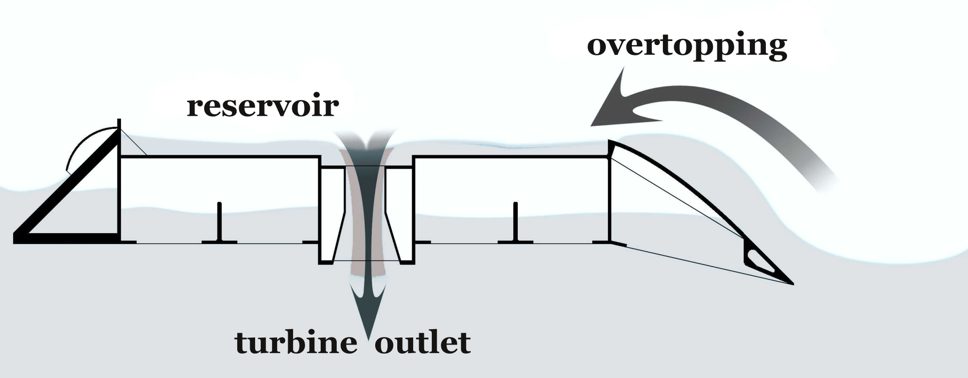
3. The development stage

An overwhelming variety of different technologies are developed these years around the world. Investors, developers and governments world wide can agree on two things only: Large wave energy power plants will be offshore and floating technologies; as that is where the wave energy is and it causes less visual and coastal process impacts.

Wave Dragon Technology

The Welsh-based UK Wave Dragon Pre-Commercial Demonstrator is a floating slack moored wave energy converter with a rated capacity of 4-15MW. The Wave Dragon Company has almost 20 years of development behind this device and has been working directly toward its commercialisation for over three years. Wave Dragon has had a 1:4.5 scale prototype deployed offshore in Denmark since 2003 where reliable power production has already been demonstrated. The Welsh demonstrator is expected to be deployed by the autumn 2009.

Wave Dragon captures the energy of waves with its two outstretched wings and focuses these waves towards its front ramp. This focusing brings 300 meters worth of wave energy towards the 140 meter front ramp, and in doing so increases the wave height; these waves then ‘overtop’ the ramp filling the reservoir behind. Wave Dragon has now created an artificial head of water using nothing more than nature’s own methods and energies; no machinery, no moving parts, and therefore little that can go wrong.



Once the water is in the reservoir we simply allow it to drain out the bottom of the Wave Dragon back to the sea. In doing so it passes through, and drives, turbines that produce electricity.

Following two decades of mainly academic interests wave energy has now also entered the focus of governments and investors and this powerful combination of interests has speeded-up commercialisation and created a firm believe that a wave industry comparable with the wind power industry will emerge.

The Wave Energy industry is at a similar stage as the wind energy industry was in the mid 1980's with several concepts under testing. A frequently asked question is therefore: "Who is going to be the winner?" like the Danish three bladed horizontal axis concept was the winner within the wind industry. It is a more complicated answer for wave energy that even by 2030 there will probably be 4 to 5 device types in the field. As wave devices must be adapted to the actual wave climate (including wave height, wave period, coast distance and water depth) the variety is much greater. In wind energy there is only one parameter, the wind velocity.

4. The financial challenge

After testing in wave tanks in scale of between 1:80 and 1:20 the developer must move to real sea testing in a scale 1:1. It can be difficult to find test sites for this first stage where the wave climate is low enough for this step to be safe and manageable, like the inland sea used for Wave Dragon prototype. More importantly, the cost and risk of going from wave tank testing to real sea testing often seams too large to attract investors.

The development time after testing in the real sea is only one generation of the device, i.e. a few years, given subsystems components which use already mature technologies. For some devices families such as the Oscillating Water Columns, or Linear Generator Buoys a special turbine or other power take off system has to be developed. This can significantly increase the time to commercialisation. For devices where known technology is used in a novel way, like the Wave Dragon and Pelamis, the time from full scale demonstration to commercialisation can be relatively short when compared to development of technologies in general. This is how wave energy can jump forward about 25 years to the cur-rent stage of wind energy.

There is space for future development and improvement for these devices but the long way from 20kW turbines to 3-5MW turbines need not be taken. The main driver for the development is: How fast can orders of wave farms of 10-50 units be a reality?

5. How long to commercialisation

To answer the question: "How long before there will be a commercial development?" This depends strongly on the approach. If we follow the current linear UK road map it will be at least 10 years. This road map prescribes:

Energy Conversion Schematic

The unit itself comprises a central platform, with a curved ramp and a large water reservoir equipped with an array of hydro turbines, and two lateral curved wave reflecting wings which concentrate the power of incoming waves.

The point of interest with Wave Dragon is that there is no use of unproven technology. The barge is based on a design that dates back to the First World War and the turbines are the type used in low head hydro stations for the last 80 to 90 years.

Preliminary Dimensions

Distance between tips of wings	300m
Wing length	145m
Length (tip of arm to rear of central housing)	170m
Maximum height above sea level	6 - 3m
Draught	11 - 14m

Test at the EMEC centre in Orkney: one year for planning and manufacturing and one year for deployment before next step.

2. Testing in arrays at the Wave Hub in Cornwall: two years for planning and manufacturing and one year for testing before the next step.

3. Testing at a round 1 first semi-commercial farms: three years for tender, planning and manufacturing and one to two years for testing before a round 2.

The process can be speeded up if the authorities accept overlapping of the phases, this has not happened as yet. If development takes place in parallel in other countries it could be speeded up, too.

6. Economy

The predicted electricity generating costs from wave energy converters have shown a significant improvement in the last twenty years, which has reached an average price at 0.10 to 0.20€/kWh. Compared, e.g., to the average electricity price in the European Union, which is approx. 0.04 €/kWh, the electricity price produced from wave energy is still high, but it is forecasted to decrease further with the development of the technologies.

Wave climate	First device	After deployment of 100's
24 kW/m	0.11 €/kWh	0.054 €/kWh
36 kW/m	0.083 €/kWh	0.040 €/kWh
48 kW/m	0.061 €/kWh	0.030 €/kWh

Table 1: Wave Dragon expected cost in €/kWh

Wave climate	First device	After deployment of 100's
24 kW/m	4,000 €/kW	2,300 €/kW
36 kW/m	3,200 €/kW	1,875 €/kW
48 kW/m	2,700 €/kW	1,575 €/kW

Table 2: Wave Dragon expected capital cost in €/kW price

7. Recommendation

With orders for many units the industry can take advantage of mass production and learning curve effects. Therefore it is important that the orders of more than a few devices are place at an early stage.

Experience from the wind industry shows that only when the US market ordered more than 50 turbines in series in the late 1980's the industrial production took off.

An important demand for a fast development is that all kind of consent processes are streamlined and that the grid connection issues do not become a barrier. Finally the incentives must be well described as wave energy cannot compete with the hidden subsidies in prices for coal, oil and gas based technologies, not fully paying the negative externality cost of their impact on the environment.

8. More than electricity

The development of Wave Dragon has until now been focused on power production. Other options are desalination of sea water and production of hydrogen far offshore.

A third option is using the power for production of mass produce of seaweed and marine algae to photosynthesise carbon from the atmosphere (www.cquestor.com).

9. Activities and acknowledgment

The Wave Dragon technology has been supported by an international group of companies and universities as shown on www.wavedragon.net. Further on the project has been supported by grants from: The Danish PSO system, the EU FP6 program (Environment and Sustainable Development contact 019983) and by EU regional fund through the Welsh Assembly Government.

10. More information

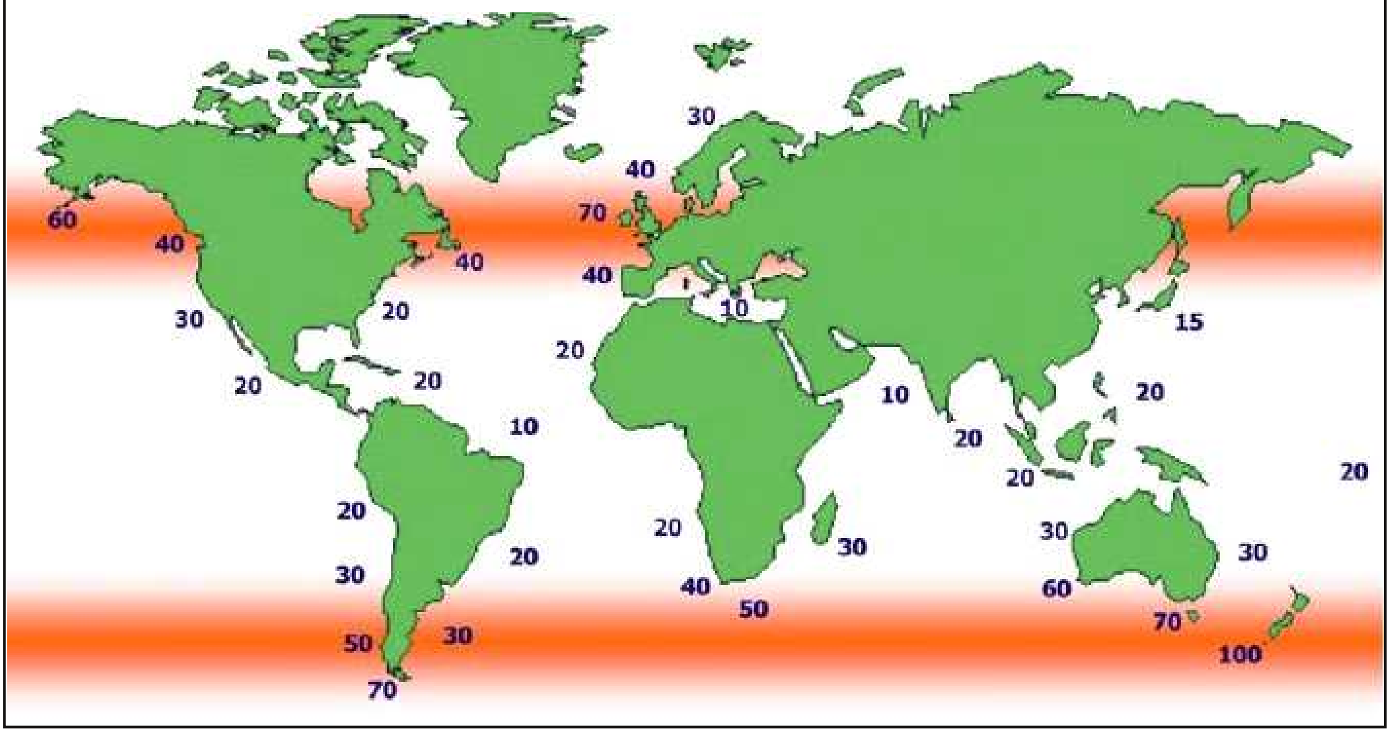
The European Ocean Energy Association has been established to strengthen the development of the markets and technology for ocean energy in the European Union (www.eu-oea.com).

The Coordinated Action on Ocean Energy Project has been established to develop a common knowledge base necessary for coherent development of R&D Policies in Europe, the dissemination of this knowledge base and promotion of ocean energy technologies (www.ca-oe.net). The publication CA-OE brochure gives an overview of different technologies.

Two new EU projects are focusing on ocean wave energy: Equitable testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environ-mental Impact (Equimar; www.equimar.eu) and Wave Planning and Marketing (WavePLAM; www.waveplam.eu)

Wave Energy

Wave energy is distributed un-evenly around the globe. In Europe wave energy origins from the North Atlantics mainly and are highest at freely exposed Atlantic cost lines from Norway in the north over the British island through to Portugal, with a annual average energy flux of 24 kW/m and upwards.



References

- Pontes, M.T. and Falcao, A.: Ocean Energies: Resources and Utilisation, 18th World Energy Conference, Argentina, 2001, 19 pp.
- Soerensen, H.C.: World's first offshore wave energy converter, Wave Dragon, connected to the grid, World Energy Council Conference, Australia, 2004, 12 pp.
- Carbon Trust: Future Marine Energy, 2006, London, 38 pp.
- Soerensen, H. C. and Weinstein, A.: Ocean Energy: Position paper for IPCC IPCC scooping conference, Lübeck, January 2008, 8 pp.
- www.wavedragon.net.
- www.wavedragon.co.uk.
- www.tecdragon.pt.
- www.carbontrust.co.uk.
- www.cquestor.com.
- www.eu-oea.com.
-www.wave-energy.net/index_files/documents/CA-OEBROCHURE.pdf.
- www.waveplam.eu.
- www.equimar.eu.

Energy Security and Climate Change Policy

Margo Thorning

- International Council for Capital Formation[1]

Background

As the International Energy Agency noted in its 2006 World Energy Outlook, the world is facing twin energy-related threats: (1) not having adequate and secure supplies of energy at affordable prices and (2) the potential for environmental harm due to increased energy use and higher levels of greenhouse gases in the atmosphere. High energy prices and recent geopolitical events remind us of the essential role affordable energy plays in economic growth and human development, and of the vulnerability of the global energy system to supply disruptions. Safeguarding energy supplies is once again at the top of the international policy agenda. Yet the current pattern of energy supply carries the possibility of environmental damage - including changes in global climate. The need to slow the growth in fossil-energy demand, to increase geographic and fuel-supply diversity and to mitigate climate-destabilizing emissions is more urgent than ever.

Fossil energy will remain dominant over next 25 years

According to the IEA report, global primary energy demand is projected to increase by an average annual rate of 1.6% between now and 2030 in the base case scenario. Over 70% of the increase in demand over the projection period comes from developing countries, with China alone accounting for 30%. Their economies and population grow much faster than in the OECD, shifting the centre of gravity of global energy demand. Almost half of the increase in global primary energy use goes to generating electricity and one-fifth to meeting transport needs - almost entirely in the form of oil-based fuels.

Globally, fossil fuels will remain the dominant source of energy to 2030, absent sharp changes in consumption and technological breakthroughs. Fossil fuels are likely to account for 83% of the overall increase in energy demand between 2004 and 2030. As a result, their share of world demand edges up, from 80% to 81%. The share of oil drops, though oil remains the largest single fuel in the global energy mix in 2030. Global oil demand reaches 99 million barrels per day in 2015 and 116 mb/d in 2030- up from 84 mb/d in 2005. Coal sees the biggest increase in demand in absolute terms, driven mainly by power generation. China and India account for almost four-fifths of the incremental demand for coal. It remains the second-largest primary fuel, its share in global demand increasing slightly. The share of natural gas also rises. Hydropower's share of primary energy use rises slightly, while that of nuclear power falls. The share of biomass falls marginally, as developing countries increasingly switch to using modern commercial energy, offsetting the growing use of biomass as feedstock for biofuels production and for power and heat generation. Non-hydro renewables - including wind, solar and geothermal - grow quickest, but from a small base, the IEA states.

The threat to the world's energy security is real and growing

Rising oil and gas demand, if unchecked, would accentuate the consuming countries' vulnerability to a severe supply disruption and resulting price shock. OECD and developing Asian countries become increasingly dependent on imports as their indigenous production fails to keep pace with demand. Non-OPEC production of conventional crude oil and natural gas liquids is set to peak within a decade. By 2030, the OECD as a whole will import two-thirds of its oil needs in the IEA's base case scenario compared with 56% today. Much of the additional imports come from the Middle East, along vulnerable maritime routes. The concentration of oil production in a small group of countries with large reserves - notably Middle East OPEC members and Russia - will increase their market dominance and their ability to impose higher prices. An increasing share of gas demand is also expected to be met by imports, via pipeline or in the form of liquefied natural gas from increasingly distant suppliers. The share of transport demand - which is relatively price-inelastic relative to other energy services - in global oil consumption is projected to rise. Current subsidies on oil products in non-OECD countries are estimated at over $90 billion annually.

[1] The International Council for Capital Formation (www.iccfglobal.org) is a non-profit, Brussels-based think tank promoting a nurturing climate for business expansion, cost-effective regulatory policies and job growth.

Subsidies on all forms of final energy outside the OECD amount to over $250 billion per year - equal to all the investment needed in the power sector each year, on average, in those countries.

Oil prices still matter to the economic health of the global economy. Most analysts conclude that the sharp increases in oil prices in 2007-08 have slowed the economic growth rates of both developed and developing countries. Most OECD countries have experienced a worsening of their current account balances, most obviously the United States. While the recycling of petro-dollars may have helped to mitigate the increase in long-term interest rates, delaying the adverse impact on real incomes and output of higher energy prices, the overall impact of higher petroleum prices has been negative for oil importing countries, especially for heavily indebted poor countries..

Investment needed to promote energy security

Meeting the world's growing hunger for energy requires massive investment in energy-supply infrastructure, according to the IEA report. The IEA base case calls for cumulative investment of just over $20 trillion (in 2005 dollars) over 2005-2030. The power sector accounts for 56% of total investment – or around two-thirds if investment in the supply chain to meet the fuel needs of power stations is included. Oil investment - three-quarter of which goes to the upstream - amounts to over $4 trillion in total over 2005-2030. Upstream investment needs are more sensitive to changes in decline rates at producing fields than to the rate of growth of demand for oil. More than half of all the energy investment needed worldwide is in developing countries, where demand and production increase most quickly. China alone needs to invest about $3.7 trillion - 18% of the world total. There is no guarantee that all of the investment needed will be forthcoming. Government policies, geopolitical factors, unexpected changes in unit costs and prices, and new technology could all affect the opportunities and incentives for Private and publicly-owned companies to invest in different parts of the various energy-supply chains. The investment decisions of the major oil- and gas-producing countries are of crucial importance, as they will increasingly affect the volume and cost of imports in the consuming countries. There are doubts, for example, about whether investment in Russia's gas industry will be sufficient even to maintain current export levels to Europe and to start exporting to Asia. The ability and willingness of major oil and gas producers to step up investment in order to meet rising global demand are particularly uncertain. Capital spending by the world's leading oil and gas companies increased sharply in nominal terms over the course of the first half of the current decade and, according to company plans, will rise further to 2010. But the impact on new capacity of higher spending is being blunted by rising costs. Expressed in cost inflation-adjusted terms, investment in 2005 was only 5% above that in 2000. Planned upstream investment to 2010 is expected to boost slightly global spare. Beyond the current decade, higher investment in real terms will be needed to maintain growth in upstream and downstream capacity.

Impact of global energy demand on carbon dioxide emissions

Global energy-related carbon-dioxide (CO_2) emissions increase by 55% between 2004 and 2030, or 1.7% per year, in the IEA's base case scenario. Power generation contributes half of the increase in global emissions over the projection period. Coal overtook oil in 2003 as the leading contributor to global energy-related CO_2 emissions and consolidates this position through to 2030. Developing countries account for over three-quarters of the increase in global CO_2 emissions between 2004 and 2030 in the base case scenario. They overtake the OECD as the biggest emitter by soon after 2010. The share of developing countries in world emissions rises from 39% in 2004 to over one-half by 2030. This increase is faster than that of their share in energy demand, because their incremental energy use is more carbon-intensive than that of the OECD and transition economies. In general, the developing countries use proportionately more coal and less gas. China alone is responsible for about 39% of the rise in global emissions. China's emissions more than double between 2004 and 2030, driven by strong economic growth and heavy reliance on coal in power generation and industry. China overtakes the United States as the world's biggest emitter before 2010. Other Asian countries, notably India, also contribute heavily to the increase in global emissions.

Bringing modern energy to the world's poor is an urgent necessity

Although steady progress is expected to be made in the IEA base case scenario in expanding the use of modern household energy services in developing countries, many people still depend on traditional biomass in 2030. Today, 2.5 billion people use wood, charcoal, agricultural waste and animal dung to meet most of their daily energy needs for cooking and heating. In many countries, these resources account for over 90% of total household energy consumption.

The inefficient and unsustainable use of biomass has severe consequences for health, the environment and economic development. Shockingly, about 1.3 million people - mostly women and children - die prematurely every year because of exposure to indoor air pollution from biomass. There is evidence that, in countries where local prices have adjusted to recent high international energy prices, the shift to cleaner, more efficient ways of cooking has actually slowed and even reversed. In the IEA's base case scenario, the number of people using biomass increases to 2.6 billion by 2015 and to 2.7 billion by 2030 as population rises. That is, one-third of the world's population will still be relying on these fuels, a share barely smaller than today. There are still 1.6 billion people in the world without electricity. Action to encourage more efficient and sustainable use of traditional biomass and help people switch to modern cooking fuels and technologies is needed urgently. The appropriate policy approach depends on local circumstances such as per-capita incomes and the availability of a sustainable biomass supply. Alternative fuels and technologies are already available at reasonable cost. Halving the number of households using biomass for cooking by 2015 – a recommendation of the UN Millennium Project – would involve 1.3 billion people switching to liquefied petroleum gas and other commercial fuels. This would not have a significant impact on world oil demand and the equipment would cost, at most, $1.5 billion per year. But vigorous and concerted government action – with support from the industrialized countries – is needed to achieve this target, together with increased funding from both public and private sources. Policies would need to address barriers to access, affordability and supply, and to form a central component of broader development strategies.

Further, several different economic analyses show that if the EU were to actually meet its emission reduction targets under the protocol the economic costs would be high. For example, new macroeconomic analyses by Global Insight, Inc. show the cost of complying with Kyoto for major EU countries could range between 0.8% of GDP to over 3 % in 2010. (See Figure 1)

According to Global Insight, the reason for the significant economic cost is that energy prices, driven by the cost of cap/trade emission permits, have to rise sharply in order to curb demand and reduce GHG emissions. The tighter targets being considered for the post-2012 are also costly, with GDP losses ranging from 1.0 % of GDP to 4.5% for a reduction to 60% below 2000 levels of emissions in the year 2020. Even the EU Commission for the Environment admits that emission reductions could cost as much as 1.3% of GDP by 2030. The fact that the European Environmental Agency projects that the EU 15 will be 7% above 1990 levels of emissions in 2010 (instead of 8% below) demonstrates that the mandatory ETS system as currently structured is not working and that further costly mandates will be required.

The role of economic growth and technology in GHG reduction

Many policymakers overlook the positive impact that economic growth can have on GHG emission reductions. For

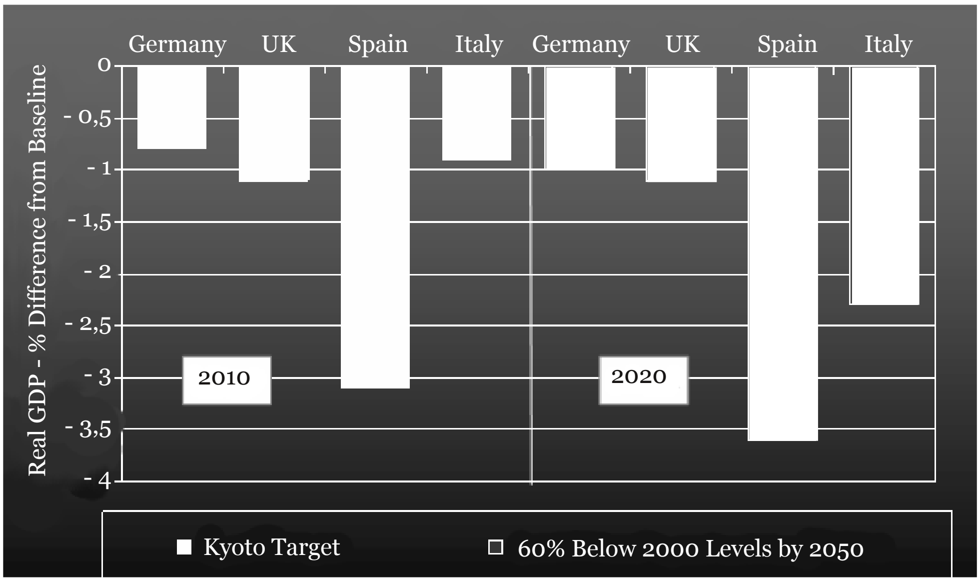


Figure 1: Impact of Purchasing Carbon Emission Permits on Gross Domestic Product Levels under the Kyoto Protocol and under More Stringent Targets on Major Industrial Economies

Source: International Council for Capital Formation "The Cost of the Kyoto Protocol: Moving Forward on Climate Change Policy While Preserving Economic Growth," November, 2005, (www.iccfglobal.org) and unpublished estimates for the U.S. prepared by Global Insight, Inc.

example, the US, with its voluntary approach to emission reductions, has cut its energy intensity(the amount of energy used to produce a Euro of output) by 20% over the 1992-2004 period compared to only 11.5% in the EU with its mandatory approach (see Figure 2). The strong U.S. economic growth, which averaged over 3% per year from 1192 to 2005 compared to about 1% in the EU, is responsible for the US's more rapid reduction in energy intensity.

Technology development and deployment offers the most efficient and effective way to reduce GHG emissions and a strong economy tends to pull through capital investment faster. There are only two ways to reduce CO_2 emissions from fossil fuel use - use less fossil fuel or develop technologies to use energy more efficiently, to capture emissions or to substitute for fossil energy. There is an abundance of economic literature demonstrating the relationship between energy use and economic growth, as well as the negative impacts of curtailing energy use. Long-term, new technologies offer the most promise for affecting GHG emission rates and atmospheric concentration levels.

Strategies to increase energy security and enhance environmental protection

Increased energy security in the developed countries including the EU will depend on factors such as increased energy efficiency, technology developments in both fossil fuels (carbon capture and storage, for example) and renewable fuels (wind and solar in particular) and possibly increased reliance on nuclear power for electricity generation. However, in order to reduce the potential threat of global climate change, it will be necessary to increase energy efficiency and reduce the growth of greenhouse gas emissions in the developing world since that is where the strong growth in emissions is coming from.

New research by Drs. David Montgomery and Sugandha Tuladhar of CRA International makes the case that agreements such as the Asia Pacific Partnership on Clean Development and Climate, an agreement signed in 2005 by India, China, South Korea, Japan, Australia and the United States, offers an approach to climate change policy that can reconcile the objectives of economic growth and environmental improvement for developing countries (see www.iccfglobal.org for full paper). Together, the Partners have 45 percent of the world's population and emit 50 percent of manmade CO_2 emissions. The projections of very strong growth in greenhouse gases in developing countries over the next 20 years means that there is enormous potential for reducing emissions through market-based mechanisms for technology transfer.

Promoting a favorable investment climate in developing countries

Drs. Montgomery and Tuladhar note that there are several critical factors for ensuring the success of an international agreement which relies strongly on private sector investment for success. Their research shows that institutional reform is a critical issue for the Partnership, because the lack of a market oriented investment climate is a principal obstacle to reducing greenhouse gas emissions in China, India and other Asian economies. China and India have both started the process of

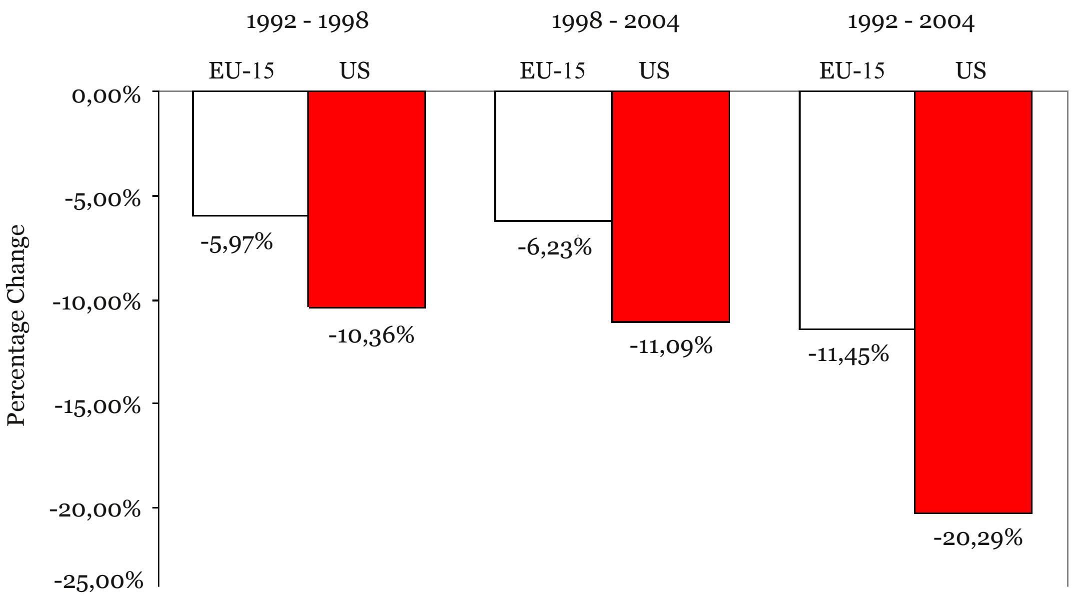


Figure 2: Comparison of EU and US Energy Intensity Reduction, 1992-2004

Source: EIA, International Energy Annual 2004. (Percentage changes are calculated using Total Primary Energy Consumption per Dollar of Gross Domestic Product.)

creating market-based economic systems, with clear benefits in the form of increased rates of economic growth. But the reform process has been slow and halting, leaving in place substantial institutional barriers to technological change, productivity growth, and improvements in emissions. The World Bank and other institutions have carried out extensive investigations about the role of specific institutions in creating a positive investment climate. These include minimizing corruption and regulatory burdens, establishing an effective rule of law, recognition of intellectual property rights, reducing the role of government in the economy, removing energy price distortions, providing an adequate infrastructure and an educated and motivated labor force.

Quantifying the importance of technology transfer for emission reductions

As described above, technology is critically important because emissions per dollar of income are far larger in developing countries than in the United States or other industrial countries. This is both a challenge and an opportunity. It is a challenge because it is the high emissions intensity – and relatively slow or non-existent improvement in emissions intensity – that is behind the high rate of growth in developing country emissions.

Opportunities exist because the technology of energy use in developing countries embodies far higher emissions per dollar of output than does technology used in the United States; this is true of new investment in countries like China and India as well as their installed base (See Figure 3). The technology embodied in the installed base of capital equipment in China produces emissions at about four times the rate of technology in use in the United States. China's emissions intensity is improving rapidly, but even so its new investment embodies technology with twice the emissions intensity of new investment in the United States. India is making almost no improvement in its emissions intensity, with the installed base and new investment having very similar emissions intensity. India's new investment also embodies technology with twice the emissions intensity of new investment in the United States.

Their calculations show that emission reductions can be achieved by closing the technology gap. The potential from bringing the emissions intensity of developing countries up to that currently associated with new investment in the United States is comparable to what could be achieved by the Kyoto Protocol (See Table 1). These are near term opportunities from changing the nature of current investment and accelerating replacement of the existing capital stock. Moreover, if achieved through transfer of economic technologies it is likely that these emission reductions will be accompanied by overall economic benefits for the countries involved.

In the first example in Table 1, the CRAI study assumed that in 2005 new investment in China and India immediately moves to the level of technology observed in the United States, and calculate the resulting reduction in cumulative carbon emissions through 2012 and 2017. This is the technology transfer case. In the second case, the CRAI analysis assumes that policies to stimulate foreign direct investment accelerate the replacement of the oldest capital with new equipment, giving even larger savings. In the third case, the assumption is that the new technology continues to improve over time, as it will if policies to stimulate R&D into less emissions-intensive technologies are also put in place. Even the least

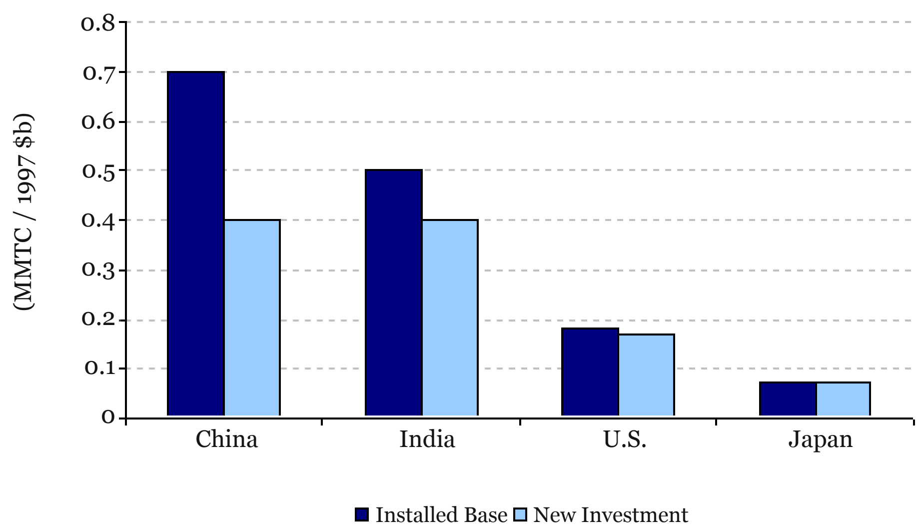


Figure 3: Greenhouse Gas Emissions Associated with Existing and New Investment in 2001 (Million tons of Carbon per $Billion of Gross Domestic Product at Market Exchange Rates)

Table 1: Cumulative Greenhouse Gas Emission Reductions Achievable Through Technology Transfer and Increased Investment

	To 2012 (MMTCE)	To 2017 (MMTCE)
Adopt US technology for new investment in China and India	2600	5200
Adopt US technology with accelerated replacement in China and India	4200	7700
Adopt continously improving technology with accelerated replacement in China and India	5000	9800
EU under Kyoto Protocol (without hot air)	600	1400
All Annex B countries under Kyoto Protocol (including US and hot air)	2800	7300

aggressive of these policies has potential for emissions reductions comparable to those that would be possible if all countries (including the US) achieved exactly the emission reductions required to meet their Kyoto Protocol targets.

The role of international partnerships like the Asia Pacific Partnership and the Major Economies Iniatiative in bringing about institutional change

Although it is clear that there is a relationship between institutions, economic growth, and greenhouse gas emissions, there is no general formula that can be applied to identify the specific institutional failures responsible for high emissions per unit of output in a specific country. If there is to be progress on institutional reform, at a minimum the key actors or stakeholders - concerned businesses, other groups with influence on opinion and policy in China and India (including local and regional governments), and national governments - must agree on the nature and scope of the problems and on reforms required to address the problems and identify concrete actions that each government will take to bring about institutional reforms.

Making progress in implementing the AP6 and the Major Economies Iniatiative (which includes the 17 countries responsible for approximately 85 percent of GHG emissions) can be accelerated if these countries' governments would fund research on topics such as the investment climate, the level of technology embodied in new investment, the role of FDI and potential energy savings from technology transfer, and the nature and impacts of pricing distortions on energy supply, demand and greenhouse gas emissions in China and India. Government support for research to make clear the direct consequences of proposed reforms for energy efficiency and the benefits of a market based investment climate for the overall process of economic growth would also be helpful.

Conclusions

To be successful, the negotiating process will need to bring forth a sufficient set of offers from each party to bring about meaningful changes in institutions with significant and quantifiable effects on greenhouse gas emissions. These offers would be embodied in an agreement on actions to be taken by all parties, and a framework under which actions would be monitored and additional steps could be agreed. This is the place where the current efforts of the Partnership's taskforces on clean fossil energy, renewable energy and distributed generation, power generation and transmission, steel, aluminum, cement, coal mining and building and appliances to identify technologies and investments that have profit potential and could also reduce emissions would become most useful. These investments would become in a way the reward to China and India for progress on institutional reform. The voluntary nature of private sector actions in the Partnership underscores the need for institutional reform to turn these potentially profitable investments into real projects.

The Marshall Plan is a good example of such a process. After World War II, Europe pledged various actions with the money provided by the US and, when it made good on those pledges, the program was extended and broadened. Exactly the same could be undertaken by the members of the Asia Pacific Partnership. Future actions by Australia, Japan and the United States desired by China and India would be contingent on success in implementing near term reforms agreed in the process.

Carbon Capture and Storage and Public International Law: Some Unresolved Questions

Katrin Kohoutek

- University of Heidelberg

1. Introduction

At least since the Intergovernmental Panel on Climate Change has presented its Fourth Assessment Report[1], possible consequences of releases of greenhouse gases (GHG) into the atmosphere dominate the media coverage. Between 1970 and 2004 the anthropogenic release of CO_2 has grown by about 80% and humans are responsible for 77% of the GHG emissions in 2004.[2] However it seems as if the supply of primary energy will be dominated by fossil fuels until at least the middle of this century.[3] There remains the question what to do with the resulting emissions. One option in the portfolio of measures to mitigate climate change is Carbon Capture and Storage, CCS. This term refers to a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere.[4] In this way CCS allows the use of fossil fuels with low emissions of CO_2.

Possible storage sites are geological formations onshore and offshore like depleted oil and gas reservoirs or saline aquifers, but the CO_2 could also be injected directly into the ocean.[5] In the ocean the CO_2 could dissolve in the water column or, below 3.000m where it is denser than water, form a "lake".[6] In the following the term CCS will only refer to the storage of CO_2 in sub-seabed geological formations unless indicated otherwise.

All measures of Carbon Dioxide Capture and Storage referred to above could together amount to 15-55% of the worldwide mitigation efforts. Sequestration in geological formations could cover the high end of this potential range.[7] As CCS means using fossils fuel with low CO_2 emissions, it facilitates a gentle transition to clean sources of energy. This way CCS can serve as a bridging technology on the way to clean energy production.

However, there remain severe obstacles to the employment of CCS on a large scale:

Capture and compression of the CO_2 require additional energy.[8]

Furthermore, CO_2 could leak[9] during transport or after being injected into the storage site.[10] The separated CO_2 has to be stored for several hundreds until thousands of years to have an impact on climate change.[11] Escape of CO_2 from the reservoir can therefore impair the whole enterprise and its aim. To secure that the CO_2 remains stored, some scheme of liability for the storage over the long time frames involved is necessary.

Leaking CO_2 can harm the marine environment through increased CO_2 concentrations in the water and, depending on the speed of the leakage, could even lead to small seismic events.[12]

If CCS would be implemented, its effects – positive or negative

[1] Intergovernmental Panel on Climate Change Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press 2005) <http://www.ipcc.ch/> (11 July 2007).

[2] Intergovernmental Panel on Climate Change 'Summary for Policy Makers' in IPCC Special Report on Carbon Dioxide Capture and Storage (Cambridge University Press 2005) 1–17, section 2, <http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/IPCCSpecialReportonCarbondioxideCaptureandStorage.htm> (11 July 2007).

[3] Ibid section 1.

[4] Ibid.

[5] Ibid section 3.

[6] Ibid section 8.

[7] Ibid section 19.

[8] Ibid section 4.

[9] Leakage in this paper means only the physical process of leakage, i.e. the unintentional release of CO_2 during capture, transport, injection or from the storage reservoir.

[10] IPCC (note 2) section 21, 22.

[11] R. Purdy and R. Macrory Geological Carbon Sequestration: Critical Legal Issue (Tyndall Centre for Climate Change Research Working Paper 45 January 2004) 2.

[12] IPCC (note 2) section 22.

- would be of global scale: CCS could considerably contribute to mitigating climate change. But CCS could harm flora and fauna in cases of leakages, too. If the capacity of the atmosphere to absorb CO_2 decreases due to a reduction of CO_2 emissions, leakages might even lead to further increases in global temperature.[13]

To deal appropriately with questions of global scale, an international regulation of CCS is needed. Therefore this paper aims to elaborate whether and how CCS can be engaged in under current treaty law regarding the protection of the marine environment and how it could be integrated into the international regime to mitigate climate change.

When balancing the employment of new technologies and their impact on the environment the precautionary principle is of importance. It has been included in several instruments which are important for the legality of CCS under public international law. The precautionary principle has been stated in Principle 15 of the Rio Declaration on Environment and Development[14]: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

Even though the precautionary principle is still evolving[15] it slowly becomes part of customary international law.[16]

One could use the precautionary principle to argue in favour of a fast implementation of CCS projects, but also to support the contrary: On the one hand it has been argued that CCS should be employed in order to achieve huge emission reductions to mitigate climate change and prevent further ocean acidification.[17] On the other hand one could easily rely on the precautionary approach to argue that CCS should not be employed until all possible risks to the marine environment are known and controllable.[18]

The advantage of CCS in the context of climate change is the fast and cost-effective reduction of emissions. However, these reductions in emissions are not induced by generating less CO_2, but just by storing CO_2 underground. Furthermore the risk of leakage reduces this advantage, leading only to a delay in emission instead of actual emission reductions. Additionally there is little knowledge as to when CO_2 will leak out and how this might effect the marine environment.[19] Furthermore, although CCS might be useful as a bridging technology, it also poses the risk that necessary steps to a general reduction of CO_2 emissions might be delayed. In spite of this, to combat climate change effectively, genuine reductions in the emission of CO_2 need to take place. However, relying on the precautionary principle in order to engage in CCS with the current state of knowledge, the risks involved and its insecure benefits seems artificial. Therefore, when the precautionary principle is mentioned in the following, it is interpreted as obliging to abstain from CCS until the problems mentioned are solved.

2. CCS and Current Law of the Sea

CCS will take place by injecting CO_2 into the sub-seabed. Through the injection process itself and through leakages CCS projects might adversely impact on the marine environment. These possible consequences for the marine ecosystem lead to the question whether CCS is compatible with treaties relating to the protection of the marine environment.

The most important treaties influencing the legality of CCS are the United Nations Convention on the Law of the Sea (UNCLOS)[20], the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (London Convention, LC)[21], the protocol thereto (London Protocol, LP)[22] and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)[23]. The latter convention is of particular interest as CO_2 has already been

[13] See C. Jaeger 'Carbon Capture and Storage: Risk Governance and Rent Seeking' (Contributtion to the workshop on 15 and 16 March 200 held by the International Risk Governance Council) 4, <http://www.irgc.org/spip/spip.php?page=irgc&id_rubrique=29> (31 May 2007).

[14] The Rio Declaration on Environment and Development (1992) 31 ILM 876.

[15] I. Brownlie Principles of Public International Law (6th edition Oxford University Press 2003) 275.

[16] W. Graf Vitzthum Völkerrecht (3rd edition De Gruyter 2004) 431, U. Beyerlin Umweltvölkerrecht (C.H. Beck 2000) 60.

[17] See the discussion which took place on the adoption of an amendment of Annex I of the London Protocol during the 1st Meeting of the Parties, 'Report of the 28th Consultative Meeting and First Meeting of Contracting Parties' LC 28/15, 22, 23 <http://www.imo.org/includes/blastDataOnly.asp/data_id%3D17921/15.pdf> (11 July 2007).

[18] See the statement of the delegation of South Africa ibid, 24.

[19] Intergovernmental Panel on Climate Change 'Technical Summary' in IPCC Special Report on Carbon Dioxide Capture and Storage (Cambridge University Press 2005), 17-49 section 10, <http://arch.rivm.nl/env/int/ipcc/pages_media/SRCCS-final/IPCCSpecialReportonCarbondioxideCaptureandStorage.htm> (11 July 2007).

[20] Opened for signature 10 December 1982, entered into force 16 November 1994; 1833 UNTS 3.

[21] Concluded 29 December 1972, entered into force 30 August 1975; 1046 UNTS 120.

[22] 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter; opened for signature 7 November 1996, entered into force 24 March 2006; (1997) 36 ILM 1.

[23] Adopted 22 September 1992, entered into force 25 March 1998; (1993) 32 ILM 1069.

injected into the sub-seabed of Norwegian Waters where the OSPAR Convention applies and because some parties to OSPAR regard the sequestration of CO_2 under the North Sea as part of their climate change mitigation strategies.[24]

To have an impact on CCS the conventions mentioned above need to be applicable to the sub-seabed, into which the CO_2 will be injected. If this is found to be the case it will be discussed if and how CCS could be compatible with it.

a. United Nations Convention on the Law of the Sea

The most important treaty applicable to marine affairs is UNCLOS. It provides general regulations for almost all legal issues regarding the use of the sea. As it is a framework convention, its very general rules have to be specified in other instruments.[25] UNCLOS is applicable to the seabed and its subsoil, see for instance Articles 1 (1), 2 (2), 49 (2), 56 (1) (a) and 76 (1) UNCLOS. The geological definition of subsoil only includes the layer of rock directly beneath the seabed,[26] which would render UNCLOS inapplicable to CCS. However, according to Article 31 (1) Vienna Convention on the Law of Treaties[27] a treaty shall be interpreted in the light of its objective and purpose. The first section of the preamble of UNCLOS spells out its aim to settle all issues relating to the law of the sea. In order to apply UNCLOS to all activities that may impact on the sea, the term subsoil as used in UNCLOS should be defined as including all geological formations beneath subsoil.[28]

The most important provisions on the protection of the marine environment are contained in Part XII UNCLOS. These provisions are applicable to any part of the sea. Article 192 UNCLOS obliges all state parties to protect and preserve the marine environment. In Article 193 UNCLOS the sovereign right of states to exploit their resources is restricted to the condition that they shall comply with their duty to protect and preserve the marine environment when employing these rights.

Article 194 UNCLOS specifies the general obligation to protect and preserve the marine environment with regard to pollution. Section one obliges states to prevent, reduce and control pollution of the marine environment from any source by taking all necessary measures consistent with UNCLOS and implementing the best means at their disposal. Article 194 (2) UNCLOS prohibits the contracting parties to engage in activities causing harm to the environment of other states or to areas beyond their jurisdiction. Furthermore states shall take those measures necessary to protect and preserve rare or fragile ecosystems, Article 194 (5) UNCLOS.

Whether an application of Article 192 UNCLOS leads to a prohibition of CCS is rather doubtful: CCS would be prohibited by Article 192 UNCLOS, if it would harm the marine environment. However, if CCS leads to less CO2 in the atmosphere, a further acidification of the oceans would be prevented, which surely preserves the marine environment. For these reasons Article 192 UNCLOS should be read in such a way that states engaging in CCS are under the obligation to regulate CCS activities by using high security standards to prevent leakages as far as possible.

An application of Article 194 UNCLOS leads to a similar result: States engaging in CCS should prevent leakages and other possible harm to the environment as far as possible through the setting of high technology standards. Furthermore the obligations of Article 194 (1) UNCLOS to reduce and control pollution indicate that states should make plans how to stop leakages and prevent further damages.

However, these provisions can apply to CCS only, if CCS amounts to pollution under UNCLOS.

Pollution is defined in Article 1 (1) (4) UNCLOS as “the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities”. Increased levels of CO2 may lead to adverse effects on the deep-sea ecosystems, such as decreased biological activity, dissolution of exoskeletal compounds or even death.[29] So in cases of leakage the marine environment could be harmed. This suggests that CO2 should be regarded as a pollutant under UNCLOS.

However, it is unclear whether leakages will occur. That leads to the question, whether states are obliged to abstain from CCS or have to regulate activities which can neither be proven

[24] K.N. Scott ‘The Day after Tomorrow: Ocean CO2 Sequestration and the Future of Climate Change’ (2005) 18 Georgetown International Environmental Law Review 57, 62.
[25] Purdy and Macrory (note 11) 17.
[26] Scott (note 24) 65 footnote 48.
[27] Vienna Convention on the Law of Treaties (with Annex); concluded 23 May 1969, entered into force 27 January 1980; 1155 UNTS 331.
[28] Scott (note 24) 65.
[29] Scott (note 24) 86.

to be harmless, nor proven to be harmful.

This question could be answered in the affirmative, if the precautionary principle would be applicable to the relevant provisions of UNCLOS. State parties would then be obliged to prevent possible environmental degradation, even if there is no full scientific certainty about the causal link between CCS and environmental damages. Hence the Articles 192 ff UNCLOS would apply to CCS.

UNCLOS itself includes no reference to the precautionary principle. It has been argued that the wording of the definition of pollution which reads "introduction (…) of substances (…) which results or is likely to result in such deleterious effects…"[30] implies that no established causal link is required to trigger the obligations regarding the marine environment.[31] That indicates that the precautionary principle can be applied to UNCLOS.

This argument is supported by a historical and purposive approach to UNCLOS: When Mr. Arvid Pardo, representative of Malta, in 1967 urged the General Assembly of the United Nations to work towards a treaty to regulate all issues of the use of the sea, he did so also to prevent adverse effects for the marine environment resulting from unregulated exploitation of resources.[32] The aim to protect and preserve the marine environment is reflected in the fourth section of the preamble of UNCLOS, too.[33] In order to meet this aim UNCLOS must be enabled to deal with arising harm which is uncertain in its incidence and impact. This requires the application of the precautionary principle with regard to the provisions on pollution of the marine environment, especially in view of the fact that such an interpretation is covered by the wording of the definition of pollution contained in Article 1(4) UNCLOS.[34]

Furthermore there has been support for the application of the precautionary principle to questions regarding the law of the sea from the United Nations Open-Ended Informal Consultative Process on Oceans and the Law of the Sea[35] and the United Nations General Assembly.[36]

These developments lead to the conclusion that the precautionary principle should be applied to the environmental provisions of UNCLOS, even if such an application is not compulsory. Therefore the provisions contained in Part XII UNCLOS should be regarded as applicable to CCS. Hence states engaging in CCS are obliged under Articles 192, 194 UNCLOS to prevent leakages and other possible harm to the environment as far as possible through the setting of high security standards.

Another provision of UNCLOS which is highly important to evaluate the legality of CCS under public international law is Article 210 UNCLOS. It deals with a special form of pollution, the pollution of the marine environment by dumping. States shall adopt laws to prevent, reduce and control pollution of the marine environment by dumping, Article 210 (1) UNCLOS. Dumping is defined in Article 1 (1) (5) UNCLOS as "any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea". CO2 is an unwanted by-product of manufacturing or energy generating processes and can be regarded as waste when disposed of for the sole purpose of disposal.[37] CCS is the deliberate storage of CO2 beneath subsoil and therefore is covered by the definition of dumping.

Article 210(4) UNCLOS requires states to establish global rules on dumping. It is generally accepted that the London Convention and the London Protocol are the global standards referred to in Article 210 UNCLOS. Both treaties fill out the general norms of UNCLOS.[38] This means that an activity which is prohibited under the London Convention, respectively the London Protocol, is also prohibited under Article 210 UNCLOS.

b. London Convention

The London Convention establishes a regulatory system for the dumping of wastes at sea. Article III (a) (i) LC defines dumping as "any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea". CCS as the deliberate storage of CO2 beneath the

[30] Article 1 (1) (4) UNCLOS, emphasis added.
[31] Scott (note 24) 69, 70.
[32] UNGA 1 November 1967 GAOR 22nd Session 1515th and 1516th Plenary Meetings, see especially sections 79, 83, 85-87 and 91; <http://www.un.org/Depts/los/convention_agreements/texts/pardo_ga1967.pdf> (11 July 2007).
[33] The section reads as follows: "Recognizing the desirability of establishing through this convention(…) a legal order for the seas and oceans which (…) will promote (…) the study, protection and preservation of the marine environment".
[34] Similarly Scott (note 24)70.
[35] See 'Report on the Work of the United Nations Open-Ended Informal Consultative Process on Oceans and the Law of the Sea at Its Seventh Meeting' UN Doc A/61/156 (17 July 2006) <http://daccessdds.un.org/doc/UNDOC/GEN/N06/432/90/PDF/N0643290.pdf?OpenElement> (30 June 2007).
[36] See for instance UNGA Res 58/240 (23 December 2003) section 52 <http://daccessdds.un.org/doc/UNDOC/GEN/N03/508/92/PDF/N0350892.pdf?OpenElement> (11 July 2007).
[37] Scott (note 24) 73, 74.
[38] Purdy and Macrory (note 11) 8, 9.

seabed seems to be covered by this definition.

However, there are doubts on the applicability of the London Convention to CCS: The definition refers only to “disposal at sea”[39] which leads to the question whether the disposal of CO_2 in geological formations beneath seabed is covered since it does not take place at sea but beneath the sea.

The objective of the London Convention is “the effective control of all sources of pollution of the marine environment”, Article I LC. This seems to include all activities within the marine area that could harm the marine environment. In the light of this objective the definition of dumping should be read as referring also to storage activities taking place beneath seabed.[40] Such a purposive interpretation would render the London Convention applicable to CCS even though the definition of dumping does not explicitly refer to layers of the sub-seabed.

The Contracting Parties to the London Convention endorsed in their 27th Consultative Meeting that the London Convention and the London Protocol are the appropriate instruments to address the implications of CCS for the marine environment.[41] For this reason the London Convention has to be regarded as being applicable to CCS. Therefore CCS amounts to dumping of CO_2 under the London Convention.

However, CCS could be exempted from dumping, if it were “placement of matter for a purpose other than the mere disposal thereof” consistent with the aims of the London Convention, as spelled out in Article III (1) (b) (ii) LC. One could argue that CCS amounts to such placement since the CO_2 is stored to mitigate climate change and consequent ocean acidification.[42] However, Article I LC provides that the aim of the London Convention is not only to control all sources of pollution of the marine environment, but also to prevent pollution of the marine environment and consequent harm to living resources and marine life. CCS might amount to pollution and possibly harms the marine environment in case of leakages. The parties to the LC agreed that placement according to Article III (1) (b) (ii) LC shall not be contrary to the aims of the convention.[43] For this reason the purpose of mitigating climate change alone cannot sanctify the disposal of CO_2 as legal under the London Convention. Hence CCS cannot be regarded as exempted from the regulations on dumping.[44] Therefore an examination whether CCS is compatible with the dumping regime of the London Convention is needed.

Dumping is regulated by the London Convention depending on the harmfulness of the substance. It is reflected in the annexes to the LC, how harmful a substance is. Article IV (1) LC provides that substances listed in Annex I are not to be dumped, whereas matters listed in Annex II may be dumped with a prior special permit and every other waste may be dumped with a general permit. Such permits are to be issued by national authorities which have had to be designated by contracting parties in accordance with Article VI LC.

Therefore it has to be examined, whether CO_2 can be dumped legally under the London Convention. CO_2 is not mentioned in any annex of the London Convention. According to Article IV (1) (c), (2) LC this means that it can be dumped with a general permit issued by the responsible authority after consideration of all the factors set forth in Annex III LC. This authority would be the national agency issuing such permits in the state where the cargo is loaded or the where the vessel is registered, if the loading state is not Party to the London Convention, Article VI (2) LC.

However, CO_2 might be industrial waste, which is listed in paragraph 11 of Annex I LC. If it was considered industrial waste, dumping of it would be prohibited according to Article IV (1) (a) LC. Industrial waste is defined in paragraph 11 of Annex I LC as “waste materials generated by manufacturing or processing operations”, waste being “material and substances of any kind, form or description”, Article III (4) LC. Despite intense debate,[45] it seems that there is still no consensus among the parties to the LC neither on how to define the details of the term “industrial waste” nor on the exceptions to it.[46]

It has to be taken into account that the Contracting Parties agreed to apply the precautionary principle to environmental

[39] Emphasis added.
[40] Similar Scott (note 24) 75; Purdy and Macrory (note 11) 19 and J. Friedrich ‘Carbon Capture and Storage: A New Challenge for International Environmental Law’ (2007) 67 Heidelberg Journal of International Law 211, 220.
[41] ‘Report of the 27th Consultative Meeting’ LC27/16, 3, 4, and 23, 24 <http://www.imo.org/includes/blastDataOnly.asp/data_id%3D16893/16.pdf> (11 July 2007).
[42] ‘Report of the 27th Consultative Meeting‘ LC27/16 Annex 7, 2; also discussed by Purdy and Macrory (note 11) 23.
[43] ‘Report of the 27th Consultative Meeting’ LC27/16, 28.
[44] Similarly Purdy and Macrory (note 11) 23.
[45] ‘Report of the 27th Consultative Meeting’ LC27/16, 24, 25; ‘Report of the 28th Consultative Meeting and First Meeting of Contracting Parties’ LC 28/15, 34.
[46] ‘Report of the 28th Consultative Meeting and First Meeting of Contracting Parties’ LC 28/15, 34.

protection within the framework of the London Convention.[47] In implementing the London Convention the Contracting Parties shall be guided by the precautionary approach, so that "appropriate preventive measures are taken when there is reason to believe that substances or energy introduced in the marine environment are likely to cause harm even where there is no conclusive evidence to prove a causal relation between inputs and their effects". To facilitate the ultimate object of the London Convention, which is to prevent pollution of the sea,[48] the precautionary principle should also guide the interpretation of industrial waste. Consequently the term "industrial waste" should be interpreted broadly so that harmful substances are hindered from entering the marine environment. This suggests that CO_2 constitutes industrial waste for the purposes of the London Convention.

Such a finding is supported by the fact that CO_2 captured from cement works is derived from a manufacturing process, hence constitutes industrial waste.[49] However, although CO_2 emerging from power stations is not derived from manufacturing or processing operations, the possible impact of CO_2 remains the same. Drawing a distinction between CO_2 and CO_2 depending on the source where it stems from seems to be artificial, even more so with regard to the objective of the Convention.

Therefore, on the assumption that CO_2 constitutes industrial waste, dumping of CO_2 is prohibited under Article IV (1) LC and consequently also by Article 210 UNCLOS. This means that CCS activities are not compatible with both instruments.

c. London Protocol

On 24 March 2006 the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter entered into force.[50] According to Article 23 LP the London Protocol now supersedes the London Convention for states which are a party to both instruments.

The London Protocol aims at protecting and preserving the marine environment from all sources of pollution[51] and is therefore stricter than the London Convention, which has as its objective only the control and prevention of pollution of the marine environment.[52] Furthermore the state parties are obliged to apply the precautionary principle in implementing the London Protocol, Article 3 (1) LP. Under the London Protocol any dumping of wastes or other matter shall be prohibited, with the exception of the substances listed in Annex I LP, Article 4 (1) LP.

Dumping is defined in Article 1 (4) (.1) LP as:

".1 any deliberate disposal into the sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;

.2 any deliberate disposal into the sea of vessels, aircraft, platforms or other man-made structures at sea;

.3 any storage of wastes or other matter in the seabed and the subsoil thereof from vessels, aircraft, platforms or other man-made structures at sea; and

.4 any abandonment or toppling at site of platforms or other man-made structures at sea, for the sole purpose of deliberate disposal."

The reference to storage of wastes or other matter in the seabed or subsoil thereof in the definition of dumping renders the London Protocol applicable to CCS.

On the 1st Meeting of Contracting Parties Annex I of the London Protocol was amended so that it now contains in paragraph 1.8 a reference to "Carbon dioxide streams from carbon dioxide capture processes for sequestration".[53] According to paragraph 4 of Annex I LP such CO_2 streams may only be considered for dumping, if:

".1 disposal is into a sub-seabed geological formation; and

.2 they consist overwhelmingly of carbon dioxide. They may contain incidental associated substances derived from the source material and the capture and sequestration processes used; and

.3 no wastes or other matter are added for the purpose of disposing of those wastes or other matter."

The amendment came into force on 10 February 2007.[54] Thus CCS is now compatible with the London Protocol. This means parties to both the London Convention and the London Protocol can engage in CCS activities lawfully, while states which are only a party to the London Convention are not

[47] International Maritime Organization Resolution LCD. 44(14).
[48] Article I LC.
[49] Scott (note 24) 77.
[50] International Maritime Organization 'International Rules on Dumping of Wastes at Sea to be Strengthened with Entry into Force of 1996 Protocol' Briefing 05/2006 (Press Release).
[51] Article 2 LP.
[52] Article I LC.
[53] International Maritime Organization 'Notification of Amendments to Annex 1 to the London Protocol 1996' LC-LP.1/Circ.5.
[54] International Maritime Organization 'Notification of Entry into Force of the "CO2 Sequestration" Amendments to Annex 1 to the London Protocol 1996' LC-LP-1/Circ. 11.

allowed to do so.

Not existent still are binding guidelines on CCS activities and on the assessment of the CO_2 streams to ensure high standards in implementing this technique.

The Intersessional Technical Working Group on CO_2 Sequestration established by the Scientific Group of the London Convention and Protocol drafted Specific Guidelines for the Assessment of Carbon Dioxide Streams for Disposal into Sub-Seabed Geological Formations.[55] However, these guidelines are still under development.[56] So by now the London Protocol allows states to engage in CCS, but there is no binding guidance on the substance. It is questionable whether this approach to CCS is compatible with the precautionary principle.

d. OSPAR

The last important convention on protection of the marine environment with regard to CCS is the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention, OSPAR). OSPAR is a regional convention under Article VIII LC, respectively Article 12 LP. According to both provisions, such regional conventions must remain consistent with the London Convention, respectively the London Protocol, thereby establishing a hierarchy between the different treaties. The scope of application of OSPAR extends to maritime areas around the North Sea, and parts of the Atlantic and Arctic oceans, including the internal waters of the contracting states.[57] OSPAR also includes the subsoil in its definition of marine area.[58] Hence it is applicable to the disposal of CO_2 beneath the seabed.

OSPAR aims at the protection of the marine environment from adverse effects of human activities, Article 2 (1) (a) OSPAR. Furthermore Article 2 (3) OSPAR obliges the state parties to use best available techniques and best environmental practice including, where appropriate, clean technology when implementing OSPAR.

The precautionary principle is included twice in the convention: State parties are generally obliged to apply “the precautionary principle, by virtue of which preventive measures are to be taken when there are reasonable grounds for concern that substances or energy introduced, directly or indirectly, into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even where there is no conclusive evidence of a causal relationship between the inputs and the effects”, Article 2 (2) (a) OSPAR.[59] This formulation of the precautionary principle is stricter than in other conventions as it requires positive action when harm can occur, but this possible harm does not need to be serious or irreversible.[60] The definition of pollution contained in Article 1 (d) OSPAR includes also a reference to the precautionary principle.[61]

Pollution is defined as “the introduction by men, directly or indirectly, of substances or energy into the maritime area which results, or is likely to result, in hazards to human health, harm to living resources and marine ecosystems, damage to amenities or interference with other legitimate uses of the sea.”

Unlike the London Convention or the London Protocol, OSPAR regulates pollution depending on the way of disposal and establishes three different, mutually exclusive regimes.[62] “Pollution of the marine area” is used in a general meaning,

[55] ‘Report of the Twenty-Ninth Meeting of the Scientific Group’ Annex 4 LC/SG 29/15 <http://www.imo.org/includes/blastDataOnly.asp/data_id%3D17923/15.pdf> (11 July 2007).

[56] There is now a revised text on which the Intersessional Technical Working Group on CO2 Sequestration finally agreed, but it has to be commented on by the Scientific Groups still, see ‘Report of the Second Meeting of the Intersessional Technical Working Group on CO2 Sequestration’, LC/SG-CO2 2/4 (containing the revised text with one section still under dispute between the delegations of Germany and Saudi Arabia) <http://www.imo.org/includes/blastDataOnly.asp/data_id%3D18651/4.pdf> (11 July 2007) and ‘CO2 Sequestration in Sub-Seabed Geological Formations: Development of Specific Guidelines for the Assessment of Carbon Dioxide Streams for Disposal into Sub-Seabed Geological Formations’, LC/SG 30/2 (containing the Agreement between Germany and Saudi Arabia and the invitation to the Scientific Groups to comment on the text) <http://www.imo.org/includes/blastDataOnly.asp/data_id%3D18834/2.pdf> (11 July 2007).

[57] The precise geographical scope of application can be found in Article 1 (a) OSPAR.

[58] See Article 1 (a) OSPAR. The Group of Jurists and Linguists established that “subsoil” covers all underground strata below the seabed, OSPAR Commission ‘Report from the Group of Jurists and Linguists on Placement of Carbon Dioxide in the OSPAR Maritime Area’ Summary Records OSPAR 2004 OSPAR 04/23/1-E, Annex 12, 2.

[59] Emphasis added.

[60] Purdy and Macrory (note 11) 35; see as an example to the contrary Article 3 (3) UNFCCC: „The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.” (Emphasis added).

[61] Purdy and Macrory (note 11) 34, for a discussion in depth of how the precautionary principle is included in this definition, see Scott (note 24) 69, 70.

[62] OSPAR Commission ‘Report from the Group of Jurists and Linguists on Placement of Carbon Dioxide in the OSPAR Maritime Area’ Summary Records OSPAR 2004 OSPAR 04/23/1-E, Annex 12, 6.

covering all three regimes. The regimes relate to either pollution from land-based sources, or pollution by dumping or incineration at sea, or pollution from offshore-installations.

Pollution from land-based sources is regulated by Article 3 OSPAR and Annex I OSPAR. This regime would apply for example to a release of CO_2 by pipeline from land into the sub-seabed. Land-based sources are defined in Article 1 (e) OSPAR as "point and diffuse sources on land from which substances or energy reach the maritime area by water, through the air, or directly from the coast. It includes sources associated with any deliberate disposal under the sea-bed made accessible from land by tunnel, pipeline or other means and sources associated with man-made structures placed, in the maritime area under the jurisdiction of a Contracting Party, other than for the purpose of offshore activities". Article 3 OSPAR requires states to take all steps to prevent and eliminate pollution from land-based sources. According to Article 2 (1) Annex I OSPAR discharges from land-based sources are subject to strict authorization and regulation of the competent authorities of the Contracting Parties. In regulating such activities the authorities have to implement the relevant decisions of the OSPAR Commission, Article 2 (1) Annex I OSPAR.

This means that CO_2 can be released from land directly into sub-seabed geological formations, e.g. by pipeline, after the competent national agency has authorized the project by issuing a permit.

It has, however, been argued that the obligation to prevent pollution as set out in Article 3 OSPAR renders CCS by pipeline injection from land incompatible with OSPAR as it could cause pollution to the marine environment.[63] Such a finding is supported by the emphasis which is laid on the precautionary principle and its strict formulation under OSPAR. Therefore can be concluded that CO_2 disposal by pipeline from land into the sub-seabed is not compatible with OSPAR. However, a decision by the OSPAR Commission different from this outcome would have to be implemented by the authority issuing the relevant permit, Article 2 (1) Annex I OSPAR.

The second regime of OSPAR relates to pollution by dumping or incineration of wastes or other matter and is regulated by Article 4 OSPAR and Annex II OSPAR. It would apply to the disposal of CO_2 from ship.

Article 4 OSPAR requires state parties to prevent and eliminate pollution by dumping of wastes or other matter. Dumping is defined in Article 1 (f) OSPAR as any deliberate disposal in the maritime area of wastes or other matter from vessels or aircraft or from offshore installations. Article 1 Annex II OSPAR establishes that the dumping regime is only applicable to dumping from vessels or aircrafts. CCS might be engaged in from vessels, however, not from aircrafts. These will therefore be left out of consideration.

The term "vessel" is defined very broadly in Article 1 (n) OSPAR, covering almost every man-made structure in the maritime area which is not an offshore installation. "Wastes or other matter" are characterized only negatively by reference to substances not being wastes or other matter, Article 1 (o) OSPAR. Consequently, this phrase is to be interpreted broadly, too.[64] Any deliberate disposal in the maritime area of wastes or other matter from vessels or aircrafts or from offshore installations amounts to dumping, Article 1 (f) OSPAR. CO_2 is not listed as being no waste, so it constitutes waste or other matter under OSPAR. As CCS is the deliberate disposal of CO_2, it amounts to dumping of wastes or other matter.

Article 3 (1) Annex II OSPAR prohibits the dumping of wastes or other matter, if the substance to be dumped is not listed as harmless in paragraph 2 or 3 of this provision. CO_2 is not listed as harmless. Hence the dumping of CO_2 is prohibited. Consequently CCS engaged in from a vessel is not compatible with OSPAR.

The last regime of OSPAR regulates pollution from offshore sources in Article 5 OSPAR and Annex III OSPAR. This regime applies to the injection of CO_2 into the subsoil from an offshore installation after transport to this installation either by ship or by pipeline.[65]

Article 5 OSPAR obliges states to prevent and eliminate pollution from offshore sources. "Offshore sources" refers to offshore installations from which substances or energy reach the maritime area, Article 1 (k) OSPAR. Article 1 (l) OSPAR defines offshore installations as man-made structures placed in the maritime area to engage in offshore activities. "Offshore activities" means activities carried out in the maritime area for the purposes of the exploration, appraisal or exploitation of liquid and gaseous hydrocarbons, Article 1 (j) OSPAR.

Article 3 (1) Annex III OSPAR establishes the general rule that any dumping of wastes or other matter from offshore

[63] Purdy and Macrory (note 11) 30.
[64] Similarly Purdy and Macrory (note 11) 32.
[65] OSPAR Commission 'Report from the Group of Jurists and Linguists on Placement of Carbon Dioxide in the OSPAR Maritime Area' Summary Records OSPAR 2004 OSPAR 04/23/1-E, Annex 12, 5.

installations is prohibited. As CO2 is waste under OSPAR and CCS amounts to dumping, CCS from offshore installations is prohibited under OSPAR.

However, it has been argued that CCS does not fall under the regime of Article 5 OSPAR and Annex III OSPAR since it is not related to the exploration, appraisal or exploitation of hydrocarbons hence does not constitute an offshore activity.[66] According to Article 1 (j) OSPAR offshore activities are related to hydrocarbons, while offshore installations are man-made structures placed in the marine area for the purpose of offshore activities, Article 1 (l) OSPAR. This wording indicates that a subsequent change in the use of a structure might be possible without rendering the installation a "non-offshore installation": If a structure has been placed in the maritime area originally for purposes of offshore activities, but later on is used solely for purposes of CCS, it was placed for purposes of offshore activities still, even though it is not used for such purposes any longer. CO2 reaching the maritime area from such an installation would fulfil the definition of offshore source given in Article 1 (j) OSAR: "Offshore sources means offshore installations and offshore pipelines from which substances or energy reach the maritime area." Hence CCS would amount to dumping of waste from an offshore installation, which is prohibited by Article 3 (1) Annex III OSPAR.

A similar question is, whether a structure in the marine area which has not been built to exploit hydrocarbons, but only for purposes of CCS, does fall under the regime of Article 5 OSPAR and Annex III OSPAR or under any other regime of OSPAR.[67]

It has been argued that the broad definition of vessel in Article 1 (n) OSPAR which "includes (...) other man-made structures in the maritime area and their equipment, but excludes offshore installations and offshore pipelines" covers CCS from a new installation at sea. This way such manner of CCS would be prohibited by the regime of Article 4 OSPAR and Annex II OSPAR.[68]

It could be argued, too, that such a structure is covered by the definition of land-based sources in Article 1 (e) OSPAR, since this definition also applies to "sources associated with any deliberate disposal under the sea-bed made accessible from land by tunnel, pipeline or other means and sources associated with man-made structures placed, in the maritime area under the jurisdiction of a Contracting Party, other than for the purpose of offshore activities".[69] Consequently, such an activity would only be subject to national authorization.

However, OSPAR aims to eliminate and prevent pollution, and to protect the marine environment, as set out in Article 2 (1) (a) OSPAR. Furthermore the precautionary principle plays quite an important role under OSPAR in comparison to other conventions. This indicates that under OSPAR the marine environment shall be protected as far as possible. Consequently the term "land-based source" should be interpreted restrictively to give way to the stricter regime to apply in order to protect the marine environment against possibly adverse effects caused by CCS.[70] Therefore CO2 injected from a man-made structure in the marine environment should be regarded as falling under the regime applicable to dumping of wastes or other matter. This means that such manner of CCS is not compatible with OSPAR.

However, similar to the London Protocol there is development in the OSPAR framework: In 2006 the OSPAR Commission established an Intersessional Correspondence Group to develop options on how to facilitate CCS under OSPAR, taking into account the developments under the London Protocol.[71] At the Meeting of the Offshore Industry Committee in Paris from 12 until 16 March 2007 the draft OSPAR guideline for risk assessment and management of CO2 in sub-seabed geological formations and a draft Framework for Risk Assessment and Management of CO2 in Sub-Seabed Geological Formations were discussed.[72] These developments suggest that an amendment of OSPAR to facilitate CCS is just a question of time.

e. Summary

To sum up it can be said that the legality of CCS under treaties protecting the marine environment often depends on whether the emphasis in treaty interpretation is laid on the precautionary principle and protection of the marine ecosystems. States engaging in CCS are obliged under Articles

[66] Purdy and Macrory (note 11) 31.
[67] Scott (note 24) 83.
[68] Scott (note 24) 84.
[69] Scott (note 24) 83.
[70] Similarly Scott (note 24) 83, 84.
[71] OSPAR Commission 'Terms of Reference for the Intersessional Correspondence Group on the Placement of CO2 in Sub-Seabed Geological Formations (ICG-CO2)' OSPAR 06/23/1-E, Annex 4.
[72] Offshore Industry Committee 'Meeting of the Offshore Industry Committee: Summary Records' OIC 07/15/1-E 19.

192, 194 UNCLOS to prevent leakages and other possible harm to the marine environment as far as possible through the setting of high technology standards. Furthermore they are under a duty not to cause pollution in areas where they do not exercise sovereign rights, Article 194 (2) UNCLOS.

Filling out Article 210 UNCLOS, the London Convention would prohibit CCS, if CO2 were classified as industrial waste, which is advocated above. Otherwise, CCS activities would only be subject to a general permitting procedure. CCS has been compatible with the London Protocol since the amendment of Annex I LP on the 1st Meeting of the Contracting Parties. The legality of CCS under OSPAR depends on the method of disposal, leaving CCS by pipeline injection from land subject to national authorization, but prohibiting CCS from vessels or offshore injections.

The question remains, whether and how reductions in CO2 emissions gained through CCS projects can be integrated into the current system to mitigate climate change.

3. CCS and the International Regime to Mitigate Climate Change

On 9 May 1992 the United Nations Framework Convention on Climate Change (UNFCCC)[73] was adopted with the ultimate objective to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system", Article 2 UNFCCC. The Kyoto Protocol (KP)[74] as a protocol to the UNFCCC establishes clear emission reduction commitments for those of its parties classified as industrialized countries in Annex I of the UNFCCC (in the following referred to as Annex I parties or Annex I countries). These parties are obliged not to exceed their assigned amounts of greenhouse gas (GHG) emissions calculated pursuant to Annex B of the Kyoto Protocol. Eventually the total GHG emissions of those countries shall be reduced by at least five percent below their respective levels of 1990, Article 3 (1) KP.

To achieve this aim Annex I parties shall reduce their GHG emissions at source or remove GHG from the atmosphere with so-called sinks, Article 3 (3) KP. Additionally they can use the so-called flexible mechanisms, which are the Joint Implementation[75], the Clean Development Mechanism[76] and the Emissions Trading[77]. These mechanisms allow states to work together to create and transfer or acquire units of emission reduction, which can be used to meet the assigned amount of emissions for the states involved. The state parties to the UNFCCC and to the Kyoto Protocol have to present their changes in GHG emissions in national greenhouse gas inventories, Article 4 (1) (a) UNFCCC, Article 7 KP.

CCS as a technology to reduce GHG emissions includes the risk of leakage of CO2 from storage sites. Neither the UNFCC nor the Kyoto Protocol had been designed to deal with technologies that pose this risk. It is not clear yet, how leakages can be integrated into the accounting system of GHG emissions and how they should appear in the national greenhouse gas inventories. Therefore it has to be examined, whether and how CCS can be integrated into this framework.

A very general question has to be answered before CCS can safely be said to be compatible with the UNFCCC and the Kyoto Protocol and before accounting questions can be addressed: CCS could enhance and prolong the use of fossil fuels since it allows generating energy by combustion with less emissions. However, both the UNFCCC and the Kyoto Protocol aim at sustainable development[78] and Article 3 (1) UNFCCC explicitly prescribes that the parties to the UNFCCC should protect the climate system for the benefit of present and future generations of humankind. Using a technology which might extend the fossil fuel era to mitigate climate change might conflict with the objectives of both instruments.[79]

The term sustainable development has been defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".[80] This concept includes the element of intergenerational equity,[81] which is also emphasized by Article

[73] United Nations Framework Convention on Climate Change (with Annexes); adopted 9 May 1992, entered into force 21 March 1994; 1771 UNTS 107.
[74] Kyoto Protocol to the United Nations Framework Convention on Climate Change; adopted 10 December 1997, entered into force 16 February 2005; (1998) 37 ILM 32.
[75] Article 6 KP.
[76] Article 12 KP.
[77] Article 17 KP.
[78] Article 3 (4) UNFCCC; Articles 2 (1), 10, 12 (2) KP.
[79] United Nations 'Report on the Workshop on Carbon Dioxide Capture and Storage as Clean Development Mechanism Project Activities' (15 August 2006) FCCC/KP/CMP/2006/3, 9 <http://unfccc.int/resource/docs/2006/cmp2/eng/03.pdf> (11 July 2007).
[80] The World Commission on Environment and Development Our Common Future (Oxford University Press, Oxford 1987) 43. This Report was welcomed and supported by the UNGA in UNGA Res 42/187 (11 December 1987).
[81] P. Sands Principles of International Environmental Law (2nd edition Cambridge University Press Cambridge 2003) 253.

3 (1) UNFCCC. If the needs of future generations shall not be impaired by today's actions, it is necessary to reduce GHG emissions as fast as possible so that the impact of climate change on those future generations is as small as possible. Storing CO_2 that might leak out of the storage site later on would mean the contrary, namely postponing the emissions of CO_2 created today into an unknown point of time in the future with unforeseeable consequences. For this reason CCS is in conflict with the aim of sustainable development as long as storage security cannot be granted.

However, Article 2 (1) (a) (iv) KP obliges those parties to the KP included in Annex I of the UNFCCC to research, promote, develop and increasingly use carbon dioxide sequestration technologies. From this provision could be inferred that CCS is not prohibited by the KP, even though it seems to be incompatible with the aim of sustainable development. This apparent contradiction makes clear that CCS could be compatible with the international climate change regime only under strict quality standards and as bridging technology, without using it as a means to delay necessary steps on the way to a clean energy production era.

Assuming that these conditions will be met, it will now be clarified how the stored CO_2 and possible leakages could be accounted for. That means that it has to be scrutinized at first how CCS appears in the national GHG inventories.

Under the UNFCCC and the KP changes in GHG emissions can take place either by reducing anthropogenic emissions at source or by enhancing anthropogenic removals by sinks.[82] Both measures appear in differently in the national inventories.

The term "reduction in emissions by sources" - commonly referred to as 'emission reduction' - has not been defined in either of the instruments. However, the wording indicates that this term deals with a decline of the emissions created by a facility releasing GHG.

Emissions can also be removed from the atmosphere by sinks and will eventually be stored in so-called reservoirs.[83] "Sink" is defined as "any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere", Article 1 (8) UNFCCC.

If CCS were classified as an emission reduction, the CO_2 would be treated in the national inventories as if it never would have occurred. However, CO_2 intended for storage might leak during transport or injection. Accounting for these leakages in the national GHG inventories is difficult, if the CO_2 leaking out has never been produced according to those inventories. This makes accounting for CCS as emission reduction intransparent.[84]

If CCS were classified as a removal by sink only CO_2 actually stored would be accounted for in the national inventories. Leakages during transport and injection would appear as emissions. This would increase the credibility of the whole accounting scheme.[85] However, such a classification is in conflict with the definition of sink as provided for in Article 1 (8) UNFCCC: Sinks remove GHG from the atmosphere, while CO_2 stored in a CCS system is removed directly from a source. Furthermore this classification would also contradict the definition of "emission" in Article 1 (4) UNFCCC, which states that emissions are releases of greenhouse gases and/or their precursors into the atmosphere.[86] CO_2 captured and stored does not enter the atmosphere at all, unless it is released accidentally.[87]

For these reasons CCS cannot be accounted for as a sink, even though this would be the more transparent solution. CCS has to be classified as an emission reduction under the Kyoto Protocol and the UNFCCC. Hence the capture of CO_2 is the phase of CCS in which emission reduction takes place. This means that the captured CO_2 appears as a change in the emission factor in the national GHG inventories of the state capturing the CO_2.[88] Leakages during transport or injection would have to be accounted for by the country where they occur, to secure the reliability of the accounting scheme.[89]

Classifying CCS as an emission reduction turns every CCS project in which capture takes place in an Annex I country into an Annex I mitigation, regardless where the CO_2 is stored eventually.[90] Capture in non-Annex I countries would always

[82] E.g. Article 3 (3) KP and Article 4 (2) (a) UNFCCC.
[83] See Articles 1 (7), (8) UNFCCC.
[84] Intergovernmental Panel on Climate Change (note1) 367.
[85] S. Bode and M. Jung 'On the Integration of Carbon Capture and Storage into the International Climate Regime: HWWA Discussion Paper 303' (Hamburg Institute of International Economics 2004) 17 <http://www.hwwa.de/Forschung/Klimapolitik/Publikationen/2004.htm> (11 July 2007).
[86] Emphasis added.
[87] Purdy and Macrory (note 11) 15.
[88] S. Bode and M. Jung 'Carbon Dioxide Capture and Storage (CCS) – Liability for Non-Permanence under the UNFCCC: HWWA Discussion Paper 325' (Hamburg Institute of International Economics 2005) 7 <http://www.hwwa.de/Forschung/Klimapolitik/Publikationen/2005.htm> (11 July 2007).
[89] Ibid.
[90] Ibid, 7, 8.

be a Clean Development Mechanism as defined in Article 12 KP.[91] This flexible mechanism allows for joint projects between Annex I parties and non-Annex I parties to create so called Certified Emission Reductions (CERs). These CERs can be used by the Annex I country involved to meet its commitments under the Kyoto Protocol, while the non-Annex I country benefits from the technology and knowledge gained through the project.[92] In a CCS project the non-Annex I country would capture CO2 with the support of an Annex I country, which would benefit from the resulting CERs.

Trying to integrate CCS into the international climate system is also challenging because of the possibility of future leakages from the storage reservoir. Such releases need be accounted for to ensure the credibility of the whole accounting system.

Since there is the risk of leakage, CCS can become a credible climate change mitigation option only if the CO2 stored and the CO2 escaped is accounted for in an accurate, complete and transparent manner guaranteeing liability for future releases.[93] Leakage from the storage reservoir could transcend the spatial and temporal boundaries of the national GHG inventories which account per year and country: Escape of CO2 from the storage site might occur a long time after injection and perhaps in another state than the one where capture took place.[94]

Therefore a system of liability for future releases needs to be established. Liability in this regard means the responsibility to monitor, report and account for the release in the national inventory and to compensate for the leakage with new emission reductions.[95]

If CCS would be classified as an emission reduction it would be possible to transfer liability to the Annex I country which benefits from the CCS project: When capture took place in the Annex I country, it is sensible to report the release in this country's national inventories, too, even though the CO2 might be stored in another country.[96] If the CO2 was stored in an Annex I country, escaped CO2 would occur in its inventories since the emission would take place in its territory.[97] A CCS project taking place as a CDM would generate CERs, the buyer of which could be made liable for leakages.[98] However, the details, especially the methodologies in accounting and monitoring questions, are far from clear and "at the frontier of scientific knowledge" .[99]

To sum up can be said that it is possible to integrate CCS into the international climate change regime, if the CCS project complies with high quality standards and is used as a bridging technology only. Accounting for CO2 stored in CCS projects and possible leakages is possible, but details must be clarified still.

4. Conclusions

The status of CCS under current international law is not clear yet. On the one hand, there are treaties regarding the marine environment which can be interpreted as prohibiting CCS. Whether this the case depends on the question in which way the precautionary principle shall be applied to these treaties. On the other hand, the London Protocol was amended in order to allow for sequestration activities and their regulation. Hence it is necessary to clarify which weight is given to the precautionary principle and what it means in this context.

Integrating CCS into the international system to mitigate climate change poses some challenges, but is possible when accounting methods are amended to include liability for leakages.

To deal with CCS appropriately, amendments to the current international law are needed in any case: Either to explicitly allow for CCS or to prohibit it. Given the recent developments it seems likely that CCS will be allowed under current instruments. However, when dealing with technolgies that pose such risks as CCS does, it seems desirable to regulate them strictly.

[91] Ibid.
[92] Article 12 (3) KP.
[93] Bode and Jung (note 88) 14.
[94] IPCC (note 1) 367, 368, 372.
[95] Similar IPCC (note 1) 374.
[96] Bode and Jung (note 88) 9.
[97] Bode and Jung (note 88) 8.
[98] Bode and Jung (note 88) 9.
[99] United Nations 'Annual Report of the Executive Board of the Clean Development Mechanism to the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol' FCC/KP/CMP/4/Add. 1 (Part I) 14 <http://unfccc.int/resource/docs/2006/cmp2/eng/04a01p01.pdf> (11 July 2007).

Rising Natural Catastrophe Losses – What is the Role of Climate Change?

Peter Höppe

- Geo Risks Research Department and Munich Re Group

In recent years, there have been increasing signs that the steady advance of global warming is progressively affecting the frequency and intensity of natural catastrophes. The following examples confirm that there has been a notable increase in such events over the past few years.

- The hundred-year flood in the Elbe region in the summer of 2002;
- The 450-year event of the hot summer of 2003, which caused more than 35,000 heat deaths in Europe;
- The record damages of the 2004 hurricane season;
- Japan's 2004 typhoon season, with an unprecedented ten landfalls;
- The first ever South Atlantic hurricane in March 2004, with damages in Brazil;
- India's highest 24-hour precipitation amount: 944 mm in Mumbai on 26 July 2005;

2005 the largest number of tropical cyclones (28) and hurricanes (15) in a single North Atlantic season since we have data on it (1851);

- The 2005 hurricane season included the strongest (Wilma – core pressure: 882 hPa), fourth strongest (Rita), and sixth strongest (Katrina) hurricanes on record;
- Hurricane Katrina, has been the costliest single event of all times, with economic losses of over US$ 125bn and insured losses of approximately US$ 60bn;
- In October 2005, Hurricane Vince formed close to Madeira, subsequently reaching the northernmost and easternmost point of any tropical cyclone;
- In November 2005, tropical storm Delta became the first tropical storm ever to reach the Canary Isles;
- Larry, the strongest tropical storm (cyclone) recorded, reached the Australian coast in March 2006; and
- Kyrill (January 2007) has caused the second largest losses in Europe caused by a winter storm.

Munich Re's Geo Risks Research unit has been researching loss events caused by natural hazards around the globe for over 30 years. These events are documented in the NatCatSERVICE database, which has been complemented by data on all the major historic natural catastrophes. Munich Re's NatCatSERVICE now contains details of more than 23,000 individual events. The analyses undertaken by Geo Risks Research provide the most accurate estimate possible of the insured values exposed to natural hazards such as windstorm, flood and earthquake with a view to Munich Re's business. The data analyses clearly show a dramatic increase in natural catastrophes around the globe, with ever growing losses. The trend curve indicating the number of great natural catastrophes worldwide (involving thousands of fatalities, billion-dollar losses) reveals an increase from two per year at the beginning of the 1950s to around seven at the present time (Fig. 1).

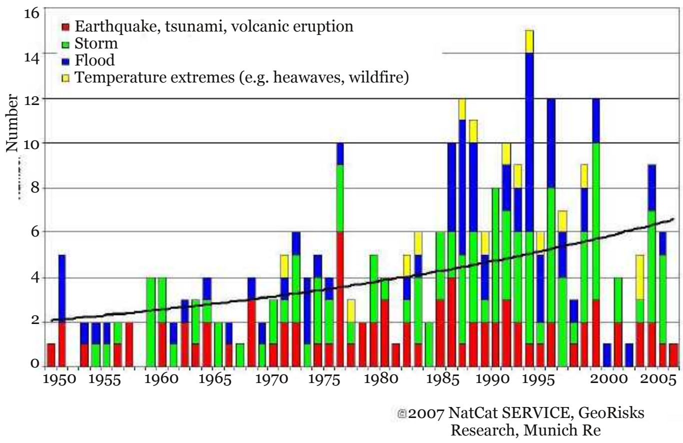


Fig. 1: Great Natural Disasters
Number of events

Economic and insured losses resulting from great weather disasters have risen even more sharply in real terms. In 2005, a record year, economic losses were as high as nearly US$ 180bn and insured losses around US$ 90bn (Fig. 2). The main reasons for the sharp increase in losses from major, weather-related catastrophes are population growth, the settlement and industrialization of regions with high exposure levels and the fact that modern technologies are more prone to loss.

The state of Florida in the USA, which has always had a high hurricane exposure, is a good illustration of the way that socioeconomic factors can act as natural catastrophe loss drivers. The population has grown from three million in 1950 to the current 18 million. The number of tourists visiting Florida

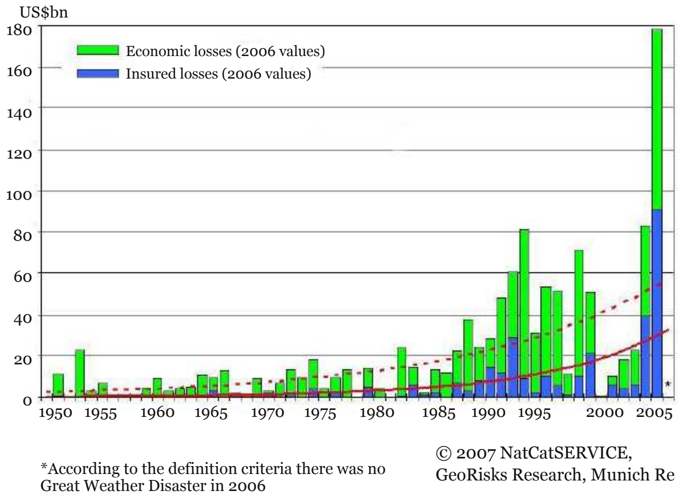


Fig. 2: Great Weather Disaster 1950 - 2006
Overall and insured losses

each year recently passed the 80 million mark. It is clear, taking into account the increase in prosperity, that present-day hurricane losses in Florida are liable to be a multiple of those of a few decades ago.

Following 2005's record figures, the insurance industry reported relatively few large natural catastrophe losses in 2006. As at the end of December 2006, economic losses from all loss occurrences amounted to US$ 45bn and insured losses US$ 15bn, less than one-sixth of the previous year's figure. The loss balance would have been higher had it not been for the fortuitous absence of severe North Atlantic hurricanes. Only three Atlantic tropical cyclones caused losses in 2006, compared with 17 in the previous year. The lower level of hurricane activity was due to exceptional meteorological circumstances: dust particles carried from the Sahara to the hurricane breeding grounds absorbed solar radiation, thus warming the surrounding layer of air at medium altitude. The effect was to stabilize atmospheric stratification and hinder the formation of hurricanes, particularly during August. From October onwards, the El Niño phenomenon in the Pacific had a curbing effect. However, during September, in the absence of either El Niño or Sahara dust factor, there were four hurricanes, which corresponds with expectations. A number of storms were steered away into the Atlantic by the dominant configuration of pressure systems without reaching the mainland, and so did not cause damage. This clearly shows that 2006 constitutes no more than a temporary respite in the general increase in weather-related natural catastrophes. As the rise in the number of natural catastrophes is largely attributable to weather related events like windstorms and floods (see figure 1), with no evidence of a similar increase in geophysical events such as earthquakes, tsunamis, and volcanic eruptions, there is some justification in assuming that anthropogenic changes in the atmosphere, and climate change in particular, play a decisive role. There has been more and more evidence to support this hypothesis in recent years:

- Analyses of air bubbles trapped in ice cores drawn from deep layers in the Antarctic ice suggest that the concentration of carbon dioxide, the principal greenhouse gas, over the past 650,000 years has never been even remotely close to the current 382 ppm (Siegenthaler et al., 2005).
- The ten warmest years on record since 1856, when systematic readings were first taken, have all been in the twelve-year period 1995–2006 (WMO, 2007). The warmest year to date was 1998.

The fourth status report of the Intergovernmental Panel on Climate Change (IPCC 2007) regards the link between global warming and the greater frequency and intensity of extreme weather events as significant. The report finds, with more than 66% probability, that climate change already produces more heat waves, heavy precipitation, drought and intense tropical storms and that the trend is rising. The expected rise in global average temperatures of up to 6.4°C by the end of the century, depending on emission and climate model, significantly increases the probability of record temperatures. Higher temperatures also enable air to hold more water vapour, thus increasing precipitation potential. Combined with more pronounced convection processes, in which warm air rises to form clouds, this results in more frequent and more extreme intense precipitation events. Even now, such events are responsible for a large proportion of flood losses. As a result of the milder winters, now typical of central Europe, there has been a reduction in the snow cover over which stable, cold high-pressure systems used to form a barrier against low-pressure systems coming in from the Atlantic. This barrier now tends to be weak or to be pushed eastwards so that devastating winter storm series like those of 1990 and 1999 can no longer be considered exceptional as also documented lately by Kyrill in January 2007. The wind readings of a number of representative German weather stations have shown a definite increase in number of storm days over the past three decades. At Düsseldorf Airport, for instance, the figure has risen from about 20 to 35 a year. (Source: U. Otte, Deutscher Wetterdienst, 2000). In recent years, an increasing number of scientific publications have indicated that there is a causal link between climate change and the frequency and intensity of weather-related natural catastrophes:

- According to British scientists, it is more than 90% probable that the influence of human activity has at least doubled the risk of a heat wave like the one that hit Europe in 2003 (Stott et al., 2004).

- Hurricane models which take account of climate change show that, by 2050, maximum hurricane speeds will have increased by an average of 0.5 on the Saffir-Simpson Scale and the associated precipitation volume will have gone up by 18% (Knutson and Tuleya, 2004).
- Publications by Emanuel (2005) and Webster et al. (2005) indicate a 50% increase in the duration and intensity of tropical storms in the North Atlantic and Northwest Pacific since 1970. This trend will continue.
- The surface temperature of the world's oceans in the tropical cyclone breeding grounds has already increased by an average of 0.5°C as a result of climate change (Barnett et al., 2005; Santer et al., 2006).
- The only explanation for the increased intensity of tropical storms in the six ocean basins is the steady rise in sea surface temperatures over the last 35 years (Webster et al, 2006).
- Climate models show that winter storm losses in Germany will have more than doubled by 2085 in some European countries due to the effects of climate change (Schwierz et al, 2007).

Geo Risks Research has undertaken hurricane frequency analyses over the past decades which take into account natural climate cycles (the Atlantic Multidecadal Oscillation, AMO). These indicate that the higher frequency and intensity of Atlantic tropical cyclones in recent years could be due both to the natural cycle (the current warm phase, which started in 1995) and global warming. Fig. 3 clearly shows that, on average, the number of destructive major hurricanes is significantly higher in the warm phases of the AMO than in the cold phases. This supports the theory that hurricanes form over very warm sea surfaces. However, it is also true that storm frequencies during the current warm phase (from 1995 onwards) have been much higher than in the previous warm phase in the middle of the last century. The difference can no longer be explained by natural fluctuation; it can only be due to global warming. The analysis presented in Fig. 4 shows very clearly that sea surface temperatures, which have already increased as a proven consequence of anthropogenic climate change, have a considerable impact on hurricane losses. The graph shows the relationship between average annual USA hurricane losses and deviation in sea surface temperatures from the long-term average for the relevant season. The conclusion: the higher the temperature, the greater the loss figure.

Annual Number of Tropical Cyclones formed in the Atlantic Basin 1851 - 2006

Source: NOAA Data handling: Munich Re, 2007

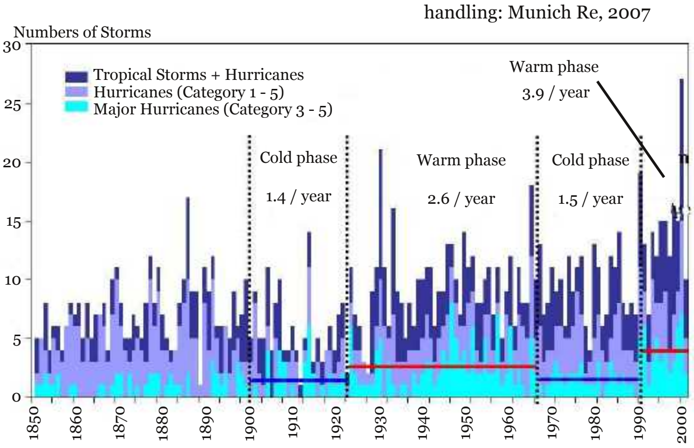
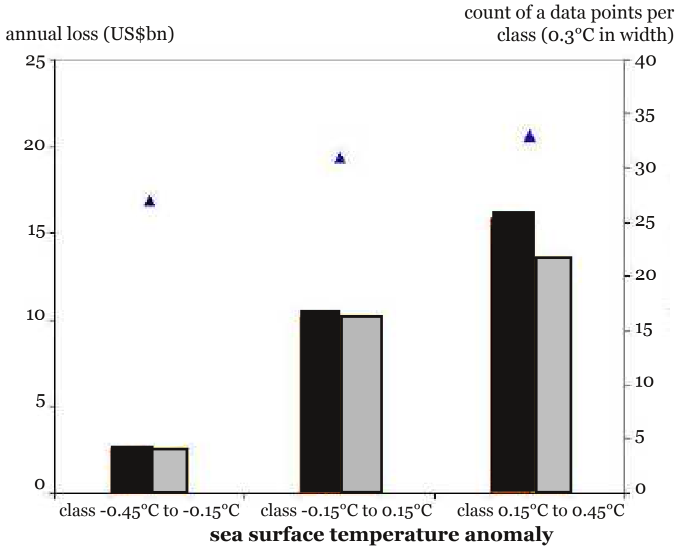


Fig. 3: Climate variability and hurricane activity



grey bars: mean annual losses according to R. Pielke's loss figures
black bars: similar as above, but since 1954 Munich Re's annual loss figures were used
triangles: number of data points per class (right-hand axis)

2004, 2005 and 2006 were beyond the +0.45°C anomaly

Source: Faust, Munich Re 2006.

Fig. 4: Mean annual normalized US hurricane losses in dependence on SST-anomalies

Even apparently anomalous events such as the unusually abundant snow in Europe during the winter of 2005 and the warm start to the winter of 2006 are in keeping with the scientific characteristics of climate change. As well as an increase in weather extremes and a general trend towards warmer winters, there is also likely to be greater variation in weather patterns. Now that a number of changes have already happened and some of the predictions for the coming decades have already been seen, the key issue is no longer if and when there will be conclusive proof of anthropogenic climate change. The crux of the matter is whether the existing climate data and climate models can provide sufficient pointers for us to estimate future changes with reasonable accuracy and formulate adaptation and prevention strategies in good time. The insurance industry's natural catastrophe risk models have already been adjusted in the light of the latest findings. For instance, they now incorporate sea temperatures that remain above the long-term average due to the ongoing cyclical warm phase in the North Atlantic; the effects of this warm phase are reinforced by global warming. We can also expect the above-average water temperatures to increase further the intensities and probably also the number of cyclones.

Even before publication of the recent study by well-known British economist Sir Nicholas Stern (2006) it was clear that climate change is not just an ecological problem; it is also an economic issue. If damage costs continue to rise, this also affects industry and primarily, of course, insurance companies. Climate change affects the insurance industry in a number of ways:

- As extreme events increase in number and severity, loss frequencies and amounts grow correspondingly
- Loss volatility increases
- New exposures arise (e.g. hurricanes in the South and Northeast Atlantic)
- Unprecedented extremes are encountered (the strongest hurricane on record occurred in 2005)
- Premium adjustments have tended to lag behind rising claims, in the past at least.

Despite unfavorable loss trends, the insurance industry continues to offer a wide range of natural hazard covers whilst trying, at the same time, to encourage its clients to focus more on loss prevention. It is also making strenuous efforts to control its own loss potentials with the help of modern geo-scientific methods. It is still difficult, however, to predict in quantitative terms the effects that future climate changes will have on the frequency and intensity of extreme weather events. Munich Re in agreement with IPCC believes that the number of severe, weather related natural catastrophes will increase in the long term as a result of continuing climate change. This, combined with the trend towards higher value concentrations in exposed areas, will increase loss potentials. In order to at least slow down the rate of climate change – it is already too late to stop it – the emphasis needs above all to be on so-called no-regret or win-win strategies, such as reductions in energy consumption. Even if such strategies were to have less impact on the climate than expected, they would nevertheless help to conserve resources (including financial resources) and show that the industrial world was aware of its responsibility towards the Third World. To adopt such strategies, which are based on the precautionary principle, is to remain on the safe side and ensure winners all round.

Where the economy is concerned, climate change signifies opportunities as well as risks. It opens up many avenues for industry to develop low-emission, more climate friendly technologies, or capture carbon dioxide released in the combustion process and store it underground (CO_2 sequestration), for example. It provides opportunities for insurers to develop new insurance products. One of Munich Re's new products is based on the clean development mechanism introduced by the Kyoto Protocol. This mechanism enables investors from industrial countries to improve their climate balance sheet by investing in sustainable projects in the developing world. However, many would-be investors are deterred by the risks involved. In response, Munich Re has introduced the new Kyoto Multi Risk Policy. The insurance industry has tremendous potential for promoting climate protection and climate change adaptation, and thus positively influencing future losses, by taking account of such issues in its products, investments, sponsoring activities, and communications. This has long been a Munich Re commitment. Munich Re's representatives share their knowledge at the annual world climate conferences (COP). The Munich Re initiated Munich Climate Insurance Initiative unites representatives from science, NGOs and the World Bank in an effort to find new insurance solutions designed to help above all poorer countries, which have no or limited access to the insurance market, to offset losses due to climate change. A number of Munich Re publications address the issue of climate change, for example "Weather catastrophes and climate change" (published by PG Verlag, Munich) and the Group has also produced "Winds of Change", a strategy game, in conjunction with the European Climate Forum. Munich Re is one of the signatories of the common statement of the Global Roundtable on Climate Change (GRoCC) on the need of climate protection signed by 85 global companies, NGOs and scientific institutes on 20 February 2007 in New York City. The objective of Munich Re's long-standing commitment is to help raise awareness of the risks posed by climate change and to prepare corresponding measures. Climate change, a global problem with decidedly adverse long-term consequences, clearly requires action based on international consensus. Regrettably, the results of last autumn's climate summit in Nairobi were disappointing. There is every sign that the consequences of global warming are already evident, not least in Germany where this year's warmest winter since records started is in line with climate model forecasts.

Mild winters create ideal conditions for severe storms such as Winter Storm Kyrill, which swept across Europe in January causing losses running into billions of dollars, primarily in Germany and the United Kingdom. Kyrill also stood out because of its duration. It produced gale-force winds (over 63 km/h) that lasted for more than 24 hours in some places. Insured losses from Franz, another January winter storm which preceded Kyrill, amounted to several hundred million dollars. In December, Munich Re had already warned of the higher windstorm risk due to the unusually warm winter, and Kyrill confirmed this forecast. Although warm winters do not only result from climate change and warm weather does not necessarily produce severe winter storms, it is nonetheless true that the last winter has been a foretaste of the future climate and its extreme weather events.

References:

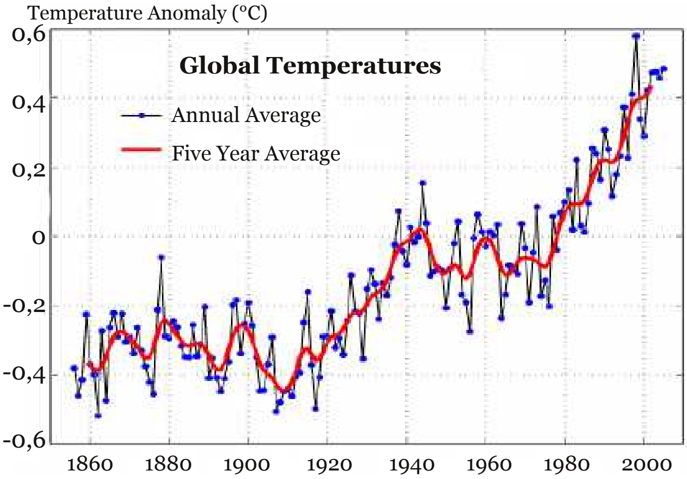
- Barnett, Tim. P. et al. (2005), A Warning from Warmer Oceans, Science 309, pp. 284– 287.
- Emanuel, Kerry. (2005a), Increasing Destructiveness of Tropical Cyclones over the past 30 Years, Nature 436, pp. 686-688.
- IPCC (2007), Climate Change 2007: The Physical Basis, Summary for Policymakers, Geneva.
- Knutson, Thomas. R., Tuleya, Robert E. (2004), Impact of CO2-Induced Warming on Simulated Hurricane Intensity and Precipitation: Sensitivity to the Choice of Climate Model and Convective Parameterization, Journal of Climate 17, pp. 3477–3495.
- Otte, Ulrich. (2000), Häufigkeit von Sturmböen in den letzten Jahren, Deutscher Wetterdienst (ed.), Klimastatusbericht 1999, Offenbach.
- Santer, Benjamin D. et al. (2006), Forced and Unforced Ocean Temperature Changes in Atlantic and Pacific Tropical Cyclogenesis Regions, PNAS 103, p. 13905.
- Schwierz, Conny et al. (2007), article submitted for publication in Climatic Change.
- Siegenthaler, Urs et al. (2005), Stable Carbon Cycle-Climate Relationship During the Late Pleistocene, Science 310, p. 1313.
- Stern, Nicholas (2007), The Economics of Climate Change: The Stern Review, Cambridge University Press.
- Stott, Peter A., Stone, Daihti A., Allen, Myles R. (2004), Human Contribution to the European Heat Wave of 2003, Nature 432, pp. 610–614.
- Webster, Peter J. et al. (2005), Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment, Science 309, pp. 1844–1846.
- Webster, Peter. J. et al. (2006), Response to Comment on Climate in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment, Science 311, pp. 1731.
- WMO Press release No. 768, WMO Statement on the Status of the global Climate in 2006.

Deutsche Bank's Corporate Climate Strategy

Hanns Michael Hölz

- Deutsche Bank

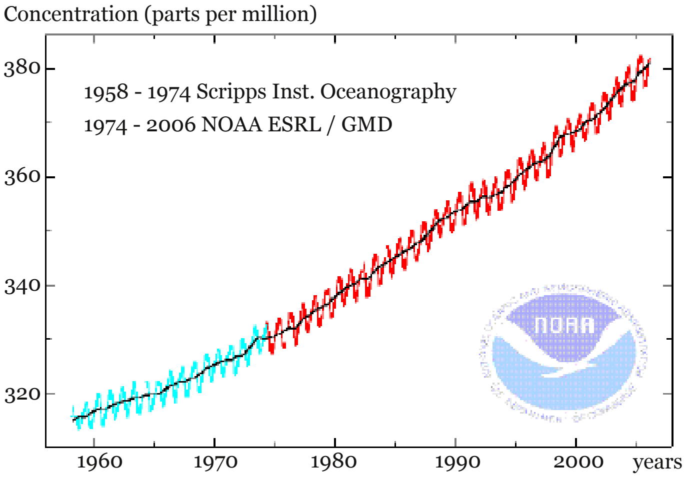
World climate deteriorating in an alarming way
World-wide, the number of natural disasters is increasing. 50 years ago, only two extreme weather events per year hit the earth on average – today the number is seven. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which was released in February 2007, also fuels the worst fears. It says that the global average temperature might rise from 2 to 6 degree Celsius until 2100. The IPCC states unequivocally that human activities are at the root of this development and its consequences. It appears proven that anthropogenic greenhouse gas emissions (above all of carbon dioxide) have been a major cause of global warming in the past 50 years.



Climate change – main reasons:
- Burning of fossile fuels (coal,
- natural gas, oil)
- Increase in travelling and transport
- activities world-wide
- Global structural change in the
- industrial sector
- Structural changes in agriculture and forestry

Main effects:
- Global increase in temperatures
- Melting polar ice caps and glaciers
- Sea level rise
- Expansion of arid areas

Atmospheric CO_2 at Manna Loa Observatory



The IPCC forecasts that global warming will continue and even accelerate, that glaciers will melt and that the global average sea level will rise. In particular, more weather-related natural disasters cause not only huge ecological and social, but also enormous economic damage, which hits corporate clients, suppliers and employees as well as investors. Former World Bank chief economist Nicholas Stern has numbered the economic consequences of the climate change for the first time in the "Stern Review on the Economics of Climate Change".

The core results are as follows:
- Climate change and its consequences might result in a 5 to 20% loss in global GDP. This is roughly equivalent to the impact of the Great Depression in the 1930s.
- If nothing is done to fight against climate change, net costs might amount to up to EUR 5.5 trillion. Even now, about 1% of global GDP – i.e. roughly EUR 270 bn per year – would have

to be spent to counteract climate change and keep the concentration of carbon dioxide in the atmosphere below 550 ppm (parts per million).

According to Stern's analysis, it is considerably cheaper from a macroeconomic vantage point to take measures against the greenhouse effect now than to finance the consequences of global warming later on.

Climate Protection – Deutsche Bank's Motives

For Deutsche Bank, sustainability is mainly about consigning a healthy environment and social stability to coming generations. In view of the "Stern Review on the Economics of Climate Change", this is not only a matter of social responsibility, but also in Deutsche Bank's economic interest. Moreover, sustainability is becoming an ever more important issue in competition. Behaviour that may be detrimental to the environment harbours market and reputational risks. Combined with careful risk management, sustainable strategies secure corporate success and ensure better ratings in the relevant sustainability indices.

Deutsche Bank's Climate Protection Strategy: Four Pillars

In the framework of its Sustainability Management System, Deutsche Bank already developed a comprehensive climate protection strategy in 2005. It consists of four main pillars:

1. Avoiding greenhouse gas emissions
2. Using and promoting renewable energies
3. Raising public awareness of climate change
4. Promoting the flexible mechanisms of the Kyoto Protocol and neutralizing unavoidable
5. greenhouse gas emissions

This strategy is dynamic: it is continuously monitored, expanded and supplemented by supporting measures.

1. Avoiding greenhouse gas emissions

Deutsche Bank has taken a number of measures to avoid greenhouse gas emissions:

- Increasing energy efficiency by regularly improving the technology
- Reducing energy consumption by informing employees about ways to save energy and by implementing energy-saving campaigns
- Taking into account energy-efficiency criteria in purchasing, in particular of office equipment
- Requiring employees to conduct video conferences and conference calls in order to steadily reduce travelling
- Supporting public transport by financing jobtickets at numerous branches
- Reducing the number of short flights by giving out BahnCards to employees who travel a lot for business reasons
- Reducing the average fuel consumption of company cars by making staff pay for part of the fuel consumption of their car
- Requiring to equip diesel cars with a soot particle filter

2. Using and promoting renewable energies

Deutsche Bank not only finances projects and companies which focus on renewable energies, but also uses and promotes regenerative energies itself. Since January 2006, 20% of the Bank's electricity consumption in Germany has come from renewable energy sources. Moreover, Deutsche Bank has established itself as a problem solver in this area thanks to its Asset Finance & Leasing department.

A recent example is the construction of an offshore wind power park in the Baltic Sea, which will generate about 300 mega watts per year. The Ventotec Ost 2 plant (total investment: more than EUR 500 m), which is to be installed north of Rügen by 2008, is one of the first offshore projects in Germany. And we go beyond project financing in our support of the renewable energies sector: Overall, our corporate client division has lent about EUR 350 m to companies in the solar energy sector (as of end 2006).

Sustainable and ethical investments

Via its subsidiary DWS Investments, Deutsche Bank offers even more sustainability-oriented investment opportunities which combine support for environmentally friendly companies with the promise of attractive returns. One example is the fund DWS Klimawandel (DWS Climate change). It pursues a two-pronged, systematic approach:

- On the one hand it invests specifically in companies which offer products, services and technologies to reduce greenhouse gas emissions.
- On the other the DWS specialists focus on companies which help to prepare for climate change and cope with its consequences.

In addition, Deutsche Bank's Private Wealth Management department offers its clients individual asset management that is oriented towards sustainable and ethical investments. Private and institutional investors can thus decide whether they want to include both traditional investment criteria and ecological, social and sustainability-oriented aspects in their personal investment strategy.

Such Social Responsibility Investments (SRI) are based on the securities included in the Dow Jones Sustainability Indices (DJSI) and the Sustainability Yearbook by SAM Group (Sustainable Asset Management, Zurich, Switzerland), which annually determines the composition of the global and European sustainability benchmarks.

3. Raising public awareness of climate change

Concrete measures to avoid greenhouse gas emissions in addition to usage and promotion of renewable energies are indispensable strategies in the fight against climate change. However, the challenge can only be coped with sustainably if the public becomes clearly aware of the problem. It is against this background that Deutsche Bank Research has been publishing numerous studies on issues such as renewable energies, emissions trading, energy policy and the international commodities markets. Furthermore, Deutsche Bank is a member of the following working groups and forums which deal with the promotion of energy efficiency, with climate protection and with emissions trading:

- “Arbeitsgruppe Emissionshandel zur Bekämpfung des Treibhauseffektes” (AGE; working
- group on emissions trading)
- Forum für Zukunftsenergien (Forum for Future Energies)
- Deutsche Energie-Agentur (dena) (German Energy Agency)

Deutsche Bank also tries to raise awareness on the annual “Earth Day”. For Earth Day 2006, Deutsche Bank organized a day of action for its employees with information booths, internet and intranet publications and lectures (for example in the framework of the Business Speakers Series) on climate change.

Participation in the Carbon Disclosure Project (CDP) is a further step to raise the public’s awareness, if with another gist: On behalf of 225 institutional investors, which manage total assets worth more than USD 31 trillion, CDP calls upon companies to disclose their climate protection strategies. The goal is to make institutional investors consider the results of these analyses when they make their financial decisions.

4.Promoting the flexible mechanisms of the Kyoto Protocol and neutralizing unavoidable greenhouse gas emissions

The consequences of climate change are already being felt, and they can be limited only by a concerted global effort. To this end the Kyoto Agreement was signed in 1997 and entered into force in 2005. In this international environmental protection agreement the EU committed itself to reduce its greenhouse gas emissions by an average 8% between 2008 and 2012 in comparison to 1990.

As greenhouse gases damage the atmosphere world-wide, it is eventually unimportant for climate protection where exactly emissions occur and where they are avoided. That is why the Kyoto Protocol foresees three flexible instruments to transfer and exchange emissions reductions:

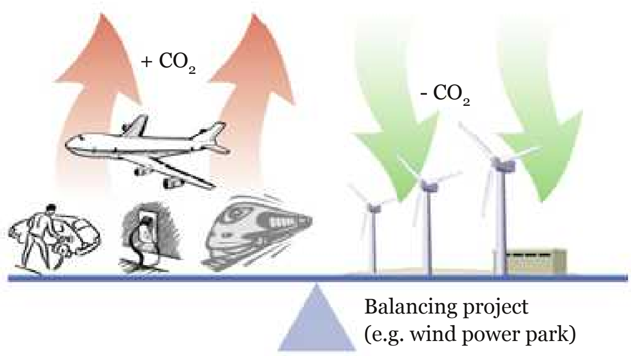
- International Emissions Trading
- Clean Development Mechanism (CDM)
- Joint Implementation

In January 2006 the EU introduced a European emissions trading system in order to reach the targets set out in the Kyoto Protocol. So far, this is the only obligatory carbon dioxide trading system world-wide. Under the European emissions trading system a limited number of Certified Emissions Reductions (CERs) can be imported, which are generated by related emissions reduction projects in developing countries and emerging markets under the Clean Development Mechanism (CDM).

Steps towards achieving climate neutrality*:

- Examination of ways to avoid or reduce emissions
- Calculation of the unavoidable emissions that have to be offset
- Decision on an offsetting project
- Purchase of high-quality emissions reductions certificates
- Annulment of the certificates

The principle of climate-neutrality



* Quality standards on which the “climate neutral” label of the project “Hessische Klima Partner” (supported by the Ministry of the Environment of Hesse) is based and in whose development Deutsche Bank participated.

Deutsche Bank is one of the pioneers in emission trading

Deutsche Bank has positioned itself on the emissions rights market very early on. As one of only two banks, Deutsche Bank invested USD 5 m in the Prototype Carbon Fund (PCF) in 2000. This was the first fund to support climate protection projects in developing countries and emerging markets, and it was set up by the World Bank. Moreover, Deutsche Bank is the only bank which participates in the Umbrella Carbon Fund (UCF) launched by the World Bank, in which it has invested EUR 50 m. It does not only invest in the CER transactions themselves, but also takes on their structuring, syndication and wrapping. In 2006, it participated in two of the largest emission reduction transactions ever in China. Overall, Deutsche Bank invests in more than 30 CDM projects.

Support of climate-neutral activities

Climate neutrality is one way for companies to take voluntary climate-protection measures. This concept is based on the global effect of greenhouse gases, too. Unavoidable emissions at one location can be offset and thus “neutralized” by additional climate protection projects at another location. On the grounds of this principle, the climate impact of any product, service, event or even a complete company can be “neutralized”.

Deutsche Bank decided to implement climate-neutral projects and thus joined the initiative “Hessische Klimapartner” in 2006, which is being continued on a national scale in 2007 under the label “Klima-Partner 2007”. In the framework of this project Deutsche Bank has already “climate-neutralized” a number of events and publications. Particular attention is given to the quality of the compensation projects. Deutsche Bank only uses CDM projects which offer high social value added.

Deutsche Bank Research: Policymakers have to take their part

In the framework of its research on the issue of sustainability Deutsche Bank Researchpublished its study “EU-Energiepolitik: Höchste Zeit zu handeln!” (“EU energy policy: High time for action”) at the beginning of March 2007. In view of growing climate risks and the lack of competition on the electricity and gas markets and against the background of increasing import dependency for important fuels such as oil and gas, the study calls upon Europe to become a pioneer in developing a new energy and environment concept in the near future. If Europe waited for North America and Asia, there would be no courageous turnaround in energy production and consumption – if, however, Europe delivers sensible solutions, other egions will likely follow suit.

The study does not only call on policymakers, but also makes constructive proposals:

- extension of EU emissions trading to other sectors (such as air travel), greenhouse gases and countries
- introducing auctions for the certificates
- introducing a joint EU target value for renewable energies by 2020 in order to make other world regions rethink their energy strategies
- giving more support to the initiatives of the Commission concerning renewable energies in the areas of biofuels, electricity production, heating and cooling, as European companies in particular can benefit from global market growth for renewable energies thanks to their technological advantage
- increasing competition in energy transmission and a complete separation of the energy networks and energy production/distribution
- increasing competition by establishing a spot market for gas, which would allow energy suppliers to tailor their pricing on the basis of up-to-date supply and demand data
- improving energy security, with Russia remaining in a key role – a reliable energy partnership with Russia seems more useful than a gas OPEC.

The study also points out the **importance of Africa**, which is being rediscovered against the background of the commodities boom of the last few years and rising uncertainties in the investors’ traditional target areas. A strategic EU energy policy should target not only the socalled “strategic ellipsis”, which covers the area from the Middle East via the Caspian region to north-west Siberia; areas such as North Africa and the resource-rich remainder of the continent, not least the Gulf of Guinea, merit much more attention and interest. Recent initiatives by European companies are encouraging, as are the results of the **EU climate summit**, which took place at the beginning of March 2007. At the summit an extension of the use of renewable energies and initial, binding targets for reducing greenhouse gas emissions for the time after the climate protection agreement of Kyoto in 2012 were decided.

Financing an Industrial Turnaround under Uncertainty: Reducing Credit Rationing

Frank Meißner and Jette Krause

- Potsdam Institute for Climate Impact Research (PIK)

Market economies are based on economic growth, leading to increasing wealth and consumption as well as higher mobility. Growth goes along with more employment, thus ensures economic participation and reduces social conflict potential. However, as the current economic system is based on the use of fossil resources, worldwide growth is tied to increasing exploitation of resources, pollution, and CO_2 emissions. In the long run, climatic change endangers not only economic growth, but well-being and human life in large parts of the world.

Climate and climate impact research, as well as natural disasters like hurricane Katrina and the storm Kyrill have fostered the awareness of this danger. Public awareness as well as scientific background is now strong enough to initiate a switch to a new path. In order to reduce greenhouse gas emissions to a tolerable level and prevent dangerous climate change, a turnaround in production is necessary. Production techniques as such and the resulting products have to become drastically less carbon-intensive. This also requires consumption patterns to change dramatically. A third industrial revolution implies changes in investment, factor allocation, wealth distribution, and price relations. Currently, it is not clear how this process can be kicked off, and how it will change the economic world.

For producers, uncertainty about the possible development towards a 'green' economy has three dimensions. Firstly, production techniques can either be kept conventional, or can be developed to become carbon neutral. Secondly, the resulting products can be more or less carbon intensive over their life cycle. And third, consumers' lifestyle can stay status quo or change towards a 'green' style, entailing changes in consumption and thus demand patterns. For companies, developing low-emission techniques and products is expensive and will only be profitable if the new 'green' products face substantial demand as well as sales prices high enough to redeem the investment made. Thus, companies face tremendous uncertainty as to how sales, cash flows and profits will develop in a 'green' economy. However, if they expect a low-carbon economy to catch on, companies will be ready to make early investments in order to reap first mover advantages. But will financial markets provide them with the venture capital needed?

If a third industrial revolution is to be brought about, the innovative potential of small and medium enterprises (SMEs) will play an important role. They are relatively flexible in their behavior, and likely to be first movers. In Europe, 99% of the companies are small and medium-sized and they contribute largely to innovations and product development. Small and medium companies are financed by credits and equity capital, where the share of the latter is relatively small. In German SMEs, e.g., equity makes up for a share of 20%. SMEs' access to capital markets is limited. The international competition in the banking sector, along with strict requirements for credit security which have recently tightened under Basel II, leads to credit rationing. Credit rationing, reducing companies' ability to invest and innovate, has already been identified as a prevailing problem for SMEs.[1]

As sketched above, massive 'green' investment and its success is subject to uncertainty in many more regards than current investment. As SMEs already face credit rationing for 'status-quo' investment purposes, they are unlikely to have sufficient access to venture capital for financing an industrial turnaround. This problem has to be tackled now if it is not to block the innovative potential which is the basis for a third industrial revolution. But how can it be solved? Is it possible to overcome this credit market failure through government action?

[1] Finanzierung nach Basel II, Bericht eines Arbeitskreises beim Minister fŸr Wirtschaft und Mittelstand, Energie und Verkehr des Landes Nordrhein-Westfalen, 2002, http:\//\//www.nrw-export.de\//export/BerichtA.pdf

The following options come to our minds: SMEs' green investment could be supported by debt guarantees, low-interest credits, or direct government investment. Historical examples show that these forms of government interventions can be successful.
In our opinion, it will be fruitful to discuss a wide range of options of governmental assistance for SMEs' investments into green technology, from advice to financial support, and to implement promising options.

The Climate Challenge as a Compelling Business Case

Herman Mulder

- UN Global Impact and World Business Council for Sustainable Development (WBCSD)

Inescapable Truth

The technical and economic scientists have spoken; IPCC: anthropogenic influence is very likely; Stern: stabilization of greenhouse gas emissions is absolutely needed, achievable and affordable if timely addressed. National and international political circles are increasingly "talking", and some are even "walking" by taking precautionary actions on the inescapable writings on the wall. Society is waking up to the notion that climate change will deeply affect natural, environmental, economic, social and behavioral aspects of all forms of life on our planet. And, last but not least, the business sector worldwide is realizing that "costing the earth" will be an increasingly relevant and dynamic factor to be addressed while doing business, and is to be embraced as part of its own "license to operate", as a business opportunity and, even, as source of competitive differentiation. However, real mainstreaming throughout the big and small business sectors worldwide is only in the very early stages. Broad-based business-thinking and, even more important, -action on the Climate Challenge has become a compelling defensive and/or offensive business case and value-proposition.

Future is now

The difference in momentum in 2006/7 compared to 1988 when the International Panel on Climate Change (IPCC) or to 1992 when the UN Framework Convention on Climate Change (UNFCCC) were created, is striking. And the pace, like the climate change itself, is accelerating. We all, in our different roles in society, start to realize that the Climate Challenge is necessitating a fundamental rethinking on how we are (un-)fit for a more resource-constraint (energy, water, clean atmosphere) in a more inclusive future world(with 8- 9bln people). In other words, how to prepare ourselves and our planet for the risks and challenges ahead, but also how to individually and collectively realize the opportunities (such as innovation in technology and business models) related thereto. And, considering the current "fast pace of the place" we should adopt a sense of urgency, lead by the notion that " the Future is Now": the cost of inaction today is likely to result in dramatically higher costs for action in a later stage.

Broad, lasting impacts

Addressing, or rather embracing this future reflects sound business strategy, in particular as it will touch almost every part of society and hence, being an integral part of business itself, well beyond the energy-, transportation-, construction-, agricultural and financial sectors. It touches every country well beyond major countries like US, EU, Japan, China, India, Brazil, Russia, South Africa, and Indonesia. It stretches beyond environmental issues: it is an integral part of the global, inclusive and fair development agenda. The impacts will be unevenly distributed among countries, peoples and businesses: there will be some who may benefit from it, but many more who will be negatively impacted. Adaptation and mitigation are both warranted. The challenge is how to minimize the negatives and costs in particular for those who were not part of creating the problem, but also how to convert a problem into an opportunity for many. And we are, in a sense, all "conflicted": losers with a "price" to pay and winners with a "prize" to earn as a direct result of climate change. We all need to take, defensively or offensively, the new meaning. Climate Challenge seriously, to cooperate and to come to early, fair, consensual, effective actions. Global solidarity will get new meaning.

Pro-Climate intervention

We cannot talk & walk alone in our competitive, yet also highly interdependent world. So the challenge will be how to create the right "pro-climate" regulatory environment in every country (as business cannot operate in a vacuum or with climate-adverse/-perverse governmental interventions): public policies and standards are required for sectors such as power, transportation, construction, manufacturing; carbon taxes; mandatory carbon footprint reporting, R&D support Equally important are mandatory international agreements (post-Kyoto 2012). No major country can afford anymore not to be part of such accords, and the signs today are more hopeful than a year ago. At the same time, and very importantly, companies should fully exploit individually, by sector, by country, or in their supply-value-chain the potential of efficient and effective "voluntary initiatives", i.e. experimenting by adopting "best practices", thereby ensuring their sustainable "license to operate", maintain a desired level-playing field and/or create competitive differentiation and value. Such codes of conduct may at a later stage be converted into more mandatory government interventions.

Waiting for others or proactive leadership?

The return on collaboration across all societal sectors will be high. But will this occur in an era of renewed multilateralism, of "glocalization" (recognizing that not everyone is benefiting from globalization), with diverging self-interests among countries and businesses? Is there sufficient shared concern or ambition? And are we taking our decisions on how to deal with our policies and investments on sound grounds/data. Don't we need to urgently repair "our broken economic compass", by internalizing hitherto deemed external costs being off-loaded on society-at-large? And is there leadership with effective "convening power", to "move & shake" towards reconciliation of the diverse positions, in order to foster early, effective collective action? Or is everyone waiting for the other, with in particular the position of the US Administration a key one for many developing countries (and most likely also business in those countries). And while some are waiting, what can more advanced/enlightened policy-makers and practitioners in governments and businesses do elsewhere to move on the inevitable agenda. Recently, the State of California, the UK government and the EU at its recent Summit have taken commendable steps, while indeed quite a number of business leaders are addressing the issue, respectively seizing the opportunity. Also the financial sector (banks, insurance companies, investment research & -funds, rating agencies, stock-/carbon- exchanges, auditing firms) is stepping up.

Making markets work for climate

Seriously addressing the Climate Challenge requires a preparedness to publicly express a vision and strategy, to make specific commitments, to set examples, to strengthen execution capability , to enhance public disclosure and to conduct pro-climate advocacy. And this relates to governments and business alike, as behavioral change in society-at-large, including by end-customers and investors, is of crucial importance. Leading voluntary initiatives by the business and "making markets work for climate" (both the preferred solution over many forms of regulatory intervention) can't function without a consistent, enabling regulatory framework, but also not without an informed and engaged society. Being seen as an issue- and best practice- leader on the right issues (including climate) in one's chosen markets will offer business leaders undoubtedly significant brand-value in their relationship with clients, shareholders, employees (young professional talent in particular).

Space for leadership

The Climate Challenge as a global issue is affecting every part of society, so "thinking inclusive and big" is essential : the CDM/JI instruments under the Kyoto Protocol, as well as the EU carbon cap & trade system must be made more effective, extended (till at least 2030) and expanded (to include US, China, India and others), with more ambition. But much more is needed: national initiatives (including public-private), sector- and/or value-chain initiatives, corporate targets. Energy-efficiency, development of new technologies, pro-efficiency/-conservation/-emissions reduction, behavioral change of some of our prevailing life-styles are contributing to combining economic growth and stabilization of emission levels. Addressing the Climate Challenge offers space for value-creation for genuine leadership. "Ecomagination" by GE is an example. And in the automotive sector the innovators have it all, at least until others have woken up to their new, inescapable reality. Quite a number of international business associations (WBCSD in particular, but also in the mining-, cement-, oil- sectors) have shown leadership.

2007 Global Compact Leadership summit at midpoint

The CEO Summit of the UN Global Compact in July 2007 in Geneva, chaired by Secretary-General Ban Ki-Moon, will be a unique opportunity to affirm the credible role of worldwide business as key part of the solution, as there is increasingly a convincing and sound business case to be made, for defensive and/or offensive reasons, as also clearly apparent during the recent World Economic Forum in Davos. Moreover the Summit is the "midpoint" between the November 2006 Climate Convention in Nairobi and the follow-up convention in Bali end of 2007.

Business as essential and credible part of solution

A profound paradigm shift in the way the business community is dealing with the environment and our future is under way: efficiency (energy, water, clean air), carbon management, conservation (forests, biodiversity) and fairness (human rights, inclusiveness, access to opportunity, no corruption) are becoming core in the space of business in its relationship with its primary stakeholders: customers, employees, investors, society-at-large. The Summit should offer the business sector to gain more credibility with society-at-large to be an interested contributor to the solution of the Climate Challenge. And such is the essence: doing the right business right and sustainable: being a trusted and “enabled” player by today’s and tomorrow’s chosen stakeholders. The value-proposition is compelling: business is not making profit by itself; it is earning it off its stakeholders as part of society.

Unleashing Consumer Demand for a Low Carbon Economy

Guido Axmann & Rasmus Priess

- Thema1 GmbH

Untapped potential in consumer markets

Consumers are increasingly regarded as protagonists in mitigating climate change. Not only are they crucial for emissions in the household and transportation sectors but through the consumption of products and services also largely determine the emissions in other sectors such as energy and industry.

Public awareness of climate change and of the need for action has continuously increased over the past months and is likely to increase further. Public polls show the general willingness of consumers to act on climate change in their personal vicinity. This however still proofs difficult as possible actions remain vague and are not put into perspective in their effect on the problem of climate change. Furthermore certain actions are not practically available to consumers as information on climate-friendly choices is missing.

Overcoming market barriers

Functioning markets may provide substantial opportunities in the transformation to a low-carbon economy. Two factors are particularly crucial in unleashing the necessary market powers:

1. Clear price signals for carbon and
2. Concise information on the climate-relevance of products

Price signals for carbon

Price signals are largely addressed through the Kyoto Protocol and the emission trading system. This is in the domain of international negotiation and still has to be developed further to transform CO_2 emission rights into a scarce commodity. This challenge shall not be addressed here but is of course of major importance in utilising market forces.

Information on the climate-relevance of products

There is however another wedge which is largely unemployed at the moment and which may provide substantial opportunities to companies already acting and willing to act on climate change. Providing consumers with concise and credible information on the climate-relevance of products could transform public attention on climate change into consumer actions. Companies able to visibly provide low-carbon products can profit from respective demand even before price signals take effect and investments are more easily justified.

The WBGU has consequently proposed to provide consumers with information on the carbon footprint of products in conjunction with information on worldwide per capita allowances of CO_2 emissions to put individual actions in a broader framework.[1] The climate-friendliness of goods and services is determined by the emissions occurring in their production and distribution. Measuring relevant life-cycle emissions of goods and services is a domain of classic life-cycle assessment and to a lesser extend environmental input-output analysis. The main challenge lies in the furtherharmonisation of the methodology to allow for reproduction of results and comparison of products.

Current trends in empowering consumers

As consumers are increasingly demanding low-carbon products companies are apt tobringing such offers to market quickly. This can be seen in a growing number of “climate neutral” products and first products being labelled on their carbon content in Great Britain. The British Carbon Trust has recently released a draft guideline[2] for determining product carbon footprints building on classic life-cycle assessment methodology and the first labelled products will be introduced in May 2007. The supermarket chain Tesco has announced to label all of its 70.000 products over time. It is therefore only a matter of time until similar attempts are to be seen in Germany and elsewhere in Europe.

It seems likely that besides these attempts at least one more category of information on will emerge: a climate label,

[1] Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen (WBGU), New impetus for climate policy: making the most of Germany's dual presidency, Policy Paper, January 2007.

[2] Carbon Trust, Carbon Footprint Measurement Methodology – Version 1.3, London, March 15 2007.

comparable to the "Bio-Siegel" in Germany or the FairTrade Label, determining minimum criteria for climate-friendly goodsand services.

The road ahead

The need for harmonisation

There is a real danger that multiple standards with regard to the declaration of the climate-relevance of products lead to inconsistency and thus confusion and potential loss of credibility and may harm the market for low carbon offers before a widely accepted standard may evolve.

Single companies should therefore not introduce such labels on their own but rather work together to develop concise and credible standards.

Building accepted standards for labelling the climate-relevance of offers

As the declaration of the climate-relevance of goods and services requires information on the entire supply chain, business should take responsibility in developing the methodology taking into account input from stakeholders and supported by science and government.

As sensitive data of companies is needed for determining carbon footprints of products, credibility should be established by external verification and certification through a trustworthy body.

The Dialogue Forum Low Carbon Society facilitates the dialogue among companies and relevant stakeholders to develop such concise and transparent measures to inform consumers on the climate-relevance of goods and services. Current activities focus on offering a platform for dialogue and learning and thus providing companies with an opportunity to engage in joint initiatives.

The British Carbon Trust provides a good example how Government can help business in embracing the chances of transformation to a low carbon economy. The Dialogue Forum Low Carbon Society engages in consulting stakeholders to promote the establishment of a similar entity for Germany.

Market driven transition to a low carbon economy

The current debate is largely focused on technological options in mitigating climate change. Investment decisions in new technologies are however determined by costs and market opportunities. If markets provide the right signals, investments in the most efficient technologies and options will automatically follow and innovation is stimulated.

Clear and concise information on the climate-relevance of goods and services therefore constitutes a crucial element in the transformation to a low carbon economy.

Dialogue Forum Low Carbon Society
www.low-carbon-society.org

Lifestyle and Consumption Changes for the Next Industrial Revolution

Fritz Reusswig

- Potsdam Institute for Climate Impact Research (PIK)

A new framing for the climate change discourse

Today, we are witnessing a re-framing of the public climate change discourse (mass media, science, and politics): from 'understanding' to 'decision making'. Until recently, we discussed mainly about whether and how anthropogenic climate change was going to happen, and the argument between climate 'believers' and 'skeptics' was the dominant one. After documents like the Stern Review or IPCC 4AR, we take climate change to be a proven fact, leave climate science debates in the background, and focus on decision making and solution options. Who has to do what in what time with what costs and which side-effects? In addition, the new climate change discourse has left behind its encapsulation as a particular environmental policy. Instead, climate policy has managed to jump across departmental fences, and made its way to everyday decision making at national and EU levels.

The general public in many European countries seems to accept (if not ask for) effective climate policies. More and more businesses react with new ideas, even if symbolic reactions still are around.

To some degree, the recent interest in climate change and climate policy is a function of fear—fed by scientific findings telling us that climate change will not only affect 'the others'—far distant future generations and far distant societies—but also 'ourselves', i.e. near generations and the communities we live in.[1] But this is not the only cause. A new feature of the recent turning of the climate change screw is not a growing alarmism, but a growing conviction (or at least hope) that modern societies can indeed do something against climate change. Technological options are available, cost reduction due to scale effects occur, and policy frameworks exist, or can at least develop rapidly. More and more economists come to the conclusion that climate change mitigation options are both at hand and can be financed without ruining the economy.

But such an economic shift has to be underpinned by a shift in lifestyles and consumption patterns. Consumers have to adopt new products, services and infrastructure, they have to invest their savings in the low carbon economy, and they have to support policies that create the political and legal environment for investment.

The role of lifestyles in the next industrial revolution

The term 'lifestyle' does not refer primarily to the short-term whims and fads of fancy individuals reading glossy magazines. These aspects may be important, but they are part of a much wider picture. By 'lifestyle' I refer to an analytical concept of how individuals lead and interpret their daily lives in a structured and patterned way, comparable to other people in the same lifestyle group. Lifestyles are characterized by the position of a person in the social space of inequality and status, by the values and goals people have, and by their behavior in terms of consumption, leisure time, saving, political activities etc. Modern societies are characterized by a plurality of different lifestyles (sometimes called social milieus).

Reports like the Stern Review or IPCC 4AR WGIII indicate that preventing dangerous climate change is possible, but early and massive action are required. Especially, we need to invest in our systems of energy generations, provisioning, and use. My question here is not exactly how much and at what time who should invest, but how the modern lifestyle

1 Some observers argue that serious climate science should refrain from participating in what they perceive as a quasi-religious doomsday media-hype. Creating fear, or any other emotional expression, is no legitimate scientific operation, and critical observers of engaged scientists, as German sociologist Max Weber, have always argued in favor of scientific objectivity and neutrality. But scientific virtues may be human follies. Virtually every scientific fact does, when passing the filter of everyday life perception, also receive an emotional evaluation. In some cases, everyday actors will keep a balanced or neutral stance, in others fear or hope will prevail. It would be dumb and self-destructive if social actors, confronted with the possibility of serious environmental feedbacks of their actions, would remain silent and emotionally not affected.

dynamics can contribute to the next industrial revolution required. In order to do so, the links between lifestyles and investment have to be identified:

- Consumers buy products and services, and their choices clearly influence the performance of businesses and the expectations of investors. Consumers' wants and their willingness to act pro-environmentally (e.g. to pay price premiums) are generally high, but often not reflected in the market. The UK based Carbon Trust found that 66% of consumers were more likely to buy products and services with a low carbon footprint (Carbon Trust, 06 November 2006). Carbon Trust has also launched a carbon reduction label that demonstrates a commitment from companies to reduce the carbon footprint of their products (Carbon Trust, 16 March 2007). In Germany, similar initiatives are currently discussed. Creating transparency for consumers about their individual carbon budget is a necessary precondition for creating low carbon products and services, and for helping the growing segment of pro-environmental consumers to translate preferences into action.
- Consumers do save, and use their savings for capital market activities. In 2006, $63.3bn was invested in clean energy worldwide, up 30% from 2005.[2] With total worldwide investment in all parts of the energy industry estimated at between $500bn and $600bn per annum, this means that around 10% of total worldwide energy investment is already going into clean energy (NEF 2006). If we look at the sources of clean energy investment (cf. Fig. 1), we find that venture capital (VC) ($2.1bn), public markets ($4.9bn), and small-scale projects ($7.0bn) make up 21% of total investment. This share—and the total amount—of investment capital by private investors could easily be expanded if more consumers became either attracted by profit expectations or by the ethical aspect of clean energy investment.

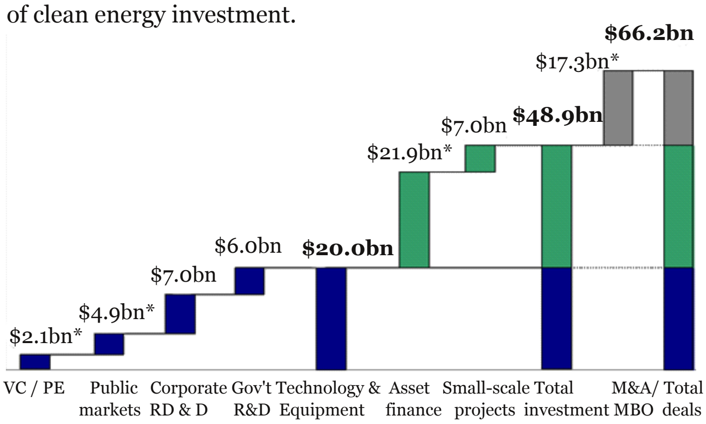


Fig. 1: Global Investment in Clean Energy by Investment Type, 2005 (source: NEF 2006)

[2] NEF expects this sum to rise up to $100bn until 2010.

- Consumers are citizens too. They support or oppose climate policies and policies that foster investment in a low carbon energy infrastructure. It is necessary to gain the support of the electorate at least for the basic decisions in energy and climate policy. We know, for example, that the success of the German wind energy industry was directly caused by two legal initiatives (the Energy Feed-in Law, and the Renewable Energy Law), but the making of these laws was triggered by a political process in which the mobilization of concerned citizens and social movements did play a crucial role (Reusswig/Battaglini 2006).

We observe that some lifestyle groups are more supportive for substantial climate policies than others. We also know that the social diffusion of a product, a technology or a social practice does not happen evenly, as the population is differentiated according to lifestyle groups, with some tensions with regard to status, values, and policy preferences. Given the new dynamic of the climate change debate today, it seems necessary to communicate some basic messages:

- Climate change is a reality, and we simply have to deal with it—both in terms of mitigation and of adaptation.
- We can avoid dangerous climate change, but we have to act now. Fortunately, all the relevant technologies are available—even if not fully developed in economic terms. But we do not need a miracle.
- Small changes of consumers and citizens in everyday life do help. But we need to make them visible, and to link them to a wider, nation- and planet-wide picture.
- Various lifestyle groups might deal differently with climate change, e.g. flying less while using imported food more heavily, or flying a lot while buying regional food. The introduction of personal carbon credits—and may be even their tradability—could help to find lifestyle group specific solutions.
- Governments should treat investments in a new energy structure with tax reductions. They should encourage financial and organizational models for community based energy generating and provisioning systems, if these meet basic standards.

Cities as actors

We can observe that cities today are emerging as actors in climate policy. This makes a lot of sense. London for example has more CO2 emissions than Greece, but only Greece has a say in international climate policy. Many cities act, and there are city networks for information exchange and common action (cf. the European Climate Alliance).

By now, these activities are more or less based upon individual activities of politicians, and restricted by administrative and financial constraints. Urban consumers and citizens have not been involved very actively. Given the willingness to do something about climate change, especially in modern and better-off urban lifestyle groups, a switch from urban climate government to urban climate governance seems necessary. Central and regional governments should empower cities to do so by reducing bureaucracy, and by creating monetary and symbolic incentives for successful cities.

If the climate issue is linked to other local issues, such as air quality or quality of life in general, such a European or U.S. model could well be implemented in booming places like China or India. The growth rate of urbanization is very high here, which at the same time is a real challenge to climate stability, but also offers the opportunity to apply the best available knowledge and technology for low carbon cities. Mutual learning may be a result.

A New Role for Design

Many people agree that dealing with climate change—both mitigation and adaptation—requires the re-shaping of many of our products and infrastructures. Engineers and economists dominate the debate. While there is no doubt that their activity is crucial, one might wonder why designers keep silent in the climate change debate. Everybody wants to know what new products and technologies we will need, how they will function, and how much they will cost. But no one asks how they will or should look like. We need a new role for design in shaping the future low carbon economy.

Design translates function into form and backwards. It bridges the world of goods and technologies to the world of consumers and their lifestyle preferences, including aesthetical and emotional values. Whether the future low carbon technology will be accepted not only depends upon its price structure, but also upon its aesthetical and emotional properties, as

City	Renewable Energy Goals	CO2 Reduction Goals	Policies for Solar Hot Water	Policies for Solar PV	Urban Planning, Pilots and Other Policies
Adelaide, Australia	x	x	-	-	x
Barcelona, Spain	x	x	x	x	x
Cape Town, South Africa	x	x	-	-	x
Chicago, United States	x	-	-	-	-
Daegu, Korea	x	x	-	-	x
Freiburg, Germany	x	x	-	x	x
Göteborg, Sweden	-	-	-	-	x
Gwangju, Korea	x	x	-	-	x
The Hague, Netherlands	-	x	-	-	-
Honolulu, United States	-	-	-	-	x
Linz, Australia	-	-	-	-	x
Minneapolis, United States	x	-	-	-	x
Oxford, United Kingdom	x	x	x	x	x
Portland, United States	x	x	x	x	x
Qingdao, China	-	-	-	-	x
San Francisco, United States	-	-	-	-	x
Santa Monica, United States	-	-	-	-	x
Sapporo, Japan	-	x	-	-	x
Toronto, Canada	-	x	-	-	-
Vancouver, Canada	-	x	-	-	-

Table 1: Selected Major Cities with Renewable Energy Goals and/or Policies (source: REN 2005: 27)

perceived by consumers and citizens.

But design should go one step further than just adapting new forms to given preferences of lifestyle groups. Given the size and the timing of the climate change challenge, designers should also think about future low carbon lifestyles, about desirable fits between form and function, about the way in which new products and technologies fit into future houses and urban infrastructures.

This requires interdisciplinary cooperation between designers, architects, city planners, and scientists from various backgrounds. And we need to invest in design education. Today, eco-design is mainly driven by the issues of recycling and dematerialization, not by climate change.

References

- NEF (New Energy Finance Limited) 2006. Global Clean Energy Investment Overview. Trends and Issues in the Financing of Renewable Energy and Low-Carbon Technology. Prepared for the Clinton Global Initiative, New York, 20-22 September 2006.
- REN21 (Renewable Energy Policy Network) 2005. Renewables 2005. Global Status Report. Washington, DC: Worldwatch Institute.
- Reusswig, F., Battaglini, A. 2006. Lifestyle Dynamics as a Catalyst of a Sustainable Energy Transition. KyotoPlus Paper.

From Crumbling Catatonia to Creative Collectivity

Hannah Förster and Vera Tekken

- Potsdam Institute for Climate Impact Research (PIK)

Crumbling Catatonia

The current IPCC Summary for Policymakers (Working Group I)[1] is just a few weeks old and concludes that it is at least 90% certain that human emissions of greenhouse gases are warming the surface of our planet.[2]

Tony Blair sees climate change breakthrough as his grand finale and wants to press the Council of the European Union for a bolder European energy and climate policy.[3]

A recent press release[4] of the DIW (Deutsches Institut für Wirtschaftsforschung) states that Germany could face cumulated economic losses of €800 billion already until 2050 if the global surface temperature was to increase 4.5° by 2100. The DIW concludes that climate protection needs to be significantly intensified very quickly.

The media reports daily about a variety of political requirements and discusses climate change. But effective actions are not in place yet. The Ministers of the Council of the European Union have just unanimously agreed on the open skies agreement. This agreement eases flight traffic between the EU and the US.[5] Airlines will be able to offer direct flight from any EU airport to the US without additional charges. The European Commission expects 26 million additional passengers on transatlantic flights during the next five years.[6] How does this fit to climate targets?

The IPCC does not question climate change any longer. Next to a focus on finding appropriate, regionally specific, and comprehensive adaptation strategies, mitigation must be of absolute priority.

This is more than one would need to apply the precautionary principle:

"... a willingness to take action in advance of scientific proof [or] evidence of the need for the proposed action on the grounds that further delay will prove ultimately most costly to society and nature, and, in the longer term, selfish and unfair to future generations"[7]

and Principle 15 of the Rio Declaration (1992):

“In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation”.[8]

Today’s policies are contradictory: The IPCC results are widely accepted. Mitigation is considered to be an essential element for the prevention of dangerous climate change. But policies, like the ‘open skies’ agreement[9], still communicate that cheap&chic lifestyles (e.g. transatlantic weekend getaways) are desirable and do not conflict with climate security. Up to recently only the scientific and public elite has been involved in discussions and decision making regarding climate change. The broad public has not yet been involved in an active way.

Through the media, the broad public has been confronted with an uncoordinated mass of specific and unspecific information on climate change. Particular mitigation options and consumption cutbacks are propagated. But unsustainable and

[1] http://www.ipcc.ch/SPM2feb07.pdf
[2] http://news.bbc.co.uk/2/hi/science/nature/6321351.stm
[3] http://environment.guardian.co.uk/climatechange/story/0,,2011130,00.html
[4] http://www.diw.de/programme/jsp/presse.jsp?pcode=569&language=de
[5] http://www.euractiv.com/en/transport/parliament-backs-eu-us-open-skies-agreement/article-162478
[6] http://www.europarl.europa.eu/news/public/story_page/062-3955-071-03-11-910-20070308STO03938-2007-12-03-2007/default_en.htm
[7] Timothy O’Riordian and James Cameron (eds.) (1994): Interpreting the Precautionary Principle. London, Earthscan Publications Ltd.
[8] http://www.unep.org/Documents.multilingual/Default.asp?DocumentID=78&ArticleID=1163
[9] http://www.euractiv.com/en/transport/uk-wins-delay-eu-us-open-skies-pact/article-162699

unaware lifestyle patterns still dominate and there is no serious attempt to inform about progressive and climate-friendly lifestyles. Individuals are confused.

As a result, many individuals are not able to react in an adequate manner. They fall into catatonia. The feeling of being helpless often overstrains individuals and thus leads to passiveness. Several people who doubted climate change now more and more accept that it is happening. However, they are overwhelmed by the catastrophe perspectives they are facing. They often conclude that it is too late to act. Passivity seems to be an appropriate solution for many people to stick with their lavish lifestyles, since everybody else could contribute immensely to shape our and our children's future in a more sustainable manner.

At the same time, parts of the industry claim that if measures against climate change are to be implemented, they will have to face negative impacts on their profits. But the past has also shown that catatonia can be broken by first-movers who transform potential threats into possibilities. Peugeot introduced particulate filters for diesel fueled cars already in 2000 and was the first to reduce CO2 emissions to levels required by the year 2005 EU emission standards. Many consumers switched their car brand to become Peugeot customers. Brand loyalty in the car industry is high, thus attracting customers who were loyal to another brand is a huge success.

But the industry primarily seeks competitive advantages. If these are not guaranteed, industry hesitates to implement new technologies, even if those were of global interest. Toyota's family car Estima is currently the most climate friendly automobile available on the (Japanese) market, with lowest CO2 emissions and gasoline usage. Because future European climate policy and emission targets are not as stringent as future targets in Japan, Toyota does not see – at the moment – a competitive advantage of introducing this automobile to the European market.

Collective Consciousness

Newspapers tell consumers how many years Planet Earth has left before it's doomed to die of climate change. Consumers are told that they will experience restrictions in their daily life if we are to adapt to the impacts of climate change. Is this really the kind of consciousness which will lead us to effective actions against dangerous climate change? Does this kind of consciousness motivate individual consumers to change lifestyles? Why should they change personal lifestyle, if it is too late anyway? No, this kind of consciousness may leave people paralyzed in expectation of all the insuperable restrictions which are about to come.

Instead of following political decisions passively, a sense of collectivity in form of a common responsibility needs to be strengthened. Additional to higher-level decision making a bottom-up self-conception of the public needs to evolve. Such new self-conception emphasizes the importance and influence of each individual and will lead to a sustainable global society of tomorrow.

Today we are scared of potential consequences caused by climate change and we provide passive support to political decisions. We stick to traditional 20th century lifestyle, simply because we are not yet aware that it can be different: Every individual is responsible for tomorrow's world and for future generations. Responsibility does not lie in the hands of a tiny number of decision makers. Individuals are consumers and voters; they are the fundament of our societies. If individuals collectively signal their need and their support for an effective climate policy, they can demand politicians to pursue a sustainable direction.

Long-term sustainable policy is better than a mono-causal and supplementary policy. A patchwork of various non-comprehensive actions to keep the pace with the occurring impacts of climate change is not rational. One of the most heard questions today is "how much time do we have for action, when should we start?".

The imperative to avoid climate and weather related impacts has been adopted as a 'guardrail'[10] by the WBGU (German Advisory Council on Global Change) guardrail concept.[11] "Cost–effective climate protection according to this guardrail requires stabilization of greenhouse gas emissions within the next two decades".[12]

There is no reason to wait, actions should already be in place, because climate change is felt to be happening, and it is also clear that the later actions are in place, the more costs will increase.

[10] See http://www.swp-berlin.org/de/common/get_document.php?asset_id=2678&PHPSESSID=
[11] See http://www.wbgu.de/wbgu_sn2006_en/wbgu_sn2006_en_voll_1.html
[12] See footnote 10.

It is about time to institutionalize an ecological consciousness that stands for the ability of mankind to prefer intact environments and intact societies to short-term extravaganza.

Creative Collectivity

Once we are conscious, we can be creative. Creativity is important, because it expresses individual willingness to deal with a subject, to explore its roots, its details, and to find solutions. Creative collectivity can achieve a lot. In the mid 19th century, the women's movement fought for women's right to vote. Together they were successful. Today, imagining a world in which women are not allowed to vote feels odd, at least in most of our globe's societies. Similarly, creative collectivity led to the end of a divided Germany.

This is a call for creative collectivity. If individuals, the consumers and voters, are collectively creative, they will find ways in which adapting and preventing dangerous climate change does not go hand in hand with restrictions, but with the joy of a new ecological consciousness. If they become aware on how much they can demand in their role as voters and consumers, they will be able to steer politicians and businesses into the correct direction. If.

Communicating Climate Change to the Public

Rudolf Fischer

- NEC High Performance Computing Europe GmbH

Introduction

In order to understand the intention of the subsequent chapters you need to know a bit about the author: my name is Rudolf Fischer, I studied physics and mathematics, and afterwards worked in the IT-industry, with special focus on supercomputing. Consequently I assume to have a better than average education and at least some intelligence.

I try to keep myself informed about what is going on in the world, and although I frequently watch news like CNN and n-tv, which I consider "news reduced to a headline level", I also have the strong desire to gain more in-depth information by reading weekly journals like "Spiegel", and for science I read the German version of the "Scientific American". I assume that this level of information is better than average.

It was the first time for me to participate in the ECF conference, and although I was not able to contribute I learned and enjoyed the meeting a lot. However, lacking knowledge I not only got partially lost, I had the impression that the discussions – as important as they may be – are not taking into account that any strategy to cope with those apparent and overwhelming issues of global warming has to be supported by an average person like me. It seems that scientists and politicians have somehow lost the contact to the ordinary people, for reasons which are naturally different for those two groups. That way chances are very limited to initiate the necessary processes and activities. Knowing the necessity for a change is not enough, it needs to be communicated in a convincing way to ensure the necessary support from a broad majority of the inhabitants of the planet.

I do not want to complain, or to blame anybody, I want to make suggestions for improvement from the perspective of an ordinary person.

What do I – the ordinary person – know?

From all those sources of information I already knew a few facts before joining the ECF conference, which were:

1. CO_2 is a major cause for the global warming.
2. The western world, and there foremost the US, produce most of it, with upcoming economies like China and India catching up quickly for obvious reasons.
3. The increase of the average temperature is by no means the most important threat, rather the consequences of it, like flooding and drought, strong storms that man-kind has never experienced before, potentially a breakdown of the production of food to an extent that will cause fatalities in the order of billions of people.

This level of information I had before, until there was a series of articles in the "Spiegel" with the specific topic of global warming and its impacts.

The item (3) is probably not really common knowledge, although known in science since at least two decades. Only recently ordinary people started wondering about the last few years' experiences concerning very hot summers, unusually strong winds, mild winters, flooding in different parts of the world. But it was not science to warn or alert them, it is their own experience, and this is a problem for the future!

What I learned, or believe to have learned, during the conference and because I started gathering such information after I had heard about the IPCC report:

1. Climatology simulations show that a significant reduction of the production of CO_2 is necessary to limit the global warming to an average of 2° centigrade till the year 2100.
2. If this amount is exceeded the impact on the ecology and subsequently the economy on earth will not only be severe, and hard to predict, it even might be catastrophic in several aspects.
3. Up to 2° the impact will be significant, but hopefully manageable.
4. In order to keep the 2°-limit a significant reduction of the CO_2-production needs to be realised:
   a. 20% by 2020
   b. 80% by 2050
5. To realise such levels of reduction severe measures have to be implemented, which will affect not only the world-wide economy but also individual lifestyle.
6. The costs of not doing this cannot really be estimated, but they will be worse.

It might be my fault not to have known earlier, but then again it would tell something. And if some of these points are incorrectly stated I might be making a fool out of myself, but then even better, since it would show my point: If I do not know by now, what can be expected from other ordinary people? What does the normal person in Europe know? There were quite some interesting interviews in the TV recently, and these supported my concerns.

The first point I am making here: the necessary information is available to the majority of the people in Europe and the western world, but it is not received and definitely not fully understood with the necessary sense of urgency and importance. And beyond the Western World and Japan it must be doubted that the average person would know. But it is these people whose active participation in and support for counter measures is very much needed. And what can be expected then from people in China and India, who are just experiencing the well deserved economical benefits of their hard work?

A Language Problem

Communication theory knows about the necessity of a common dictionary for efficient exchange of information. But it is a sad fact that the languages of science, politics, and the ordinary people seem to be incompatible. So the obvious facts are not well communicated in sufficient clarity, and consequently reluctance to really agree to counter measures will result.

Scientific Statements

The scientists should understand that the normal person can not really interpret scientific statements. A scientist would state like follows:

If the temperature increase cannot be limited to 2° the impacts on our life will most likely be severe.

This statement contains the notion of not being able to precisely tell what will happen, and as such is probably correct. It also contains the hint to strong supporting evidence. However the ordinary person will interpret this statement like:

A temperature increase of more than 2° could cause trouble, but it is not sure whether it happens, and if it would happen what the impact would be.

In particular there seems to be no well-defined notion of probability in the common understanding. For example some people are asking for more nuclear power plants now. There are statements like:

On average such a nuclear power plant will generate a real problem once in a thousand years.

The ordinary person – and unfortunately also politicians, whose average understanding of the facts seems not to be more elaborate, and who often act according to an agenda which can be in opposition to common sense – would interpret such a statement as:

Relax, it will take a lot of time until something will happen ...

Especially there is little understanding that a small probability for something to happen also implies that it definitely will happen!

And in case there are a hundred such nuclear power plants in the world and that the estimation is correct, the real fact would be:

On average every ten years a disaster is to be expected.

Note the different personal interpretation, which is not just a quantitative one:

- “One thousand years” means that it will not affect the individual person, and not the children, nor grand-children.
- “Ten years” means everybody has to be concerned and will be affected during the life-span.

Specific Case Global Warming

A major issue in the discussion with the broad public is the fact that the earth-system is non-linear, and although this is a scientific or rather mathematical statement, it very much seems that the implications of this fact are not intuitively understood. One typical effect of non-linearity is that one can apply a lot of pressure to a concrete wall, and nothing happens, but that applying 0.1% more could break it. Similarly, we produce a lot of CO_2, and very likely there is an unknown and perhaps unpredictable state where an additional injection of only one ton of CO_2 into the atmosphere in principle could break the earth.

Instead ordinary people will always argue that their individual small car only causes a minimum contribution to the worldwide production, and therefore the big contributions should be countered first. This is linear thinking, and as much as this can be understood from a personal point of view and is ethically agreeable, it would not work that way.

The second fact, which seems to be hard to understand, is the sort of “delayed response” which the earth system would exhibit on every action we might take. It is largely not understood that whatever we do, the benefit of it might not be visible in a short timeframe, or, perhaps difficult to argue then, during our own life.

These two facts, non-linearity and delayed response, which do not pose any intellectual problem to scientists, have to be communicated to the public, and certainly some bright people will find sort of model-experiments to explain such system-behaviour.

Democracy

Normally we hear "democracy is the best of all bad implementations of a constitution". It still is a remarkable achievement which has cost a lot of blood in the past. But then, no offence intended, during the conference I very often heard statements like "the scientists have to talk to the policy makers", "science and politics have to decide", and so on. The fact is: the distance between politicians and ordinary people is rapidly increasing, for quite some unpleasant reasons. But if the ordinary people will not be on board no measure will ever be taken, or at least not be supported long enough. On the other hand, nobody should assume that the broad masses are stupid, or not able to act in a responsible way. I think most people in this world have high ethical standards and a very profound feeling of responsibility. Therefore, the scientists have to talk to the public, not to the policy makers in the first place. Otherwise quite some reluctance against any real and necessary counter-measure will result. Even more so if political aspects cause decisions which everybody realises are not the most natural or economical ones – we currently have such a case in Germany, where the most natural way to steer fuel consumption of cars is neglected due to arguments which result from totally different aspects.

Suggestions

Therefore I would highly appreciate if the information and the subsequent discussion could be taken more to the public, out of the ivory towers and political circles, no offence intended. I see it is happening, but looking at the debates in the past I am wondering whether it is enough. Perhaps it is an indication that our climatologists were warning for at least two decades and only now suddenly it becomes a political topic. Doesn't this show that the communication to the ordinary people was lacking?

First of all I am Terranian, then European, then German, but I want to stay modest, so although the Forum is European I would make suggestions for Germany only, it should be easy to adapt them elsewhere:

- The scientists should generate simple model-experiments on a level which relates to normal experiences and intuitive understanding, and which reflect features of the problem of global warming or the earth-system itself. From a personal experience, it was about ways of teaching special relativity in ordinary school, I know this can be quite challenging.
- Such experiments should be the central topic of a series of TV-spots. If all-day issues in traffic can be a topic in such broadcasts ("Der siebte Sinn"), which proofs it is financially feasible, why not this much more pressing and severe problem?
- Potentially this could be augmented by some of those typical scientific magazines. An example would be "Quarks & Co.", the visualisation of very complex systems and related facts and effects is very well designed, and this is exactly what I have in mind.
- I would prefer, however, to have this kind of magazine broadcasted already during early evening. The reason is simple: I definitely think that children and the young generation should be involved in this process, which in any case will cause repeated need for new and perhaps even more critical decisions, and it might be them to take the responsibility. In any case it affects their future more than ours, almost their complete lives. And I believe that children often have a very clear understanding, we grown-ups are very much used to a current lifestyle and way of thinking, and whether we can personally change might be one of the biggest questions. And every child will easily convince parents to act in a responsible manner by asking what is going to happen.
- Going further along this direction one might consider to set up a series of lectures on different levels of school. Perhaps the politicians would even agree to make such education part of the curriculum. However such lessons strongly depend on those model experiments mentioned above, very good scientific input is needed.

Conclusion

I hope this contribution is not entirely stupid and useless, but I am not knowledgeable, and I thought this lack of knowledge would at least indicate something. What we are facing is severe, it is not about a minor change in industry, nor about a different car, rather it goes from ecology over economy to the personal lifestyle and will probably affect our way of thinking. Perhaps this situation bears some positive aspects. We are forced to rethink; perhaps mankind will learn to live in harmony with mother earth. For the individual this could imply a change in mindset, away from consumption oriented celebration of wealth and power, a road we are all following, a road we all hate. Being forced to be modest and to concentrate on non-materialistic and rather idealistic values we might put more emphasis on knowledge, culture and wisdom, and any kind of life on earth.

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European Climate Forum

P.O. Box 600648 ● 14406 Potsdam ● Germany
info@european-climate-forum.net ● www.european-climate-forum.net