



## Workshop Report

### **Reconciling a Sustainable Energy Future with the Liberalisation and Privatisation of the European Energy Market**

**Workshop of the Working Group on Energy of the  
Network of European Environmental Advisory Councils (EEAC)**

**organised by the  
Dutch Council on Housing, Spatial Planning and the Environment  
(VROM-council)**

**held in  
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This report has been prepared by:

Ronald Flipphi  
VROM-council  
PO Box 30949  
2500 GX The Hague  
The Netherlands  
Tel: +31-70-3391505  
Fax: +31-70-3391970  
E-mail: [vromraad@minvrom.nl](mailto:vromraad@minvrom.nl)  
Internet: <http://www.vromraad.nl>

&

Ian Tellam  
CE  
Oude Delft 180  
2611 HH Delft  
The Netherlands  
Tel: +31-15-2150150  
Fax: +31-15-2150151  
E-mail: [ce@ce.nl](mailto:ce@ce.nl)  
Internet: <http://www.ce.nl>

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Focal Point of EEAC  
c/o Sachverständigenrat für Umweltfragen  
Postfach  
D – 65180 Wiesbaden  
Tel.: +49-611-754197  
Mob.: +49-171-9900379  
Fax: +49-611-731269  
E-mail: [ingeborg.niestroy@uba.de](mailto:ingeborg.niestroy@uba.de)

from February 2002 the Focal Point will be located at

c/o RMNO  
P.O. Box 93051  
NL – 2509 AB Den Haag  
Tel.: +31-70-3155-210  
Fax: +31-70-3155-220

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## Summary

This report contains the most important discussions and documents which flowed from the two day workshop in Amersfoort, the Netherlands, in October 2000, on **Reconciling a Sustainable Energy Future with the Liberalisation and Privatisation of the European Energy Market**. It follows the chronological sequence of presentations and discussions that took place at the workshop and has been compiled using the audio recordings which were made at the time.

The **Opening Workshop**, chaired by Professor Wim Turkenburg, of Utrecht University and a member of the VROM-council, set the scene for the two days of presentations and discussions. In this session Dr. Ingeborg Niestroy of the German Council of Environmental Advisors, which is the current Focal Point for the European Environmental Advisory Councils (EEAC) – explained that the EEAC's Working Group on Energy had asked the workshop to provide an answer to two main questions:

- What EU policies are obstacles to sustainable energy strategies in Member States?
- What are national best practice strategies for sustainable energy development?

The presentation on **Energy and the Challenge of Sustainability: the World Energy Assessment (WEA)** was given by Professor Turkenburg, who was member of the editorial board of the WEA study. The WEA has been produced under the auspices of the United Nations' Commission on Sustainable Development (CSD). It can be described as being somewhat more optimistic than, for example, the International Energy Agency's World Energy Outlook (WEO) concerning the ability of efficiency improvement, advanced technologies and new and renewable energy technologies to lead to a stabilisation of CO<sub>2</sub> emissions. The WEA's optimism is partly due to its reliance on the use of advanced fossil fuel technologies, especially CO<sub>2</sub> recovery and storage. This session therefore focussed in particular on the potential of CO<sub>2</sub> recovery and storage technologies with regard to climate protection. This led to some debate on the impact that liberalisation may have on large-scale energy research and development.

In the following session, Professor Kornelis Blok of Utrecht University, representing the research consultancy Ecofys, presented his paper on **Carbon Dioxide Emission Reduction in the European Union: Options and Policies**. Professor Blok described the two schools of thought in Europe concerning the role of government in promoting renewable energy. The question in this regard is whether consumer demand for 'green' electricity, coupled with good feed in tariffs, will provide enough of a stimulus for renewables, or whether regulations are needed to impose renewable energy quota's or obligations. Professor Blok went on to describe in detail the impact which liberalisation is having on combined heat and power (CHP) in Europe. The discussion, further, touched on the role of renewable energy certificates within the EU, and concluded with some discussion on voluntary agreements and energy taxation.

The next chapter is an update of the presentation on **Policy Options and Instruments**, which was given at the workshop by Jip Lenstra, Head of the Energy and Vehicle Technology Division at the Dutch Ministry of Environment. It is based on an interview with Jip Lenstra that took place in June 2001. It mentions the important fact that CO<sub>2</sub> is enshrined as a pollutant within Dutch environmental law, and describes the range of instruments that are currently being used in the Netherlands in an attempt to reduce national CO<sub>2</sub> emissions. In this context, voluntary agreements, the Dutch tax on energy, and Dutch standards for energy use in the building sector are described. A reference is also made to the Dutch carbon trading system, which is currently in the final stages of the design process and which will be presented before the end of 2001.

Dr. Catherine Mitchell, of the Warwick Business School in the UK, made a presentation on **The Relevance of Liberalisation to the Development of a Sustainable Energy Supply**. Dr. Mitchell explained that competition is currently taking place only in generation and transmission and that this is not leading to sustainable energy. Dr. Mitchell stressed that competition in distribution is essential to the stimulation of new and renewable energy technologies because sustainable energy is directly

linked to distribution companies. Network operators currently simply buy and sell electricity, passing the costs on to the consumer. This provides no incentive for network operators to save energy on the demand side or to provide anything other than conventionally generated centralised power.

Liberalisation does not have to be bad for sustainable energy and should be able to offer new possibilities, but halfway liberalisation as it is currently being carried out is the worst of all worlds. Dr. Mitchell further pointed to the need for social and environmental indicators to be created to improve the benchmarking approach to liberalisation that is being promoted by the UK government in its paper, *Energy Liberalisation Indicators*. Further, Dr. Mitchell directed participants' attention to the UK's Working Group on Embedded Generation, which is discussing whether there is an inherent barrier to sustainable energy within energy liberalisation, and which is making information available at <http://www.dti.gov.uk/energy>.

Walt Patterson of the Royal Institute of International Affairs in the UK then gave a presentation on **Future Sustainable Energy Systems**. Patterson pointed out that it is both technically and economically possible to move towards a sustainable energy system; the reason it is hard to move in this direction is political; we and our elected leaders are not making the choices to move us in the direction of sustainability. It follows from this that powerful interests must be engaged on the side of sustainability if there is to be any progress. Patterson further made clear that the price of electricity is always influenced by, for example, the tax regimes on fuels, the asset accountancy, subsidies and cross subsidies and the treatment of so-called natural monopolies. This means that the price of electricity is never purely determined by the market and is always what the government wants it to be.

Patterson sees a way forward for sustainable energy that takes these facts into account and that engages powerful political interests. This involves an increased focus on the sale of energy services (e.g. heating, lighting) and less focus on the sale of fuels and electricity. This approach takes advantage of recent advances in, for example, fuel cell-, wind turbine-, photovoltaics-, power cable-, and power electronics-technologies, which make it possible to hugely increase the efficiency of the energy system infrastructure. Patterson stressed that research and development in this direction is already being undertaken by large companies such as Ballard, Daimler Chrysler, General Electric, Capstone, Allied Signal, ABB, and others, which see these technologies as major commercial opportunities. He further described how the inherent uncertainty involved with energy liberalisation is encouraging some companies already to move in the direction of providing a range of energy services in long-term contractual relationships with consumers, rather than simply selling kilowatt hours to consumers who may suddenly switch to another supplier. Patterson's presentation led to some debate on the merits of energy services and a discussion on the possibilities of using inherently intermittent renewable energy technologies, such as wind turbines, in a decentralised energy system.

The final session focussed on **The Way Forward** and was chaired, again, by Professor Turkenburg. Some major points that had been made over the past two days of the workshop were summarised by John Flemming of the UK's Royal Commission on Environmental Pollution. These were as follows:

- A number of the EU's arrangements, regulations and directives which have been put in place in the name of competition and a level playing field are not conducive to efficiency. There is, in fact, undesirable and unfair competition taking place that is not conducive to the production of electricity at least resource cost.
- Setting climate targets too high is likely to drive industries away to areas where environmental targets are lower or non-existent; this would be likely to lead not only to job losses but also, probably, to increased greenhouse gas emissions.
- It would clearly be desirable if carbon dioxide would be recognised within the EU framework as being a pollutant. This would raise the possibility of integrating energy efficiency, fuel substitution and even carbon sequestration within the EU's Integrated Pollution Prevention and Control (IPPC) regulations; these would then not have to be promoted separately through other policies.

- The EU state aid regime is a major obstacle; it should be made possible to differentiate between 'good' and 'bad' state aid.
- It may be difficult to reconcile a sustainable energy policy and a single energy market with the devolution of the EU's Kyoto commitments. A particular problem may occur in the arrangements for supplying 'green' electricity across borders. Efficiency requires that the price of a unit of CO<sub>2</sub> should be the same throughout the EU (and ideally throughout the world). But the shadow prices associated with national renewable energy quotas are likely to differ in different countries. It is hard to see how an integrated market would deal with these differential prices and this problem needs further examination.
- The EU's gas and electricity liberalisation regulations have not moved into distribution companies. The way to allow energy companies to begin providing services, rather than simply providing fuel and kilowatt hours, is to create regulations that turn distribution network operators into market facilitators that outsource many of their functions and that buy and choose the cheapest options.

Further, there was some discussion on the legal status of EU ratification of the Kyoto Protocol and on whether the group should perhaps in future debate the science of climate change.

There was also a proposal that the group should in future include more exchange of experience on the success and deficiency of the liberalisation process within different countries, in relation to sustainable energy. This was elaborated upon with suggestions to discuss emissions trading, and the role of nuclear power as a technology for the amelioration of climate change.

It was felt that the group's focus should remain on how to achieve a sustainable energy system within the context of liberalisation. The central question should be what policies are needed at the national and EU level, making use of the potential of liberalisation. A proposal was made that the group should focus on frameworks for dealing with instruments, and on concrete measures. It was agreed that there are a number of subjects that must be dealt with and a number of important questions that remain unanswered.

The session closed with some discussion on the possible institutionalisation of the working group and on possibilities for a follow up meeting. Lastly, thanks were expressed by the participants to Professor Wim Turkenburg and Ronald Flipphi of the VROM-council for having organised the workshop, and the session ended with a round of applause!



# 1 Introduction

This report contains the most important discussions and documents which flowed from the two day workshop in Amersfoort, the Netherlands, in October 2000, on **Reconciling a Sustainable Energy Future with the Liberalisation and Privatisation of the European Energy Market**. It follows the chronological sequence of presentations and discussions that took place at the workshop and has been compiled using the audio recordings which were made at the time.

As far as possible, the presentations and discussions have been transcribed verbatim, although some discretion has been used in the interest of making the report readable and concise. Where possible, participants' names have been ascribed to the interventions that they made. Where the editor was not completely certain of the speaker's identity then this person has been described simply as a 'participant'.

The main body of this report contains transcripts of the sessions that took place in Amersfoort. Accompanying documents were made available for most sessions. When available, these accompanying documents are referred to at the beginning of each section and are contained in Annex III of this report. Annex I contains the list of participants. Annex II is a resource section; it contains suggestions for further reading, and a list of relevant information on the Internet.



## 2 Opening Workshop

The meeting is opened and chaired by Professor Turkenburg in his capacity as member of the Dutch Council on Housing, Spatial Planning and the Environment. The meeting begins with an explanation by each of the participants of their backgrounds and their work in relation to energy.

Then Dr. Ingeborg Niestroy of the German Council of Environmental Advisors - which is the current Focal Point for the European Environmental Advisory Councils (EEAC) - explains that the EEAC's Working Group on Energy has asked this workshop to provide an answer to two main questions:

- What EU policies are obstacles to sustainable energy strategies in member states?
- What are national best practice strategies for sustainable energy development?

Following this, Professor Turkenburg begins the discussion as follows.

Turkenburg: I would like to set the scene. We are interested in understanding what kind of policies or instruments can be used to achieve sustainability in the energy field, and we must especially recognise the fact that in the energy sector liberalisation and privatisation is taking place. Another question is whether we should focus on CO<sub>2</sub> policy development. Sustainable development is more than just reducing CO<sub>2</sub> emissions. Should we not also take into account other environmental concerns, as well as social and economic aspects related to energy consumption? These are questions that we will circle around during this meeting, ending with some clear conclusions. The report of this conference may be used as an input to other processes.

Walt Patterson: It isn't necessarily so that liberalisation is opposed to sustainability. It may be even a precondition.

Turkenburg: I agree. The question remains whether you still need strong government policy to achieve a sustainable energy future and how this policy might look like.

Patterson: You can't have a market without strong government policy.

Participant: I think we should decide whether we need to focus on promoting technologies or should we concentrate on instruments, e.g. pricing. What kinds of instruments are needed?

Patterson: We're still thinking in terms of markets as being for the purpose of transactions in units of fuel and electricity. Rather than a much broader circumstance, particularly markets in energy services, which are what people actually want. Government policy has to define what the market is for and what kind of transactions are included in the market place. And how the transactions are mediated. As long as all you are doing is selling units of electricity then the government has no particular role to play, but the government has to set the context and has to set the language.

Participant: I would disagree. It's not clear that the government has a role to do that. That is as much a technological question as any other. The UK Royal Commission on Environmental Pollution looked into the possible role of Energy Service Companies. The Commission came to the conclusion that the role they could play is probably very limited because the nature of the contract is very complicated and the nature of the work that they would undertake is also very complex. There are also well known problems in the housing and residential market where exactly the same question arises. Do you have a market for bricks and mortar or do you have a market for accommodation services? Amongst those accommodation services are various heating and lighting services. How are these bundled? These are very complicated matters, which are certainly not defined by governments although they may offer various intervention points for government policies. For instance, if one starts from the position that the most obvious economic instrument would be a carbon tax then that is at a quite different level of generality then whether you use government measures to stimulate the substitution of energy service supply companies for electricity and gas supply companies.

Participant: What will be the outcome of this conference?

Turkenburg: It would be useful to produce a report that would contain not only a summary of this meeting and a number of conclusions but also the presentations of the speakers and the input delivered by countries participating. Perhaps this report could be shared with a wider audience within the European Union.

Participant: In relation to influencing EU policies. A point that would be of interest to this group would be a requirement on the council of energy ministers to integrate environmental considerations into EU energy policies. That is a process that is being gone through by each council of ministers. The status of that exercise would be of particular interest to this group.

### 3 Energy and the Challenge of Sustainability: the World Energy Assessment

Professor Wim Turkenburg  
Department of Science, Technology and Society  
Utrecht University  
Padualaan 14  
3584 CH Utrecht  
The Netherlands

Turkenburg: This workshop is focused on Energy and the Challenge of Sustainability. I will use this opportunity to share with you some conclusions and results of the World Energy Assessment that will be published within a few weeks. The World Energy Assessment (WEA) has been prepared in the context of the work done by UN Commission for Sustainable Development (CSD). Energy and sustainable development will be a major focus of the CSD meeting in April 2001. The WEA report has been made as input to this CSD meeting. The role of the WEA study within the CSD process is somehow similar to the role of the UN Intergovernmental Panel on Climate Change (IPCC) reports within the meetings of the Conference of Parties to the UN Climate Change Convention. The IPCC reports reflect scientific knowledge in the area of climate change. The WEA reflects the knowledge and debate on energy use, needs, technologies and policies. The WEA process started in September 1998 and ends in April 2001.<sup>1</sup>

Within the WEA process there is an editorial board, the chairman of which is Prof. José Goldemberg. Within the board I have been responsible for the chapter on renewables. The assessment has been initiated by UNDP, UN-DESA and the World Energy Council (WEC).

The WEA focuses first on present energy systems. It points out that these are not sustainable and that a paradigm shift is needed. It outlines what kinds of solutions there are available to achieve a sustainable energy future. It points out some scenarios towards sustainability and it pays attention to policies and instruments to achieve it.

Climate change is just one area of the environmental dimension of sustainability. Other dimensions are the social and economic one. 'Sustainable energy' also means that we should promote access to energy at affordable cost. That is a major concern in developing countries: providing access to energy services and providing greater physical safety and security of supply. Reducing environmental costs of energy use on a local, regional and global level is another item. These concerns should be addressed when debating sustainable energy.

Carbon emissions overall are increasing with large variations between different countries. There is international agreement that stabilisation of the CO<sub>2</sub> concentration should be achieved. There are debates about the level at which stabilisation should be achieved. According to the government of the Netherlands the level should be 450 parts per million (ppm). The EU says 500ppm. The US says 550ppm. Greenpeace International says 350ppm. Showing that there is a range of opinions, which we should know when discussing what should be done to achieve a sustainable energy future.

Stabilising at a level of 450ppm probably means: achieving a 50% reduction in Greenhouse Gas (GHG) emissions within 100 years, world-wide. This probably means a reduction of 80% in the industrialised countries. This would require a reduction of 1.5% per year on average, which is a challenging target if combined with another target: to achieve an economic growth of 2-3 percent per year.

A good source of information on the energy future of Europe is the International Energy Agency's World Energy Outlook to 2020. This outlook shows that – with present policy measures - the CO<sub>2</sub>

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<sup>1</sup> For details, see: [www.undp.org/seed/eap/activities/wea/](http://www.undp.org/seed/eap/activities/wea/)

emission in the European Union will probably increase instead of decrease. It supports the conclusion of the World Energy Assessment that the kinds of energy we produce and the ways we use them will have to change.

The WEA study investigates a number of options and technologies to achieve a sustainable energy future. Much attention is given to the potential of (1) increasing the efficiency of energy and materials consumption, (2) renewable energy sources and technologies and (3) advanced technologies to use fossil and nuclear energy sources.

When discussing the potential role of fossil fuels in a sustainable energy future, one question that arises is whether the debate should be on climate change and environmental pollution or on available resources?

The WEA concludes that fossil fuel resource shortages will not be a problem in the foreseeable future. There are probably enough oil and coal reserves and resources for many decades. There is probably enough gas and oil for 50-100 years and enough coal for many hundred of years. The WEA concludes that there are no reasons to expect that resource shortages will occur. Also, fossil fuel prices are expected to be low. Consequently, the question is whether these resources can be used in ways in which CO<sub>2</sub> will not be emitted.

There are a number of new technologies. One option is CO<sub>2</sub> recovery from industrial plants including power plants and storage of the CO<sub>2</sub> in depleted natural gas fields, aquifers and deep coal layers. CO<sub>2</sub> utilisation is also an option, but with limited potential. Fossil fuel conversion to hydrogen combined with CO<sub>2</sub> capture and storage is also a route that can be followed. CO<sub>2</sub> recovery and storage is a feasible option. Its application to reduce CO<sub>2</sub> emissions will probably create a lot of debate over the coming years. The question is whether it is an acceptable option that can be applied safely and economically for a long period of time.

The company StatOil is involved in a demonstration project in the North Sea where CO<sub>2</sub> is being stored (about 1 Mtonne per year) in an aquifer approximately 1000m below the seabed. The project is economically viable. Research is done to understand the behaviour of injected CO<sub>2</sub> in the aquifer.

In conclusion: WEA says that the present energy system is not sustainable but it can become sustainable in the future. Sustainable energy scenario's can be developed, also in the context of reducing CO<sub>2</sub> emissions to a level such that the atmospheric concentration will remain less than 450ppm. However, it will require a lot of new government policies and instruments. One chapter of the WEA study and a number of sub-chapters are dealing with this question. Further details can be found in a short summary of the WEA study (see Appendix III).

Participant: The International Energy Agency (IEA) produces the World Energy Outlook. How would you sum up the different intentions that there were in producing the WEA?

Turkenburg: Some co-workers of the IEA were involved in producing the WEA. The WEA can be summed up as being more normative ('what can and should be done' versus 'what will happen') and somewhat more proactive and perhaps more optimistic than the World Energy Outlook. In relation to energy savings, for example, the WEA says that globally energy intensity is decreasing by less than 1% per year. With proper government policy, however, using options to improve energy efficiency, energy intensity can be reduced by 2% per year. Further, with shifts to more service oriented economies in the industrialised economies the energy intensity in industrialised economies could be reduced by 2.5% per year. The IEA takes a more conservative point of view and sticks to a maximum possible figure of 1-1.5% per year.

However, one should noticed that the WEA's optimism relies to a large extent on technologies based on the advanced use of fossil fuels. New renewables will have a bright future but their application on a substantial scale requires further development and cost reductions. Consequently, their application should probably be combined with advanced use of fossil fuels (CO<sub>2</sub> recovery and storage) for many decades to come. That is why I emphasised this technology in my presentation. There will be competition in future between different energy technologies with low or zero CO<sub>2</sub> emissions. If people are will-

ing to accept underground CO<sub>2</sub> storage (and it's not clear whether such acceptance will be there) then probably fossil fuels will have a bright future too. Including coal. Coal resources are likely to be available at around one dollar per gigajoule, which is very low and much lower than present natural gas supplies. If we would convert coal to hydrogen, combined with CO<sub>2</sub> storage, then hydrogen will be as expensive as natural gas. So we may produce 'clean' hydrogen from coal at a cost level which is comparative to natural gas at the moment. Consequently, also coal can have a future in a sustainable energy system.

Participant: Does that figure for coal mean that flue gas desulphurization and carbon sequestration is taken into account?

Turkenburg: Yes. In this approach you first convert fossil fuels like coal to hydrogen. Then you have a clean energy carrier that can be used, for example, to fuel cars or power plants with zero emissions.

Patterson: My fundamental problem with the WEA is that it deals with energy policy as if it were exclusively defined by energy carriers – by fuels and electricity. And with the energy infrastructures - either the fuel delivery infrastructure or the service delivery infrastructure - at best implicit in the whole analysis as though it were entirely going to be determined by the price of a tonne of coal or the price of a barrel of oil. I find this an utterly unsatisfactory approach. If they had really been looking for a paradigm shift, the paradigm shift you want is a paradigm shift in the description of the problem and the description of the opportunities that are there, including policy opportunities.

Participant: CO<sub>2</sub> recovery and storage itself will need to consume fossil energy. What is the balance likely to be?

Turkenburg: There is an energy penalty when solving the environmental pollution problem. When using desulphurization technology, for example, fossil energy is used. Likewise, fossil energy is used in CO<sub>2</sub> recovery and storage. Let us look at electricity plants. The conversion efficiency of a plant without CO<sub>2</sub> removal – say a modern coal plant, an ICGCC – would have a conversion efficiency of about 42%. If you implement the technology to recover CO<sub>2</sub>, then the conversion efficiency would decrease to about 37-38%. And the production costs of the electricity would increase by 30-40%.

Participant: Would there then be no net CO<sub>2</sub> emissions?

Turkenburg: There would be a reduction of about 90% in emissions. There are also technologies that would prevent any CO<sub>2</sub> emission at all. But these would probably be a little more expensive.

Participant: Is that 30-40% increase in the cost of delivered electricity a relatively small premium compared to the cost of other renewable energy technologies?

Turkenburg: Yes. Renewables can have a bright future, but in terms of cost it will be difficult for them to compete in the long term if society is willing to accept CO<sub>2</sub> storage. We can produce electricity from fossil fuels at a cost level of 4-5\$ cents per kWh with hardly any CO<sub>2</sub> emissions.

Participant: What are the costs.

Turkenburg: The costs are related to investments, energy, maintenance and operation costs. The investment costs are related to equipment and infrastructure needed to recover, clean, transport and store the CO<sub>2</sub>. Most technologies involved have already been demonstrated. So, if we would like to apply this technology it can be done. There is experience with both recovery and storage. Recovery technology has been developed because industry often needs pure CO<sub>2</sub> for production purposes. Storage technology has been developed because CO<sub>2</sub> is sometimes pumped into oil wells in order to get more oil out of the wells. If we would apply demonstrated technology only end if this application would be done tomorrow, then the increase in electricity production costs would be higher (in the range of 50-100%). If – in the longer term - we would use more advanced technology then costs reductions are likely. This requires R&D. One of the questions then is: who should pay the research and development. Should it be government or should it be industry?

Participant: Is there not a volume problem in the transportation or storage of CO<sub>2</sub>, which limits the physical ability to utilise this technology in any kind of meaningful size.

Participant: There is an assumption that this problem can be solved by liquefying the stored CO<sub>2</sub>.

Participant: There are quite large voids available, particularly sub-sea saline aquifers, and the volume available there would be considerable.

Turkenburg: The second IPCC assessment report, published in 1995, mentions this point and concludes that global storage capacity for CO<sub>2</sub> is in the range of 300 to several thousand gigatonnes of carbon. Storing 300 gigatonnes of carbon would have the same impact on CO<sub>2</sub> emissions as, for example, a tenfold increase in the present capacity of nuclear power. This is compared to 6 or 7 gigatonnes of carbon, which are being emitted at the moment per annum at a global level due to our energy consumption. However, there are questions concerning whether there may be negative environmental consequences related to storage. The question of leakage and CO<sub>2</sub> escape, for example. First analysis indicate that we are able to handle these concerns in a proper manner, although further research is required to get full understanding of the issues involved.

Patterson: I attended a lecture on this by Bob Williams [senior research scientist at Princeton University's Centre for Energy and Environmental Studies; Convening Lead Author of the WEA chapter on advanced technologies]. He explained that the volume question is dealt with by picking depths below 800 metres where the CO<sub>2</sub> is supercritical at the injection point. In other words, it is not in a gaseous form at all. A lot of analysis has also been done of the profile and distribution of the CO<sub>2</sub> in an aquifer over hundreds of years including the amount which might get out through leakage. Most of the work is theoretical at this stage but the quantification is scrupulous and the overall analysis is impressive.

Participant: Is this technology not simply a way of buying time?

Turkenburg: Yes, it is a way of buying time to develop and implement renewables. It may also allow further use of fossil fuels in sustainable energy system. In addition: It could be an approach to involve OPEC countries in climate change negotiations.

Participant: Time is very valuable.

Participant: But is this really dealing with the problem?

Participant: Assuming that the problem is carbon then the economic solution is a carbon tax and the question is how high should you pitch a carbon tax. The market will then look for cost-effective technologies to reduce CO<sub>2</sub> emissions.

Participant: This might not only be a way to continue to use coal more sustainability. But this would also give you the cheapest possible source of bulk hydrogen. So if you really are serious about developing hydrogen as the next bulk carrier then this might be the next jumping off point for it.

Turkenburg: If you want to develop hydrogen as a bulk carrier then the cheapest source of hydrogen is indeed fossil fuels. Secondly would probably be hydrogen from biomass – and we may have huge amounts of biomass available if we want. Then maybe (in 50 years perhaps) it might be attractive to produce hydrogen from solar photovoltaics and from wind, but that is currently very expensive. So hydrogen from fossil fuels will be an important starting point for a hydrogen future.

Participant: Who should provide the research and development funding for this.

Turkenburg: The example of StatOil which I mentioned shows that in some cases companies can already do it on a commercial basis, depending on governmental incentives like a carbon tax. On the other hand a lot of technology still needs to be developed and there – apart from industries - governments have an important role to play.

Patterson: The problem I have with this is that the coal industry – which has an interest in continuing present production methods – is flatly not interested in developing CO<sub>2</sub> storage and recovery. All they want to do is sell the next cargo of coal. They have a time horizon of tomorrow afternoon and they are not interested in this. And if the coal producers themselves are not interested in this then it is not going to happen. Why should governments do it if industry doesn't want to?

Turkenburg: Governments have to involve the industry in achieving emission reduction targets.

Patterson: All I can say is good luck to them. I've been trying for a long time!

Participant: There are examples of the coal industry using carbon sequestration technology. In America, for example, it is happening.

Participant: This discussion does not seem to be very sharply focussed on the implications of energy sector liberalisation. There clearly is a problem that liberalisation, privatisation, fragmentation of any of these industries, reduces the feasibility of organising collaborative research, if that is how you think it ought to be organised. Because the chances of any one coal company, for example, of capturing the benefits of solving the technical problems are rather small. This is why the role of government is important. And one of the frightening developments around the world in recent years has been the collapse of research in all of these energy related and environmental areas. It has fallen to a quarter of what it was – as a proportion of GDP – compared with 20 or 30 years ago. This is an interesting phenomenon, which calls for some analysis and perhaps some corrective measures. It is not clear that it should be the industry that does it.

Turkenburg: In the US there is less investment in research and development and also less investment in capital intensive technologies such as nuclear. Also in Europe it is clear that there is less industrial research into clean coal technologies and less research into renewables. Due to privatisation and liberalisation the energy industry – including the power sector – is more interested in making profit on short term and less on realising a sustainable energy system on longer term.

Participant: Is it clear that large-scale energy development is out of fashion. Is there evidence that decentralised markets – regardless of what sector it is in – are capable of undertaking very large scale research and development. There is evidence that they are capable. Look at the scale of certain mining developments and certain oil field developments, and also pharmaceuticals. This shows that many companies are looking very far into the future and are engaging in long-term research and development. The proposition is that the private sector will not do long term research. But the private sector is doing such research. So it is an unsustainable proposition.

Patterson: I would agree completely with that. And as far as the decline in government funded research and development over the past thirty years is concerned, firstly I'm absolutely rejoicing because that money was almost entirely spent on very large, very long term and ultimately – as it turned out – futile technologies (like syngas projects in the US and large wind turbine parks using inefficient technologies). When decisions have to be justified to shareholders then one has to concentrate on actually visualising a pathway to the market for that technology so that you can ultimately make a return on it. That is a discipline, which should be strongly endorsed in the energy technology sector. And it is not true to say that energy technology research and development has been severely hampered by that because the work which is being done now on fuel cells, on wind turbines, on microturbines, and so on, is entirely coming from private sector companies that expect to make money out of these technologies. And I'm strongly in favour of that.

Turkenburg: It is my understanding, based on statistics, that there is a shift from long term to short term research funding, also in the private sector. If we are discussing options for solving the climate problem then we need to focus on long term solutions.

Participant: That is correct but one of the questions is whether the signs are there to convince people that there is going to be a market. If people were convinced that there were going to be a carbon tax then they would undertake much more research in this area.

Turkenburg: I agree, but we will come to discuss these and other instruments later.

Participant: A classical economist reaction to the problem is to subsidise things you want and tax externalities and things you don't want.

Participant: And tradable permits?

Participant: Tradable permits are not as such a solution. They only have value if there is some restriction on them. So tradable permits are only a response, and an improvement, on non-tradable quotas. But if you don't have quantitative limits then there's nothing worth trading. I would not favour quantitative limits. My intuition is that there is a gap between the private return and the social return and that gap is the value that corresponds to a tax or a subsidy.

Turkenburg: Discussion on instruments will follow later. I would now like to give the floor to professor Kornelis Blok who will speak on (European) policies and measures that can be applied to reduce greenhouse gas emissions associated with our energy use.

## 4 Carbon Dioxide Emission Reduction in the European Union: Options and Policies

Professor Kornelis Blok  
Utrecht University / Ecofys  
P.O.Box 8408  
3503 RK Utrecht  
Netherlands

[see also Professor Blok's accompanying paper, which is contained in Annex III of this report]

Blok: Liberalisation has caused some problems. Conventional energy prices have decreased and this has widened the gap with renewables. On the other hand, green electricity is being marketed by many companies. It is unclear whether regulation will be needed or whether consumer demand alone will be enough to promote renewable energy. There are two schools of thought on this in EU.

One, the dominant school, says good feed in tariffs for renewables are needed. For example, Germany has, for wind, feed in tariffs of half a Euro. This means that there is great demand for wind-produced power and most of the wind energy produced in the Netherlands is being exported to Germany. This system has disadvantages, though: it is costly for electricity companies who have to pay for it, and there is no drive for cost reduction. The other school says we should have a system of quotas or obligations. Every energy distribution company, or every user, should have an obligation to buy, or to sell, a certain fraction of renewable energy. An example is the non fossil fuel obligation (NFFO) in the UK.

Participant: On the question of whether you have an incentive to reduce costs when prices are fixed. This is not really true. In Germany, for example, the amount is reduced on a yearly basis. It goes down from 90 to 80 then to 70 Pfennig.

Participant: That can also be a perverse incentive to rip out the PV system which was put in place three years ago in order to get the 90 Pfennig again.

Blok: Concerning combined heat and power (CHP). There are different estimates of how much CHP is produced in Europe, depending on what assumptions are used in the calculations. There are only three countries that have substantial CHP supplies and these are Denmark, Finland and the Netherlands. In the Netherlands CHP is mostly industrial. In Denmark it is mostly district heating, including the commercial sector. Most countries have less than 10% and the differences are explained by differences in policy.

In the Netherlands there were, since 1980, good feed in tariffs and voluntary agreements with energy companies and manufacturers on implementing CHP. This whole package led to a growth in CHP production. In Denmark a lot of government regulation supported CHP. In many countries these policies were missing and government monopolies did not support CHP.

Concerning the costs of electricity from CHP. It can be applied in a variety of applications: industry, service sector and district heating. A range of equipment is available from 100 kW gas engines to 250 MW combined cycle systems. Costs are also very different. Large industrial plants produce fairly cheap electricity, about 3 eurocents per kWh. Some small-scale systems and district heating systems are expensive. In the latter this has to do with the high cost of the heating distribution network.

Even the cheapest CHP options are not able to compete on the power market in most cases because, since liberalisation, the price of electricity from conventional sources has fallen so much. The CHP industry is in trouble and the overall situation for CHP is negative.

Participant: Is the vulnerability of CHP in a liberalised market a result of institutional or contractual arrangements, or is it a result of CHP being uncompetitive in terms of costs.

Blok: It depends on the national regulatory context. In the Netherlands, for example, there has been a discussion on whether the grid tariffs (the costs that one pays to transport electricity) are positive or negative for CHP. That can make a difference of course. But the general idea is that with full liberalisation you get rid of all the traditional bottlenecks for CHP which have to do with, for example, feed in tariffs which were not high enough, payments for standby power, and all those kind of additional things. The positive aspect of liberalisation is that all those costs are simply taken care of by the market. But we see now that the prices are so low, and it may take five or ten years before they increase again, because it may take that long before new investments will have to be made. So, for the moment, the situation is fairly bad. And that has to do with the fact the cost of electricity from CHP is in the same range as the cost of conventionally produced electricity. That is different for renewables. The costs there are so much higher than conventional that this extra difference is not so important.

Participant: Why is it that conventional electricity has become cheaper while CHP has not?

Blok: It has to do with the present market situation. We have excess capacity at present. Therefore no additional capacity needs to be built. So electricity can be sold – on the spot market – for no more than the fuel costs.

Participant: But some electricity producers are selling at less than the fuel costs. How is that possible?

Participant: What is happening is that the share price of some companies has dropped. Sometimes as much as 15% in 12 months. This is because they've been cutting prices so continually that they are now selling at less than their production costs. And that is not a stable situation.

Participant: For power producers who became wealthy and 'fat' during the pre-liberalisation monopoly period it is possible for them to afford this. For CHP, however, it is more difficult to survive.

Participant: It is still monopolistic behaviour that is going on. Prices are being dropped on the market in the hope that competitors can be driven out of business. After which companies intend to come back and recover the losses.

Participant: Since 1998, 30% of CHP has been lost as a result of this.

Participant: The other point is that there is no incentive to install residential CHP when building houses if one can simply tap into the excess capacity which is available through the grid.

Participant: How long will this excess capacity exist? Five years?

Participant: There is going to be a major capacity reduction with the phasing out of nuclear.

Blok: In this context, the lifetime extensions of conventional power plants are going to become much more important. Conventional power plants will probably stay in operation for much longer than was originally planned.

Participant: Is the attention to CHP justified, considering the minor role that it may be able to play in reducing CO<sub>2</sub> emissions?

Blok: A switch from a conventional coal and gas powered power plant to a gas powered CHP plant leads to reductions of 250 g of CO<sub>2</sub> per kWh. However, half or two thirds of that amount can already be achieved simply by switching to highly efficient combined cycle power plants. So there remains only a one third advantage to be gained by switching to CHP. So there will always be an advantage to be gained from using very well designed and efficient CHP plants. But this advantage may be fairly limited.

Participant: If one looks at the EU's Integrated Pollution Prevention and Control (IPPC) Directive there is an obligation to save energy. But this is almost impossible to implement.

Blok: This has to do with the lack of knowledge among legislators concerning energy efficiency and CHP. They have knowledge on SO<sub>2</sub> and other pollutants. But there is a lack of knowledge on energy efficiency.

In fact the IPPC Directive is misplaced. CHP is always a more efficient method of heat production than traditional boilers. But it is not a more efficient method of electricity production. So the problem is not the efficiency of power plants but of boilers. What the directive should say is: new heat generators in industry, for instance, steam boilers, should be CHP. That is almost always technically possible and that would be a way to go.

So one should follow the traditional route in environmental policy making. One should say, what is the best available technology at a certain moment, and the best available technology in the area of heat generation is CHP.

Participant: In the UK the non fossil fuel obligation has disappeared as part of the liberalisation process and changes in the pool arrangements and we are now moving towards a quota system. But the quota comes with a price ceiling. There is an opt out clause. One can buy a price certificate from the government in lieu of buying green electricity from somebody. That is at a fixed price or at a fixed premium. And the level at which it is being proposed is such that the producers of higher cost renewables say that they are not going to be able to compete.

Also, if your national system pays a premium for green electricity then you have a difficulty in regarding anything from any other member state as being anything other than green. And that is clearly nonsense if we want to get these kinds of systems going. It is correct that that still exists. There was a ruling at the European Court to that effect. That it would be discrimination if you give imports a lower price, which is associated with a difference in pollution, involved in the production.

Blok: The draft directive on renewables says that all countries should have a certification system so that, for all electricity that is sold, it can be clear whether it is green or not.

Participant: That would imply that we need a EU wide agreement on what constitutes green, then? There are some areas, for example, such as waste incineration, where opinion is divided.

Blok: There is one system, called the Renewable Energy Certification Scheme (RECS), which is an association of a number of energy and other companies and NGOs which are working on developing schemes in which there are several grades of green. Some systems may include wind and solar, while others may include CHP, for instance. There would be various kinds of certificates but the idea behind this is that the market will become transparent.

Participant: The problem at the moment is that there is no agreed definition of what one is buying when one buys a green certificate. With respect of the UK, the UK has said that any company that wishes to sell a green certificate to another country can do so. But they can't take the CO<sub>2</sub> emission with them. Other countries have got tradable green certificates based on megawatt hours; others have certificates based on kilowatt hours. The differences in systems are large. A uniform system therefore seems to be a long way off.

One way forward could be to form a 'bubble' of a small number of countries who could agree on what a green certificate is and could then trade green certificates. Say just two or three countries together.

Participant: If you open your country to imports and if you would want, within your country, to pay a premium for green power, then anything, however dirty it would be – even including lignite from Poland, for example – would have to be given a preferential tariff unless there is some uniform agreement on what green is. That is of course a major deterrent. It is not a question of how to form a bubble

of three countries to do sensible things. It is a question of whether you can prevent people taking advantage of the arrangements to do silly things.

Participant: But a certificate scheme could prevent that.

Participant: Only if it were a mandatory union wide certificate scheme.

Participant: There is also a question of how much can be achieved using green certificates. Essentially, it is asking people to pay voluntary taxes on a large scale. And it is doubtful that people will be willing to do that. Anybody who has factored that in as making a substantial contribution to the achievement of the Kyoto objectives, it seems to me, needs their head examined. If you want a green system supporting these quotas which is backed up by trade in the member states, which is the characteristic of an EU wide liberalised energy market, then you need something much more effective than that.

Blok: I agree. But in the coming years we have the voluntary green energy market. You will need certificates anyway. And gradually as the market will develop and quotas will be implemented then of course certificate schemes can be reinforced and even joined to one European scheme. That is my view of how it could be developed.

Participant: But it is not clear to me what will come through the link from France. Will that be classified as green energy, or black energy?

Participant: There is a different view on the trading of certificates in the UK. The UK is very up front in saying that it will only support renewables that lead to CO<sub>2</sub> reductions. Therefore if there is to be international trade of green certificates then Britain has to know that if it buys a unit that it is getting somebody else's CO<sub>2</sub> credit. Now, Britain has very good resources: the price of a tradable green certificate is the difference between the market price and the premium price. And because we have had a competitive policy for a long time we actually have very low prices for renewables relative to the rest of Europe. So we have very low tradable green certificate prices. So in theory not only do we have a good resource but we also have low tradable green certificate prices. So we would be a net exporter. And the last thing the government wants is to have wind farms in a Welsh hill somewhere, for example, that the credits get sold to Greece, for example, and effectively makes that wind power plant a conventional power plant without any benefit in terms of climate change policy for the UK. So the UK will do everything possible to prevent that from happening.

Participant: We are now focussing on green certificates. But this is of course a more general problem. We are watching energy of all sources now and as long as there is some space in the quantity of CO<sub>2</sub> which countries are emitting and they see cheap possibilities to reduce that then they will be willing to sell this electricity, but they will stop in due time.

Blok: I do not yet see the problem for the UK because as long as the UK produces wind energy you reduce CO<sub>2</sub> emissions in the UK. Even if you sell the certificates without the approval of the government no CO<sub>2</sub> credits could be sold to Greece.

Blok: To go back to my presentation. I was finalising my section on CHP.

At present the incentives to support CHP are not strong enough. Stronger incentives are needed. Higher feed in tariffs would help and these are being put in place in the Netherlands, for instance. Another option is voluntary agreements with electricity producers or manufacturing industries. Lastly, a CHP obligation – similar to a renewable energy quota – is possible. And this is something that is being considered in Germany. There are, therefore, various possibilities to strengthen CHP policies. Some of them are problematic in the context of a liberalised market. With higher feed in tariffs, for example, there is the possibility of free riders because there are so many different types of CHP.

The problem that CHP faces is that most policies are directed at electricity. In the Netherlands there were very good buy back tariffs for CHP and this has led to CHP plants which had high electricity pro-

duction but not so good heat production. So the advantages in terms of emission reductions are much smaller than they could have been if these plants had been better designed. So policies for CHP should be balanced and should support both heat and electricity production if they are to be effective.

I will skip the section in my presentation on energy efficiency standards and on voluntary agreements for electrical equipment but that is also an area where the European Union is very active. There is labelling, there are standards and there are voluntary agreements. But the total effect is still fairly limited due to the long lead times of policy development.

Participant: You mentioned the obligation in Germany. What the government plans is to fix a quota for CHP in Germany? There was also mention of a quota in the UK. I would like to know, how is a quota fixed? How is a percentage of, say, 10%, arrived at?

Participant: To an extent they are 'plucked out of the air'.

Participant: One of the explicit objectives of the current British government is to keep some coal mines operating. That is why it would not be 100%.

Participant: UK has a current target of 'working towards' 10% by 2010.

Participant: But why the number? Why one number rather than another number?

Participant: I agree that it would be preferable to work out a way of putting a value on the carbon emissions and give rise to something on that side rather than a percentage.

Blok: To some extent it can be based on what is potentially possible, on what can be reasonably achieved within a certain timeframe. In the end it is of course a matter of negotiation in decision making.

Participant: Given that it is difficult to find a correct percentage would it not be easiest to raise taxes on carbon dioxide?

Participant: The UK quota will have a premium ceiling built into it. It could happen that we get up to the ceiling at 8% and 10% won't be achieved.

Blok: I think it is useful to say something about voluntary agreements because they are an upcoming policy area. In particular voluntary agreements in industry. These are in place now in a number of countries. Coverage of energy use by voluntary agreements varies from country to country. In some countries coverage is only half. In the Netherlands almost all energy use is covered. This also has to do with the way it is done. In Germany, for instance, there is just one unilateral agreement.

Participant: Do these agreements relate to emissions?

Blok: Generally they relate to energy efficiency.

Participant: In the UK there are a number of agreements, although their voluntariness is open to question.

Blok: For Denmark, agreements are individual and are made with each separate company. If a Danish company enters into an agreement then they are exempt from carbon taxation. So still it is voluntary but there is a substantial penalty if you do not enter. There are, therefore, many different ways of designing voluntary agreements. Generally, it is accepted that the concept began in the Netherlands where the agreements are very detailed and there are very extended monitoring systems and where a lot of money is spent on keeping all the agreements running. Research has shown that the Dutch agreements system is nearly half as expensive as a subsidy system.

Participant: Are the long term agreements in the Netherlands still on track? Are companies still complying with them?

Blok: On average yes. There are agreements with 30 sectors. 20 sectors are behind, but these are all small ones. The big ones, like chemicals and steel, which make up 70% of total energy use, are on track. There are a lot of complications with monitoring, however, and here and there, there are some loopholes.

Participant: Does the monitoring allow for the transfer of production out of the Netherlands?

Blok: Yes, because targets are expressed in terms of energy consumption per unit of product. Of course there are some problems. It is important that governments negotiate with companies and set ambitious targets, and that is a process which they still have to learn and partly that has to do with the lack of knowledge on the government side, that is still a problem. Further, there need to be clear targets and timetables in the agreements. Long lasting government support is necessary. Furthermore it is important to note that voluntary agreements work well for large energy intensive companies, but not for large economic sectors with large numbers of small energy extensive companies. Monitoring should be done on a physical basis. There should be clear monitoring guidelines in advance. And independent verification is needed. This is lacking in the Netherlands and it is considered to be a big problem. In fact that is the reason that we can't be sure that companies are on track.

Concerning energy taxation. There was a proposal from the Commission in 1997 on minimum excise duties. This was a proposal to broaden the existing directive, which was only valid for motor fuels, to include all energy carriers, and setting minimum duties that all countries should implement for these energy carriers. There were also quantitative proposals on how high these should be. Price increases of 20% were considered. One principle was that the tax should have the same level. For example: 0.7 Euro per gigajoule for both electricity and for natural gas. This means that it would not be very effective in promoting CHP. The effect would be limited: 50 million tonnes of CO<sub>2</sub>. This is a very small contribution compared with the needed reduction of 550 megatonnes. Nevertheless, although it is a small tax and the effect is small there has been no progress at all in recent years in its implementation. This illustrates that a carbon tax, if it is to be implemented at the European level, encounters so much resistance that it hardly makes any progress.

## 5 Policy Options and Instruments to Reduce CO<sub>2</sub> Emissions

Jip Lenstra  
Directorate of Climate Change and Industry  
Division Energy and Vehicle Technology  
P.O.Box 30945  
2500 GX The Hague  
The Netherlands

[N.B. The following is an update of the presentation that Jip Lenstra made in October 2000. It is based on an interview that took place at the Dutch Ministry of Environment in June 2001.]

Lenstra: A very important step was taken for environmental management in the form of the Dutch environmental management law (the 'wet milieubeheer'), that concluded that CO<sub>2</sub> is an air polluting substance. The enshrining of this principle in law made possible subsequent developments in Dutch environmental policy.

There are various examples of what can be done. Environmental permits can be used, for example, to reduce CO<sub>2</sub> emissions and energy consumption. Another possibility is covenants and long term agreements. These are instruments that encourage the implementation of technologies of an agreed type in terms of their environmental performance. It is also agreed that all investments that give a rate of return of at least 15% must be done, and that is the basis of all these policies.

Many people make the mistake of describing the Dutch government's environmental agreements with industry as 'voluntary'. This is a misnomer. The agreements are not voluntary at all: they are negotiated. From the outside the process may appear to be extremely friendly. But at the basis of the negotiations is the threat of legislation. So this instrument is, in practice, tougher than it may appear to be. From the point of view of government these voluntary agreements are quite beneficial. One particular advantage is that there is much less of an administrative load for government departments to deal with. It should be remembered, however, that legally the Ministry of Environment (VROM) is in a position to impose regulations.

Concerning the tax and regulatory system and in particular the Dutch ecotax. It is possible to define the impacts of an energy tax on different economic sectors. One thing that is clear is that an energy tax higher than a few guilders per ton hits certain industries so hard that these industries become no longer viable. The ecotax in the Netherlands takes this into account and ensures that measures are hard enough to encourage innovation in environmental technology and to improve environmental performance, but not so tough as to put industries in a position that they would be forced to relocate in areas where environmental regulations are less stringent. The rationale here is that relocation of industries to areas with weaker – or no – environmental regulations would have not only a negative effect on the Dutch economy, but also an overall negative impact on the environment.

For this reason the Dutch ecotax differentiates between low and high-energy users. The tax is used to cover smaller companies and households. For larger, energy intensive, industrial energy users, regulations are used.

Further, an important element of the Dutch energy tax system is that it is budget neutral. That is to say, the tax is compensated for by a relaxation of tax on labour. This has the overall effect of making energy more expensive and labour less expensive, which is an important principle at the heart of the policy.

The Dutch ecotax has led to an increase in energy prices of 40-50% since 1996. This is, however, not enough, and higher prices will be needed. Further, there is a tax exemption on 'green' electricity (elec-

tricity produced by renewable energy technologies). If you produce renewable energy and deliver it to the grid then you get a tax exemption on deliverance to the grid. This is an innovative way to stimulate clean energy production.

Another important point in this context is that it's easier to move towards clean energy than it is to reduce demand. This is a point that is missed by many policy makers. From both a technological and an economic point of view it is easier to reduce CO<sub>2</sub> emissions by changing to clean production than by reducing energy consumption.

The Dutch energy tax, in addition, is part of a broad raft of environmental policy and is situated within a number of instruments in the area of ecological tax reform and green budget reform.

The Dutch system also includes standards for energy use in the building sector. These include the 'Energie Prestatie Norm' (EPN) and the 'Energie Prestatie op Locatie' (EPL). The Dutch term 'energie prestatie' can best be translated as 'energy performance'. The Energy Performance Standard (EPN) is calculated taking into account the physical details of a building (such as the roof, walls and windows) to arrive at an acceptable average amount of energy which that building may (theoretically) use. The Energy Performance of a Location (EPL) is a (voluntary) standard at another level. It deals with an entire building location. This is particularly used in new building developments where large numbers of buildings are built at the same time. The EPL is an index, which is directly linked to the amount of primary fossil fuel energy, which may be (theoretically) used, on average, for an entire location. This gives developers a framework within which to design housing schemes which may take account not only of demand side measures such as housing insulation, but also supply side measures, such as district heating, the development of solar boilers, solar photovoltaics and local wind turbine electricity generators.

The Energy Performance Standard (EPN) is a regulatory instrument. That is to say, building developers' plans in the Netherlands must conform to these standards in order to obtain planning permission; the way in which this standard is met is left up to the developers. The Energy Performance of a Location (EPL) is used as a guideline and has (not yet) become a regulatory instrument.

Dutch environmental policy in relation to energy is generally speaking based on targets and makes no distinction between clean supply or less consumption. This has caused problems of acceptance with some people in Dutch society who are conservation-minded and who view strong government regulation to encourage energy conservation, and in particular to increase energy efficiency, as essential.

In relation to the Dutch carbon trading system. The Dutch Council on Housing, Spatial Planning and the Environment (the VROM-council) advised that a Commission on CO<sub>2</sub> trade should be set up. This Commission is currently still deliberating (July 2001). It is not a study Commission. Its goal is, rather, to propose a feasible carbon trading system for the Netherlands. It has not set out to explore all the possibilities in relation to CO<sub>2</sub> trading, only feasible, implementable possibilities. The Commission will publish its advice in 2001.

## 6 The Relevance of Liberalisation to the Development of a Sustainable Energy Supply

Dr. Catherine Mitchell  
Centre for Management under Regulation  
Warwick Business School  
University of Warwick  
Coventry, CV4 7 AL  
UK

[see also Dr. Mitchell's accompanying paper, which is contained in Annex III of this report.]

Mitchell: The problem with liberalisation as it is happening at the moment is that it is setting up barriers for new entrants and new technologies. The underlying incentives for the energy companies, which are already in place, are for them to continue with what they are already doing.

Liberalisation means separation into separate generation, transmission and distribution. Sustainable energy needs competition also in the distribution area. But this is not happening at the moment.

Member states were required to adopt the Electricity Directive by March 1999. Provisions of the Gas Directive were to be adopted by August 2000. The gas arrangements have been slowed down as a result of various disagreements; this is partly because it is harder to get competition into gas fields (smaller number of owners) as opposed to power generation plants.

The energy markets are so dynamic and changing under the gas and electricity directives. This is contrasted by the way in which people are actually working. The goal is competition in generation, transmission and distribution. The latter two are so called natural monopolies.

There are two main problems in relation to the directives. First, competition is really only at the interface between transmission and distribution. Second, it is no longer clear that transmission and distribution is a natural monopoly. In fact, in the UK, what can be seen is that there are strategic companies that have all the regulatory demands on them for owning the wires, which have got rid of all the operational staff. What is tending to happen is that a small company is carrying out management operations and tendering out the operational work. This is very good for sustainable energy because it removes the institutional inertia of a large organisation, if you can get that far...

The problem of the directives is that they are not thinking about real competition in distribution. They just stop at the interface between transmission and distribution. It's a half way measure. It is liberalisation but without full competition and this is absolutely the worst world for sustainable energy. It would be much better to have a benign monopoly that would be supportive of sustainable energy then the situation now, which is creating real barriers for sustainable energy.

Looking at liberalisation it's important to look at upstream and downstream, competitive and non-competitive areas. It is easier to get competition into transmission companies than into distribution companies. If you get competition down into distribution companies then liberalisation is good for sustainable energy. Otherwise it's bad. This distinction is very clear and very important.

Participant: Why is this distinction so important?

Mitchell: Because distribution companies are where sustainable energy is directly linked to. Renewable energy is connected to the distribution network, CHP is connected to the distribution network, heat goes down its own network, energy efficiency impacts on customer demand, which affects the throughput of electricity. So if you have a distribution company that is passive, takes centralised power and passes it to the end consumer. Or if you have an active company which is trying to match demand through services then the overall cost of providing services to customers can be lower and can match

the needs of the system in terms of using embedded generation to reinforce the system. The overall cost of the system can come down and can make the system more economic. But at the moment because the network operators have electricity coming into the system and the costs are just passed to the customer, even if they are high, they have no incentives to do anything in a more cheap way or to use anything other than centralised power. So what is necessary is that those costs that occur, that just automatically get passed on to customers, must become cost reflective, so that the distribution network operator can think, every time that they do something that costs them money, 'is this option or is that option cheaper'. Then they can pick the cheaper one. And that may be centralised power or it may be sustainable energy. And then they can pass on to the next of point of cost and they can have a choice. At the moment there are no choices within that system. There is no incentive for them to think about using embedded generation or sustainable energy for any reason.

The underlying charging mechanism is not cost reflective. All the requirements of competition upstream, such as better information, and markets developing, for example, none of these have happened at the distribution level.

The customer has to be able to choose who supplies their energy. The connection to the grid has to be open and accessible and the prices of connection have to be transparent. You have to know what each of the costs in each of the system are and what you're paying for. There has to be choice in terms of the customer.

Participant: So how do you implement competition at that level?

Mitchell: You just shouldn't have cost parcels. This is a key problem. At the moment generation comes through from transmission into the distribution systems and transmission tends to provide a number of benefits of running these systems as part of that transport of centralised power. And as a result of that, the distribution network operators have no interest in looking at embedded generation or sustainable energy.

Participant: I understand that and you've said it already. But what do you mean by competition at the distribution already. How can that be organised?

Mitchell: The customer can choose a supply company. Distribution is separate from supply. When you buy your electricity you buy it from a supply company. As part of the liberalisation process, by 2007, these companies have to be separated. So, customers have to choose suppliers, suppliers choose from where they buy their electricity. Currently those suppliers have to pay certain costs and they have no control over those costs. Distribution network operators have to accept certain costs on them and they have no control over what those costs are. And all this gets passed on through to customers. What you want is that everyone who has a cost enforced on them has an option on the cost. And it may be still that in that situation they will do exactly the same thing. But at least the incentive within the price control regulation is not that they just continue to do the same thing, which is what it is now. And which is also what is within the electricity liberalisation process.

Participant: It seems to me that part of the problem here is terminological. In the Netherlands there is choice over the distributor. But if you define the distributor as the person who owns the wires up to the meter then I doubt whether you do have that choice because to have that choice implies having multiple sets of wires. But I can have my contract with a supplier who can be any supplier. So I'd be very surprised if the situation in the Netherlands would be really very different.

Participant: As far as I understand, at the moment, a distribution company in the Netherlands is the supplier and also owns the distribution network in that region.

Participant: In that case you don't have a choice.

Participant: Yes. You can still go to another supplier, or another distribution company, although that company has to use the distribution network in your region.

Participant: In which case, in English terminology, that would be a supplier. And if there's a problem, such as a break in the wires, and someone has to fix it, you have to go back to the regional distributor, which is the one that owns that bit of the network.

Participant: The distinction is that there isn't the supplier-distributor distinction in the Netherlands. Instead you have common carriage by one combined company over another's wires.

Mitchell: What I'm saying effectively is that the way the regulation is set up is inflexible. And the result of that is that the final cost to the consumer will be higher, just because there isn't choice in there. And what you want is more flexibility. Regulation at the moment is setting up barriers to sustainable energy. When you've got rid of that barrier, you're still not making sustainable energy competitive. But you're certainly getting rid of the barriers. I would argue that even if a sustainable energy option is competitive it may not be in the interest of a distribution network operator to support it. Because it won't go into a price control mechanism which in the future gives it more benefits. So what you need to do is to make them neutral to centralised power or to embedded generation that goes into the distribution network.

*Energy Liberalisation Indicators* is a paper which is jointly supported by the British and Dutch governments. The background to this is that the British government has moved further along the path, in terms of liberalisation and privatisation, than the rest of Europe. Britain has had a very open policy such that half of its industry is foreign owned. It is now concerned that it has put costs into liberalisation that won't be recouped because the rest of Europe is not liberalising. So the British and Dutch government set up a study to establish indicators of liberalisation. The aim is to turn these into commonly accepted indicators throughout Europe against which countries should be assessed. Then pressure can be brought to bear on countries to meet all these indicators. The paper aims to produce overall scores, based on an arbitrary scale from 0-10. The UK is at 8.3. The average of six European countries was 5.4 and the minimum was 1.7.

The point is that the UK will be increasingly pushing for benchmarking of liberalisation within the EU based on these indicators. This means that the prices of energy will come down. One of the indicators of regulatory influence focuses on state subsidies. A state subsidy for sustainable energy marks down the indicator. We would therefore be interested to halt this process of benchmarking which will effectively become very detrimental to sustainable energy. Not only do you have the directives, which are not fully comprehensive, but also moving towards this benchmarking approach it increases the problem. So it seems that liberalisation at the European level is moving in a not very helpful direction.

Participant: What is the attitude of the Commission to this benchmarking approach?

Mitchell: The head of DG Competition, Christopher Jones, is very much in favour of it.

Participant: But it is problematic.

Mitchell: It is a problem. In fact I talked to a person at the Department of Trade and Industry in the UK who is responsible for this and he agrees that actually the way to assess competition in energy is to assess the degree to which you have competition in distributing companies because that is much more sophisticated. But his view was that the approach would be too complicated.

Participant: But you are not marked down for having a sustainable energy policy.

Mitchell: Yes you are.

Participant: But if you pursued your environmental objectives by having a carbon tax there would be no impact on your liberalisation indicator. If you intervened on environmental grounds in ways, which are less market-liberal-conforming, then you are liable to be marked down. So it is not that a concern for the environment as such is a liability but it does mean that the instruments you would be likely to use would be liable to being marked negatively. So what you need is either to push the sustainable energy people into using appropriate methods. In which case that would be a direction in which I

would like to see them pushed. Or you need more subtlety in devising the liberalisation indicators to take account of the constraints imposed by the other program.

Mitchell: I think what is needed, for a renewables policy, is a percentage obligation. Now that is about as market oriented as you can get other than at a higher level when you might have a climate change strategy which doesn't actually have a renewables strategy within it. And that would be least cost. Now as soon as you start to do anything which is much more focussed and directly linked to a particular situation then those are perceived not only as state aid but they also would be marked down. I believe that, in relation to sustainable energy policies there should be a two tier understanding, that a level playing field is needed, and to get rid of disincentives within a current market system, so that it's just neutral (the whole win-win argument). And then once you've sorted that out you're unlikely then to meet your targets and you will need some obligations etcetera to do so. I think that we are beginning to see that the least cost ways of doing it are not necessarily being targeted as effectively as they might in theory appear to be.

Participant: But your argument that the UK government appears to be pushing this, and I'm not sure exactly how it was treated and whether it's regarded as a regulatory influence but coming back to what Jip Lenstra was saying this morning, I regard as extremely unliberal arrangements which appear to be similar to the Dutch ones in which the climate change levy as it relates to major energy intensive industries is abated as a result of an agreement negotiated between an industry association and some government department. That is essentially an illiberal, dirigiste, corporatist, potentially corrupt mechanism. It isn't a misnomer to call it a tax and it isn't a very liberal mechanism. But that is a mechanism that the UK government is pursuing. So they themselves are going to be dragged down by their own indicators or they're going to have to give at least the Dutch at least as high a score as they give themselves. Now of course they were the two who commissioned this study but if someone were to do it by a more genuinely liberal and market conforming measure then they would be able to outperform the problems of this particular indicator. So it is not quite as bad as you were suggesting.

Participant: I don't understand why long term agreements are by definition not liberal or not market conform.

Participant: Because basically in market relations, one of the crucial things, and it may or may not be a virtue, is anonymity in market transactions. The reason that you get the price that you do is not who you are but because of the nature of the transaction. So there may be a quantity discount. But if your name matters and so on then that is not a proper liberal arrangement. And with these ones one doesn't know, there's no mechanism to ensure, because there is no set of criteria that establishes that a deal that has been struck with a cement maker, for example, is not in some sense consistent with a deal that is struck with a brick maker. It's partly a matter of legislation. Legislators should say, how much you pay depends on what you do, not on who you are nor on how skilful you are in negotiating.

Patterson: There is something, which needs to be on the table explicitly. In the UK the networks, by which I mean the transmission networks and the distribution networks, are still operating according to standards of performance that were laid down in 1977 under the old Central Electricity Generating Board (CEGB). And they are now, bizarrely, administered by the Office of Gas and Electricity Markets (so called, although in this case it isn't a market it's a monopoly). Moreover, it is a monopoly in which the investment that goes into the networks is still paid for by captive customers, who have no choice in the amount of money they pay for the service of the networks. And the decisions about how investments in the networks are made are ultimately vetted and cleared by the Office of Gas and Electricity Markets. It is a travesty to say that the UK electricity system is fully liberalised. It is not. A crucial part of the system is still a traditional franchise monopoly.

Mitchell: But it is still further than Europe.

Patterson: I don't mean that it isn't in some respects better. But it is no more transparent and no more liberal than it was under the old CEGB.

Mitchell: When liberalisation took place in the UK regulation was put in place to match the way things were done before. So the things which made money before became the price incentives of the liberalised market. Everything else has changed, around it. But what haven't changed are price incentives: how electricity companies actually make money. And until that is broken (which, for me, means that competition is ensured in distribution and that it is cost reflective) it will basically continue to be used in the same way as it was in the monopoly system, which is, essentially, centralised power.

So the conclusion in terms of European indicators is that the UK will push for benchmarking of these sorts of indicators. There are current problems with gas liberalisation but it will become increasingly competitive. A major question is whether we have a market when there are three major players. We are moving towards a situation in which there are a small number of big players in Europe. From my perspective a market isn't competitive unless it allows new entrants.

Participant: But the fact that there are three incumbents doesn't necessarily mean that there are barriers to entry.

Mitchell: I would agree completely. But it is a question whether new generators can come in on fair terms and with straightforward access and it is very important that that is part of the equation and that is not something that is any way discussed within the terms of the Commission.

Participant: You say that distribution network operators should be obliged to ensure competition in generation and supply. It seems to me a bit odd. My understanding is that distribution network operators are just ordinary commercial companies.

Mitchell: Under their license they are required to ensure competition.

Participant: But the ensurance of competition is surely a function for a public agency such as a regulator and not a responsibility that it's reasonable to assign a commercial entity.

Mitchell: It is something that is being pressed for in Europe.

Participant: There was a case recently. This is perhaps what you mean by ensuring competition. It involved United Utilities, which had taken over a UK electricity company and then gave itself a management contract. They were taken to the European Court for failing to use properly prescribed procurement procedures. That is an obligation on them to behave in certain ways, which is not quite the same as an obligation to ensure competition.

Mitchell: Well, it is in their license. And it means things like making sure that access is open. They have to ensure that their interface with generators or suppliers is non-discriminatory.

Participant. In Germany there is no supervising authority. Therefore the market is not functioning. We don't have a good system.

Mitchell: Essentially I'm saying that it takes a long time to get liberalisation going. We've had 10 years of liberalisation and it's only since the Labour party got in, in 1997, that any moves to regulate in favour of environment has happened. The government has set up The Working Group on Embedded Generation. This is a group of distribution network operators, national grid, customer representation, CHP people, energy efficiency people, renewables people, who have come together to discuss this question of whether or not there is an inherent barrier to sustainable energy within energy liberalisation. Everyone in the group accepts that they are acting in the face of skewed price signals. No-one seems to be asking for policies to positively promote sustainable energy; everyone seems to agree that barriers should be removed in order to create a neutral level playing field. This is a huge step forward that electricity companies and the UK regulator is admitting this. This is all on the Internet at [www.dti.gov.uk/energy](http://www.dti.gov.uk/energy). There are very interesting papers. It would be interesting to try to replicate this process in other European countries.

Participant: Can you sketch the main barriers?

Mitchell: Planning permission to deploy renewables, network access, connection issues, charging issues, lack of information about the network. All of these things are very opaque and for a distributive generator or an energy service company or someone who wants to do demand side management none of the information that they need in order to provide and cost services is in the public domain. And even if it were in the public domain and they could offer services or do something they get no help from electricity companies because it is not in their economic interests. That is because they are regulated based on assets. So when they do anything it is always in their interests to increase their asset base because then their return can get bigger. And it is positively against their interests to spend more money on operating and maintaining that system – doing things differently.

Participant: The UK regulation was meant to get away from some of the well-known distortions of the US rate base system. It was supposed to be based on the price cap system, which would mitigate some of the problems. But the rate base system has crept back in. The other point which was emphasised by the Royal Commission in this connection is that the national grid itself has to be redesigned to accommodate a much larger proportion of capacity being embedded, distributed and also in many cases also intermittent. So there can be genuine economic reasons for not being very welcoming of some of these sources of supply until they've improved the structure and nature of their network. And it is not clear what incentives if any they have to do that.

Mitchell: None.

Participant: So the people who are trying to push sustainable energy have to push something through the regulator onto the grid operator and particularly the grid developer – including some research because not only could the present system not do it, and although it would be feasible to accommodate more, actually there were some genuine technical problems and engineering problems that would have to be solved along the way.

Mitchell: That is clearly a huge barrier but that is not inherent to the price control of the system. That is because with centralised power built in a top down way it will cost a lot of money to create the capacity for a different kind of system. That is clearly an additional cost that will have to be paid for. It is essentially a political question that has to be dealt with.

Essentially, the increase of liberalisation and privatisation will lower prices. In order to lower prices a lot of mergers are taking place and some very large companies are emerging. These companies are fending off take-overs by keeping their prices as low as possible. They will be trying to stop as many social and environmental obligations on them – which raise their costs – as possible. They certainly will oppose them if they think that they, rather than another big company, will suffer from them. There will be huge pressure to bring down prices which is bad for sustainable energy, there is going to be huge pressure to not have such obligations. If obligations are imposed then there will be pressure towards them working with the market and being least cost and that is good in some ways (good for the customer) but it is not good for the long term development of technologies and diversity of technologies. And if there are to be social and environmental obligations then there has to be very strong and clear guidance from government and a strong political mandate for sustainable energy. And unless governments are prepared to stand up and say 'yes, this is what we want and somebody has to pay for it' then the pressures will be much greater to get rid of these kind of things.

So my conclusion is that liberalisation does not have to be bad for sustainable energy, it should be able to offer new possibilities, but halfway liberalisation as it is currently being carried out with the gas and electricity directives is the worst of all worlds.

## 7 Future Sustainable Energy Systems

Walt Patterson  
Royal Institute of International Affairs  
Chatham House  
10, St. James Square  
London SW1Y 4 LE  
UK

Patterson: I have sent three papers to support my presentation [*Low Impact, Full Circle* and *Energy 21: Making the World Work*, which are contained in Annex III of this report].

I have been asked to talk about future sustainable energy systems. These three papers should give you some idea of how I feel about future sustainable energy systems. If you've had a chance to look at the papers then you'll see that it isn't hard to imagine future sustainable electricity systems, the technology is available. The hard part is getting there from here. The reason it is hard is not technical or economic – despite what you may have heard to the contrary. The reason is political. People tend to overlook the fact that energy policy itself is first and foremost political. It is about the choices that governments make that affect tax regimes, company law, subsidies, cross-subsidies, laws, regulations, standards, government procurement, international agreements and so on. The choices that governments make create winners and losers, individual and corporate. Politics in this area – energy policy – is about making choices in which both the winners and the potential losers accept the consequences of the policy decision. In democratic societies the only way we will be able to develop and implement policies that lead to sustainable electricity systems, or indeed to any other aspect of sustainable development, is if we as a society really want it to happen. At the moment, it is quite obvious – and we have been hearing more evidence to that effect at this workshop – that we and our elected leaderships are not making the choices that will bring about sustainable futures. Because, at the moment, too many powerful constituencies, think that the choices favouring sustainability are going to turn them into losers.

Unless we can address this fundamental issue, and address it effectively, all the national reports in the world are not going to get us closer to sustainability, in electricity or anything else. That is why I believe the future of electricity is an especially vital aspect of human energy use when we are thinking about sustainability, because for electricity I can see a way forward. A way that may engage powerful interests on the side of sustainability. If you have seen the three papers I've submitted you might have been able to get a flavour of what is on my mind and I'd like to review them for you now briefly.

The very first systems for electric light were all on the same site – the generator, the wires, the switches, the lamps – and they were constrained by the available technology to power the generator: usually either water or steam power. Thomas Edison's great idea was scaling up the whole system in order to reduce the unit capital costs of the whole operation. It was still stupifyingly expensive but it was lower.

The first installation was set up in lower Manhattan and it served the offices of the New York Times, and Wall Street, for example, which were of course willing to pay the prices for the spectacle of electric light. But the original idea that Edison had was to scale up the whole system. And he charged his customers according to how much light they used, the number of light bulbs. Then – and this is a very important point – something happened which has been fundamentally undermining the whole proposition ever since. They introduced the electricity meter. And from that time on, once it was no longer a question of selling electric light, but instead a question of selling electricity by the unit, it was in the interest of the person who was selling the electricity for the person on the other side of the meter to be using inefficient lamps. Because to get the same level of illumination you have to buy more electricity. In other words you have an incentive which is directly contrary to optimising the performance of the whole system.

Now, the economies of scale of water power and steam power, particularly eventually the steam turbine, determine what eventually became a common technical model for electricity all over the world. And it was driven by the pursuit of ever-larger economies of scale. You needed networks of course because you had so many loads and the loads were progressively so much smaller than the generators that you needed increasingly elaborate and widespread networks in order to maintain the whole system in operation.

Remember that this is a system that is operating in real time. This is like a huge machine. It's not like the gas supply system. Because there is no storage in an electricity supply system, not of electricity. There may be storage of other things in certain kinds of systems but it is not stored as electricity. And that turns out to be a crucial difference, which we'll get back to in a moment.

The networks, in turn, allowed the early system operators eventually to persuade politicians that they should be given monopoly franchises. I find the term 'natural monopoly' very hard to defend in this context. In fact the monopoly franchise is first and foremost a political monopoly. It was and always has been a political monopoly. It was granted in the 1920s and was maintained up and until liberalisation in the 1990s. It is a political monopoly, and it is crucially important to the technology of electricity because it allowed the system planners to plan and to finance increasingly large installations. Not only very large power stations but very large long transmission lines and other capital-intensive investments. Because the monopoly franchise supplying what came to be captive customers for what came to be an essential service meant that they could guarantee a stream of revenue. And therefore it was quite straightforward to finance a power station that might take six years to build before it ever generated a unit of electricity or a unit of revenue. And it was of course also possible to build a great deal of redundant equipment which you need on an electricity system because, as I say, it operates in real time, and you have to have backup circuits and backup generation available for fault conditions and for unexpected performance of the loads on the system.

What happens when you start liberalising the system? In the UK, all the stress was laid on the fact that we were privatising the system, that we were selling the assets, that we were changing the ownership of the assets on the system from government owned to privately owned. That's irrelevant. The privatisation part of the process is interesting, but not relevant to the long-term future of the electricity system. And in fact there have been studies done demonstrating that the performance of electricity systems does not depend on the ownership of the system. The US system, the German system, the Japanese system, have been privately owned from the outset. In fact both the German and the Japanese systems were privately owned after pressure from the US when these countries were reconstructed after the Second World War. These countries were not allowed to set up national systems of the kind that were set up in France and subsequently in Britain and many other countries. But the ownership was irrelevant. The important consequence of liberalisation is the introduction of competition. Because this immediately changes the allocation of risk in the planning and evolution of an electricity system.

Let's back up a step. All the assumptions that underlay the initial liberalisations – starting in Chile and then in the US and spreading all over the place – was that there was a close analogy between gas supply systems and electricity supply systems. And, in particular, that electricity is a commodity and that it is produced and supplied in much the same way that gas is. This is a fundamental misconception. Electricity is not a commodity. A commodity – as I use the term – is something that you can withhold from the market until you get the price you are willing to accept. This does not apply to electricity. You cannot store electricity. You can store fuel. And fuel is a physical substance. Natural gas, say, comes out of a hole in the ground at a certain place. If you want to use it anywhere else, you must transport that fuel physically to that other place. Whereas electricity, in principle, you can generate anywhere. At a price. I usually just say ask the person sitting next to you on the bus with the buzzing headphones. Electricity is different.

If you then pursue the logic of this. Liberalisation changes the allocations of risk in an electricity system. You no longer have captive customers guaranteeing your revenue stream. If you are the owner of one of the assets of an integrated operating system in real time, you want your asset to be generating

as much revenue as possible all the time. And in an electricity system that means operating, most of the time. We haven't yet figured out a way to compensate owners adequately for things like performing a spinning reserve, or providing reactive power. They always used to be taken as part of an integrated complete system on a monopoly basis. That's no longer true.

So, if, instead of captive customers, you now have bankers and shareholders facing the risk of investment in new facilities. If they have the option of investing in less risky facilities, they're going to pick that option. And as it happens, just at the time that liberalisation started to bite – first in the US, then in a number of other countries – a new technological option for generation happened to come along, which had attributes which were fundamentally different from the old water and steam power technologies. I'm talking of course about the gas turbine. Gas turbines burning natural gas. It was a coincidence that the gas turbine suddenly became of interest for stationary baseload electricity generation just at the time that liberalisation happened and just at the time that we suddenly realised that there was a lot more natural gas around a lot cheaper than anybody had realised up until the late 1980s. All of these things converged.

So you suddenly found a new trend happening on electricity supply systems. That it was no longer the case that a better power station was always a bigger power station farther away. You were now faced with the possibility that a better power station might be a small power station quite a bit closer. And this means that you are now starting to see a change in system configuration: the actual technical configuration of systems. At first the gas turbines were seen to be just another option for central station generation. But they have now begun to realise that it is easy to site gas turbine stations compared to coal-fired stations or nuclear stations or dams. And you can site them quite close to or even on the site where the electricity is going to be used. They don't require fuel storage, they produce no solid waste, the emissions to air can be very low, water requirements are not very demanding, they can be sound-proofed pretty effectively so that even up close they are not noticeable, and the land area requirements are not necessarily very demanding. So this is a totally different approach to the actual generation part. And that is only the beginning. Because the new further options for generation that are now heading very rapidly for the marketplace take this new trend much farther and it is a trend downward in size not up. A trend to much smaller generation, much more of it, of course, much closer to users, and possibly actually integrated with the loads right on the site where the electricity is to be used. So you now have the standard gas turbine going up to a couple of hundred megawatts or a bit larger. You are now seeing a lot of the most exciting developments in gas turbines on small units. Machines of which you could get a couple of dozen into this room. They can fit into a corner and produce 40 kW and will do so if you wish in a cogeneration mode so you can use them either for generating heat, or indeed for generating refrigeration. And, one of the most interesting aspects of this is that it actually gives you the control over your own power generation if you happen to be the owner and operator of that on site generation. Keep that in mind, because that is also going to be important.

You now have not only the small generation, many in microturbines; you have the imminent possibility of fuel cells in various kinds and sizes, with different fuels. You have of course got many different module renewables, some of which are better suited to comparatively remote installations as it might be off-shore windfarms and things of that kind. Some of which might be quite close (some types of biomass applications) and of course everybody's popular favourite, the photovoltaics. In the case of photovoltaics let me also remind you that although we hear regularly about how horrendously expensive they are, there was a building built in central Manhattan, New York, which had the choice of using either a photovoltaic façade, or Italian marble. And they decided on the photovoltaic façade because it was cheaper. So if you take the photovoltaics as part of the building, rather than as a generation technology, you suddenly get a slightly different view of the cost, particularly because a lot of different photovoltaic installations actually look rather attractive.

So you're now getting into a very interesting problem. Because, although you have a lot of new options for generation – and these new options are getting more and more interesting for commercial reasons and for reasons of control and reliability – you have the problem that the networks which interconnect all these technologies are still configured and managed in the traditional way. They are still thought of as being primarily one way, radial delivery systems to take very large quantities of electricity from very large generators, break it up and send it out to a lot of small roads in a one way system. And

that applies both to the high voltage part of the network and also to the low voltage distribution part of the network. It's still thought of as a one way delivery system. And this is completely inappropriate for the sort of configuration that is suggested by the proliferation of small local generation. Because for small local generation, what you want is a lot of generators that are interconnected in a mesh-linked two way network, which can in fact much more readily be self stabilising than the traditional one because the size of the loads and the size of the generators is close. One of the big problems for stability on a traditional system is that unless you have a lot of redundant stuff ready to come into play in instants. The closing, say, of a main steam line valve on a 500 MW turbo alternator set sends a huge transient through that network and will trip protective devices for hundreds of kilometres. And it is that problem which is the problem that creates a lot of the instability on a synchronised alternating current network. Whereas if you have a system in which there are no generators three or four orders of magnitude larger than the loads, but that the generators and the loads are all within one or two orders of magnitude in size (except for the really small ones), then you have the possibility of a network which is much more readily self stabilising than the traditional method.

Turkenburg: If you would go further and implement intermittent energy technologies like wind and photovoltaics then you need to have power provided through networks in the traditional way. That is contradictory to what you are saying. What is your solution to that? Would you propose something like windfarms connected to large storage systems in one place?

Patterson: Stay with the story; we'll get there.

If you actually then start looking at what you can do with the networks. I mean, let's assume that the generation side is under control. We were talking yesterday about research and development and how it gets funded. One of the things that I find really reassuring about this is that the research and development, indeed the demonstration, of the new generation technologies is being done by the companies that are manufacturing them and expecting to sell them. It's not being done by governments. It's being done by Ballard, Daimler Chrysler, General Electric, Capstone, Allied Signal, ABB, and so on. Companies all over the world that see these new technologies as major commercial opportunities. Now, if you then start thinking about how you want to change the networks; first of all you have to recognise that a very very large scale synchronised AC network is enduringly stable because of the inertia of the big rotating machines on it but that it also has this possibility of very violent transients going through it. So if you want to try and reduce the vulnerability of having the entire network go down in a cascade trip – when one protective device overloads another circuit overloads another circuit and blacks out the whole western seaboard of the US, or the whole of France – then you start introducing AC DC AC links. You start introducing DC linkages in particular. A lot of high voltage DC is now coming into the system not only because it's cheaper, for long distances, to carry large quantities of electricity, but some of the new technologies for high voltage DC will also carry comparatively small quantities of electricity more cheaply than synchronised AC. And the great thing about DC is that it doesn't carry transients. So you have the possibility of blocking off the transients that would otherwise crash the system.

And you have also, at the same time, now got a rapidly expanding shopping list of more and more sophisticated power electronics that will carry, if necessary, very large flows of current.

Turkenburg: We are not all experts here in the energy field. So would it be possible, if you use many technical details, to explain them a little bit.

Patterson: OK. Well, if it was the power electronics you were worried about, I was just about to explain that. What these are is light transistors, except that instead of switching currents that are almost invisibly small, they switch enormous electric currents without difficulty. And, at the same time, you can have, now, power cables – that you can get your hand around – which will carry 50 MW. And some of the possibilities now are up to 300 MW for a single power cable. So the possibility is not only of having these networks reconfigured, but of having them buried. So that they become an invisible part of the energy infrastructure.

I can not imagine why anyone in the Netherlands could possibly object to wind turbines because you cannot see the skyline anywhere without pylons. It's absolutely ubiquitous. So, if it's visual intrusion you're worried about I think wind turbines are preferable.

Anyway, I'm just running through this story perhaps a little too rapidly and a little too technically. The point is that the technologies are there. And there are a lot of big players that want to get them into place. And, the reason why this interests me is not just because I think it is technically fun. But it also produces a very important corollary point. Because, remember what I said that electricity is not a fuel; electricity is different. The whole reason for the elaborate superstructure of electricity systems, traditional electricity systems that we have all over the world, was purely and simply because, at the time, that was the low cost way of delivering electricity services. Now suddenly the possibility arises of delivering electricity services at even lower cost with a system that does not have the attributes of the traditional system.

And the interesting problem there is that the whole process that we've been talking about for the past couple of days; this whole elaborate institutional infrastructure which is being set up in Europe and in North America and in various other parts of the world about a market – so called – in electricity, is, in my view, fundamentally misconceived. Because electricity is not a commodity. You can treat it as a commodity in a transitional stage, and I'm sure that that will continue to be the case for maybe another decade or so. And it will probably be the case for some participants in some contexts for some time thereafter. If it is perceived that the ultimate purpose of this is to sell anonymous units of electricity at a customer's meter, which is what it is at the moment...

Think about this. If you are competing with some other suppliers selling anonymous units of electricity at some customer's meter, the only thing you can compete on is the price. You have no way to distinguish yourself otherwise. Which means, of course, that your margins get perilously thin if you're trying to undercut the other guy. If, at the same time, your customer can change supplier in 28 days, as he or she can in the United Kingdom now, your customer base is terrifyingly volatile. And this is an extremely good way to go bankrupt. And a lot of electricity people who've realised in the last couple of years that this aspect of the so-called electricity market is suicidal, from a company point of view. That there must be some other kind of business they can do other than selling units of electricity. Because, as I say, you can't store it. You have to have the whole physical apparatus in place and operating in real time in milliseconds in order to be able to fulfil your customer's requirements. And if your customer suddenly changes his mind, or her mind, and leaves you flat, then you're stuck with that apparatus. And what has been very interesting to me in the past 18 months or so is how many of the biggest players that were previously thought of in terms of the assets they owned in the electricity business are getting out of the asset part of the business. You watch what Enron is doing. Enron is selling its physical assets. I think that process is going to continue. And what it's going to do to the infrastructure both for electricity and for other parts of the energy infrastructure I don't yet know. But it is going to be very interesting and it could be very disruptive.

We've talked a lot in the last couple of days about the price of electricity. Presumably the price of electricity by the unit. And how the whole long-term objective of liberalisation has been to lower the price of a unit of electricity. Every time I hear someone refer to the price of a unit of electricity I remember a wonderful quote from a gentleman called Patrick Moriarty, who was the chairman of the Irish electricity supply board in the late 1980s. At the Financial Times Electricity Conference he itemised the things that affect the price of electricity. He said, you've got the tax regime, the asset accountancy, the treatment of the so-called natural monopolies, subsidies, cross subsidies, the tax regimes on fuels and things of that sort. He summed it all up by saying: the price of a unit of electricity is what the government wants it to be. And I believe that. I believe that even in a liberal market context, at the moment, the price of a unit of electricity is as long as a piece of string. You can adjust it as you see fit. It is not an appropriate measure of value. And it is certainly not an appropriate basis upon which to define a long-term business.

Anyway, as I say, the result is that a lot of enlightened companies, realising this, are now beginning to realise that they – as a corollary of this – have to find different types of business and different types of relationships to have with their customers. And this is a huge culture change. It is a culture change not

only for the companies but also for the customers. Because the customers are not used to thinking about this. They have always taken for granted that they had to pay whatever the electricity bill was and that was all there was to it: somebody would keep their lights on. And suddenly that isn't necessarily true. And I think that one of the consequences of this – and I'm seeing this starting to happen now with some electricity companies – that they are looking to establish longer term relationships with their customers on the basis that what they are providing is not units of electricity but the ultimate peace of mind that the customer wants. That they will assure that the customer has the comfort, the illumination, the motor power, the information handling. Whatever. In other words it is the removal of hassle that is the service that is being provided. And I've seen some spectacular examples of that in recent years. The biggest one that I know of was the contract that was signed in the autumn of 1999 between Enron and Owens Corning in the US which was purported as being for 1.2 billion US\$ over a period of ten years in which Enron undertook to manage everything involving energy on something like twenty industrial sites for Owens Corning – this is one of the biggest US manufacturers of fibre-optics and related technologies. And Owens Corning said: we don't want to think about this anymore. Enron said: fine, we'll do it, we'll negotiate all the necessary contracts for fuel and electricity. We will go into your process plants and evaluate the buildings and the technology and if they need upgrading we'll do that, we will go through all the uses of energy that you have and make sure that you're getting the maximum use out of them. And we will make a profit doing this because both of us are going to cut down on our energy use and our energy costs. And we're going to get better service and better products out of it at the same time.

Participant: So their interest is to lower the energy use in fact.

Patterson: Well, that isn't their primary interest. That is the corollary of what they think. What they want to do is to lower their energy costs. And improve the performance of the energy we do use. But it isn't fundamentally that they want to go in and lower the use of energy. That just happens as a consequence of doing things better. Which is why I think this is a very much more exciting approach to actually upgrading the energy infrastructure, rather than focussing entirely, as I keep saying, on fuels and electricity. You have to have people in whose interest it is actually to improve the buildings, to improve appliances, to improve the motors, to improve the lighting, and so on and so forth. Because it is something that they a) have the confidence to do and b) can see a way to make money doing. And I think, in the context of electricity, that this is going to turn out to be an extremely important line of development.

And there is a corollary to this. It was mentioned briefly. I'm not sure by whom. Possibly by you Catherine [Mitchell] this morning. I think you mentioned TXU Europe [a company which specialises in risk management and energy trading]. The other end of the scale, of course, and one of the things I've been working on and worried about in the context of the follow up...

This is my previous book, it's called *Transforming Electricity*. Obviously I'd be delighted if you wanted to read it. But I should also mention that I'm now working on a follow up book, which is called *Keeping the Lights On*. And one of the problems I have is that in a market context, whether the market is for units of electricity or for services, there are some customers who are going to be more attractive than others. And there is going to be a category of customer that nobody wants. The customer who is poor, unable to pay the bills, or in a low-density rural area with little access to the networks and so on and so forth. And I am absolutely convinced that it is going to be an important role for any democratic government to look after the weakest in society. And one of the things that has to be looked after is their access to electricity and other energy services. But TXU Europe has launched a series of projects. One of which is in a town in Britain – and I saw the newsletter report of this a couple of weeks ago – in which they are effectively taking over the energy services for the town. They're giving out compact fluorescent lamps, they're providing insulation, they're upgrading the performances of the residences and so on. And they're doing this in conjunction with what they call a *stay warm* tariff, which they are offering now on a pilot scheme basis – which they hope to offer across the country – in which they undertake, for low income customers, to provide a guaranteed level of comfort in the house for a fixed monthly or annual price. Not according to how many units of electricity or gas they use. And if the customer signs up to this *stay warm* contract the company will then carry out an audit of the house and if

it's appropriate to insulate it, or to improve the doors and windows, or put in better heaters and so on, they will do that as a way to fulfil their part of the contract.

TXU Europe is doing this with support of the British government-funded home energy efficiency scheme. What is interesting is that this is funded out of the government's social security budget; not out of the energy or environment budget. And I think that, again, is going to be quite important part of this. When governments contract for services, rather than for units of gas or electricity, and pay accordingly... What we had in the UK in the past was the so-called fuel supplement, where the government will pay low income, pensioners, disabled, and so on. They will pay them an additional sum of money, which is supposed to be used to pay their electricity bills and gas bills. Well this money doesn't even get warm in the hands of the pensioner before it is in the hands of the electricity company. So, rather than doing it that way, you actually do it the other way. You call for tenders to other electricity and energy services companies and you say we have this housing estate, which is miserable. We have so much money in the social services budget, make us an offer. What will you charge us to operate these houses so that they give at least a minimal level of comfort to the people who are living there, in whatever way that you think is appropriate, whether it involves improving the infrastructure, or putting in more electricity and gas: whatever. And see what they get. Because I guarantee that, in most cases in the UK, the first choice will be to improve the infrastructure because it's so terrible at the moment. Scottish Power are doing this now in Glasgow for something like eighty thousand houses, with some money from the government.

This new line of activity for companies that used to be electricity companies seems to me to be an extremely promising way to see genuine improvement in the whole energy service infrastructure of society, rather than simply in the delivery of units of fuel and electricity. Because it is in the interest of an energy service supplier and applicant to optimise an entire local system including any local generation that might be in that system in order to get the maximum services out of the system. So that you optimise the total investment in the fabric of the building, in the performance of all the end use loads, and actually then – and only then – in the generation. And I think that is an extremely promising line of development but I don't know how far it's going to go and I don't know how fast it's going to go and it's going to cause a lot of trouble for traditional systems. Because if you have this kind of activity going on in part of the system but not in another part of the system and there is, so to speak, a supplier of last resort in the other part of the system, and the other part of the system is having to supply loads which get peakier and peakier, going up and down more and more during a day because some of the best loads have been taken off the system then...

The sixth chapter of *Transforming Electricity* is called Bumpy Transitions, because I don't think this is going to go smoothly, I think there are going to be some major disruptions. I think there are going to be, as you have seen in California, a lot of major disruptions even in places you wouldn't expect them, simply because the uncertainty and the possibility of going in different directions keeps people from taking decisions on investment or otherwise in participation in the consequences of liberalisation. They stay out. And, as a result, the people who are still expected to be participating in the market have nothing to buy because nobody is selling them anything.

I mentioned to Catherine this morning that I wrote a working paper which was for limited circulation because I wasn't sure how well I understood it or how much I believed it, for this workshop which we had in March on keeping the lights on reliably. Because reliability, for an AC system, is one of the most important and difficult things to deal with.

The UK people at the workshop were all completely unperturbed by any reliability issues that arose. And they said that the system was, before privatisation, routinely described as 'gold plated' by the old CEGB (Central Electricity Generating Board) engineers, meaning that they had far more redundancy in the system than anyone could possibly want. The claim now from Ofgem, the Office of Gas and Electricity Markets, is that the system is now 25% more reliable. And you have to ask yourself, is this necessarily a good thing? First of all, what is your criterion for reliability? And it turns out that the criterion for reliability in the UK is something called 'customer minutes lost'. Which means that if you have a power cut but the power comes back on quickly then that's only a very short 'customer minutes lost'.

If it happens to switch off your computer when you're in the midst of writing something, and then turns it back on again, and you lose a morning's work, then, too bad...you were only off for about a millisecond. And apparently one of the main forms of investment, which is now being taken in the networks by the distribution companies in the UK, is in so called automatic reclosers. It doesn't deal with the fault, but it keeps down your 'customer minutes lost' so that reliability – so called – is better. And there are people who are much better versed than I am in the performance of the UK electricity system who say that we are heading for a big big surprise. I wouldn't be surprised myself; I think it looks precarious.

However, that's by the by. The big problem is – as I said before – that the network part of the system is still being maintained as a monopoly paid for by captive customers, and is still being maintained in the operation and management mode of a traditional system, rather than one which is appropriate for decentralised generation. And, indeed, the combined heat and power people and the renewables people in the UK are absolutely panic stricken about the consequences of this new Utilities Act because it is marginalising them. Far from making a so called level playing field it is pushing them right out to the edges because it is laying all sorts of heavy requirements on them for connection protocols, for back-up, for charges for access to the network, and so on, which is going to make it very difficult to justify investing in a new cogeneration plant or in a renewables farm; as long as this act is in place. I think it's a serious missed opportunity. But it's another example of where the UK has led the way by making the mistakes first. Back in the mid 1990s when I was travelling around Europe I regularly had people come up to me elsewhere and say 'we really like what you're doing with electricity in England, so that we can watch and see what happens'.

Turkenburg: Are there any questions?

Flemming: Well, not so much questions. If they were questions I might be tempted to interrupt. They are comments. Walt started with this question about the metering. It is interesting if you compare – and I take his point about storage – if you compare electricity with water, the traditional use in the UK, the basis for charging for water, was either the value of the property or the number of taps, which is a fairly close analogy to the number of light bulbs that you mentioned having been the original basis in the United States. And I think many people would see the move, in that case, from water rates based on those to water meters as actually being a step in the direction of conservation and efficiency although obviously a lot depends on the cost of metering. There is nothing unique about electricity suppliers in that what they want to do is to sell their product; they don't have an interest in economy. Bakers have an interest in your not looking after the bread they sell you carefully so that you come back and buy more rather than economising on what you've got. And the same is true of everybody else who sells you shoes or...

Patterson: The difficulty is that these are not real time systems.

Flemming: No, I accept that they are not real time systems. But it is in that rather than in any difference of the ... And the point about captive customers: they are not efficient risk bearers. To allocate the risk to customers or taxpayers is inefficient compared to doing it on the capital market where people essentially volunteer and you pay the right price. But the problems that Walt refers to are genuine ones and ones that the Royal Commission report for the most part recognises. We weren't very optimistic about energy supply companies simply because the nature of the contract seems quite complicated. You have to say what it is exactly that they will deliver, you have to have contingencies which have to do with the expansion of the business, and so on, which are quite tricky. In the case of the residential ones that you mentioned, it is only feasible where there are large publicly owned housing estates because the problem with most of the fuel-poor in the UK is that they are pensioners living in rented accommodation of one kind or another. And a switch to your kind of contract wouldn't solve anything very much because if they wanted to come in and insulate the house they'd still have to negotiate how far the enhancement of the value of the property went to the landlord – so it would have to become a three party contract which would be quite complicated. But it is true, and I was very struck, and I don't know whether other people read the two pieces of British government propaganda which have been put on the menu for this conference. One is the one that Catherine [Mitchell] was referring to this morning and there's another one on the social consequences. And one of the things, when we had a state monopoly, that monopoly had certain universal public service obligations, such as dealing

with people in remote areas. They may have been wrong. Actually, in fact I think they probably were wrong. But the way in which that document glosses over the consequences and suggests that those things have been effectively transferred to and picked up by the privatised industries is...

Patterson: is quite wrong!

Flemming: ...is untrue. And there is no way. As soon as you have competition then you can't impose collective obligations and there can't be an obligation on an individual supplier to see that everybody or anybody in particular gets supplied. You just can't do that. Which is why it's appropriate that many of these things be, in fact, picked up by social security agencies.

There are two other points that I'd like to make which are slightly different. In mentioning the vulnerability of some of the traditional suppliers. Walt mentioned the fact that in the UK a customer has the right to terminate his present supply agreement at 28 days notice. And that is not a liberal feature; it's an irrational feature. A liberal feature would say that any two adults can sign any contract they like, subject to some regulation on the monopoly. The 28-day rule, as I understand it, was introduced by some of the regulators originally in the context of a transition. We had this phasing in. Competition was introduced first for the major consumers of electricity and then there was a reduction. So there were incumbent suppliers. I had a contract with somebody. The formerly nationalised and privatised were still dominant incumbent. And they might have been tempted or they might have been able to frighten me about what was going to happen and I would have signed up for a twenty year contract and the regulator, who had an obligation to supervise the introduction of competition was very anxious to avert that. And in a sort of disequilibrium period of transition from dominant supplier to competition a restriction of that kind might have made sense. But if you've actually got a liberalised and competitive regime then there's no reason to impose a restriction on contract length. And it should be possible for suppliers who want an assurance associated with building a new power station that is going to take a long time, then they should go out and sell long term contracts on electricity, and that should be legal and enforceable. And there is a clear case there for the relaxation of the regulations.

The other aspect that Walt alluded to and is not quite so easily resolved in practice and that is the question of standards of supply, and security. Now, if I don't use a computer then I don't care about a thirty second close down. So, ideally, one would want people who do have computers to be in a position to buy a quality of service that I don't need. What I'm worried about is the contents of my freezer, and as long as the breakdown is less than twenty-four hours, or whatever the magic number is, then I don't mind. But other people would have a lower tolerance. And, in principle, one might be able to have contracts of different degrees of interruptability, or different degrees of assurance that could be priced on the market. In practice that's very difficult to achieve because if you would have a thirty second tolerance or a ten second tolerance and I have a ten hour tolerance and we are next door to one another, we probably get the same service and it's quite difficult to separate that out.

Patterson: That's absolutely right. And there is a lot of concern now developing in the United States about the increasing importance of Internet and related on-line electronic data processing and transfer for business. Not for chat groups, which is getting to the point now where a so called Internet Hotel, as they call it, which is a windowless building filled with servers, is going to require an electricity supply which Americans call six nines: 99.9999% reliable. And that gets really difficult. It is actually one of the reasons why there is a burgeoning market for things like fuel cells in the US, because they can provide that kind of reliability.

Flemming: Maybe, if they decentralised, then that actually has the advantage of allowing you to differentiate.

Patterson: Yes, you can develop a market in reliability. It does entail reconfiguring the whole system. Because these Internet Hotels are not going to be isolated. They're still going to be part of the network. But they will have supply themselves, which guarantees this uninterrupted power supply. A lot is going to be happening here. And it is going to be happening in a system context, rather than in the context of individual components such as one generator or one motor or what have you. That is not where the action is going to be. The action is going to be in changing both the technical configuration

of the systems and the financial and institutional and decision making structure of the systems. And that is why what I think what is happening in the electricity context gets very interesting in the context of sustainability. Because if you do think about the opportunities for optimising the whole system along the lines that we've seen, for example, described by Amory Lovins, the opportunities for improving the infrastructure are enormous, just in technical terms. What you have to do is get over this fundamental problem that I have always had with energy efficiency. You can write down a whole long list of barriers to energy efficiency. But the bottom line barrier to energy efficiency is that we just can't be bothered. There are other things which we think about instead. So I hardly ever use the term energy efficiency now, because what I want is 'better performance'; that means better product if it's a product outfit, better working conditions, better living conditions, etc. And in my view the best way to do that is to think in system terms. To try to think of all the contributing factors that go to make a place comfortable, to make it a nice place to work, to make it a good place to produce goods and services. And so on. Rather than thinking in terms of the parts of the system and particularly the subordinate parts of the system that deliver the fuels and the electricity.

Turkenburg: I have a question. You have been describing developments that have been going on autonomously. Your expectation is: decentralisation. This requests for other networks and companies that are going to deliver services. You also describe a lot of problems and risks that might happen. In this context I already asked you a question which you didn't really answer yet. If you are going to invest in photovoltaics and wind turbines, you invest in an intermittent supply of electricity. Unless we would store part of the generated electricity for moments – let's say during nights when we need large amount of electricity but we have no wind.

Patterson: I don't know which nights you have but my nights tend to be fairly full of wind.

Turkenburg: Well, we did a lot of research on that. And on what is the cohesiveness on electricity demand and power supply from renewables. The outcome was that, with wind and solar, you're not really saving capacity, you're saving energy. So we need somehow other capacity for operation, you might say, to achieve a reliable electricity supply. This suggests that would have not only a decentralised system but – in addition – a centralised one including heavy networks.

If you think about wind energy in the Netherlands: we have a lot of problems implementing wind turbines onshore. So now we are discussing the installation of 5000 MW maybe 15,000 MW offshore. Then you need, again, networks, maybe DC, to bring the electricity onshore. But if you invest in networks then you want to use them as intensive as possible. So it is probably attractive to install a storage system combined to wind turbines: probably a compressed air storage system. That would also allow delivering baseload power. So then you have a renewable energy system, but another system than you described: not decentralised. So I'm puzzled with everything that's going on in your view: is this a complete picture of what may happen?

Patterson: Let me make this clear. I'm not talking about a lot of little systems isolated from one another. I'm talking about a much less lumpy system in which the actual generation and loads are much closer in size one to another. Now, even if you have a big windfarm, 10-15 km offshore say, the individual generators are not going to be more than maybe 5-10 MW per machine. That is two orders of magnitude smaller than a typical steam turbine set. That is what I mean by smaller scale. I don't mean household size. But you are going to have a range of generators, which are significant from perhaps one kilowatt in size for households up to biomass plants of up to 50 MW, maybe, even 100 MW if you have a good source of biomass. Certainly if you run it as a cogeneration plant. So I'm not talking about a whole lot of Mickey Mouse [small] stuff. I'm talking about a system that has a very wide diversity of different inputs to the system, from different kinds of technologies, some of which use fuel. Some of which are actually either going to be using biomass, or natural gas, or conceivably even coal with sequestered CO<sub>2</sub> and so on. And in the long term I don't even exclude nuclear power. If they can finally get their act together and get a small-scale machine that is easy to site and easy to service. The problem with nuclear plants at the moment is first and foremost that nobody wants to finance a plant that's going to take six years to build.

Mitchell: In order to have what Walt foresees, you as a company have to be in a system where you can say to the distribution network operator: I want to do this, how much will that be. And you have to

be able to do it. It has to be legal, and all the rest of it. A key problem, I think, is that there are not that many things you can do. So it's very difficult to offer these services. And I think that if you're looking at it and you're saying well: this is how it is now, this is how you think it's going to be, how is it going to happen. A key part of it is that you have to be able to do that in regulatory terms and you just can't at the moment.

Flemming: There are genuine difficulties. One is the standby power, to the extent that there is intermittence, whether you can provide people with an incentive to do that, which I think Walt himself indicated is not necessarily easy. It is also the case, again, if you have intermittence, and if they aren't all sorted out by storage nearby, that it is quite likely that there are going to be a number of links in the network on which the actual transmissions under the radial model – you know that everything that comes out of the power station has to go down the line – but if you have a back-up station that doesn't actually do very much, most of the time, and a lot of embedded generation you need as much capital investment in your distribution network but very much less actually, the number of kilowatt hour wire kilometres of transmission is likely to be very much reduced. And that means that you have to try to recover the capital charge of the network with a much higher charge per electron transmitted.

Patterson: That depends on how you price the transmission services of course. And that's a very controversial subject. I had better confess that I am finding myself toying with the very long term model which is based a lot more closely on what we now see happening to telecoms. Where you have all these long networks; where you are permanently connected to the network and you use it as you wish. And the charges for transit of a particular message or a particular bunch of electrons on the network are no longer of interest. The network is just operating all the time. And you pay a fixed charge for your permanent connection to the network, as you do now on ISDN lines, that sort of thing. Where you have all these long networks. And if you have a network which, as I say, in which you do not have these large 'cuckoos in the nest': these large 500 MW and 1000 MW steam cycle plants which can bring the whole thing down, if you do not have that problem, then this problem of standby and backup is really irrelevant. Because you have such a large interconnected network and such voltage stability through the network, section by section, that if there is a reasonable match between generation and loads on the network, then the system will be self-stabilising. You have the power electronics and the other control technologies available now to do this.

Turkenburg: I'm not convinced. Let's assume that we would install in the Netherlands 10,000 MW wind turbine capacity. Total installed capacity in the Netherlands at the moment is more or less 20,000 MW. So we are going to add 10,000 MW wind turbines feeding to our grid system. If the wind goes down, as it often happens, then you have a very unstable situation. So if you are going to wind turbines, and in addition photovoltaics systems and so on...

Patterson: You mention wind turbines and photovoltaics. You don't mention anything about all the microturbines, fuel cells, and all the other stuff, the biomass plants...

Turkenburg: I am focusing on these two renewables.

Patterson: Yes. And they will play a role. But they won't necessarily be the whole system. And in the case of photovoltaics, let me also run by you another favourite argument of mine, which I think I mentioned last night. You've seen in all the official analyses, the reports about how the next century is going to go, that you will have... No matter what happens to oil, and coal, and gas, the world usage of electricity is always going to vanish at the top right hand corner of the graph, it's just going to keep on growing indefinitely. But think about this, if you build a new office building, and you build it properly, and you build it with three sets of cable: one for telephones, one for synchronised AC, one for DC, and you have a fuel cell in the basement, and a photovoltaic façade on the building. And most of the loads in your building actually require low voltage DC. All your electronics, all your computers, a lot of your appliances, your lighting should work perfectly well on low voltage DC because it has to have ballasts anyway if it's fluorescent. If you are using your own on-site DC, generated in the fuel cell in the basement and the photovoltaic façade and modulated by the power electronics control, to run all of the services that you require in the building, you are not even going to measure how much electricity you use. You'll measure the gas coming into the fuel cell but you will not measure the electricity.

And the interesting thing is that the word 'statistics', in English, means 'information of interest to the State'. Now if you don't measure the amount of electricity you use, the State certainly isn't going to measure it. There will not be a database from which you can draw the graph vanishing out the top right hand corner. It will be a sort of 'Walkman economy'. You don't measure the amount of electricity that you generate in the Walkman that you carry around with you. You're generating electricity. But it isn't part of the electricity economy of society because you generate it on your own premises and use it without measuring it. And the same will be true for that kind of office building. Or any other kind of installation which generates and uses its own electricity.

Harley: I wanted to mention the issue of storage. You said there isn't the capability to store electricity. And I wonder whether you picked up anything on the Regensis Project...

Patterson: It's not storing electricity, it's storing chemical energy; and it's wasting a quarter to a third.

Mitchell: But don't you think it's a good thing? Don't you think it provides all sorts of opportunities that weren't there before?

Patterson: I'll wait and see whether it operates and is economic and if it does yes, of course.

Harley: The plan is to install it at Little Hartford as a black start facility.

Patterson: Good luck to them. As long as they're spending their own money on it.

Participant: What's the name of the project?

Mitchell: It's called Regensis.

Patterson: It's a reversible fuel cell the size of a small house.

Mitchell: No. It can be just a few watts. And one of the problems of the conventional electricity system is that if the whole system goes down it's very difficult to get it up and running again without coal power plants, which have a momentum behind them. But this little thing will allow just about any power plant, renewable or otherwise, intermittent or otherwise, to have black start capability. So it does really alter the ability of different technologies to provide security to the system. So it is fundamentally different. Now I'm not a technical person and I don't totally understand these things but it does seem to me that of all the hundreds of things that have come about in a long time it does seem to be...

Patterson: Well if it does do all the things they say it will do and it turns out to be economic then good. Good luck to them. I can only say that I mentioned this to Bob Williams last week and he jumped all over it. He said it was a design that would never cut it as a fuel cell; that the design was simply not good enough: I don't know. I will wait and see if the company that produced it can get it running properly. Their track record so far is not that great.

Turkenburg: I'd like to stop the session here and thank Walt for his presentation.

## 8 The Way Forward

In this, the final session of the workshop, the main findings were summarised and a discussion took place on follow up. Professor Turkenburg chaired this session.

Turkenburg: We intend to make a publication based on this workshop. A summary reflecting what has been presented and what has been discussed. I would like to focus on some specific issues that, in the European context, might become an agenda for further discussions. I have asked John Flemming to summarise some of these points for us.

Flemming: Let me start by making some preliminary remarks. Then I have four or five points. I shall not speak at great length. The preliminary remark is that there has been a lot of reference made to a level playing field and fair competition and so on, which I believe is at least potentially and probably an actually misleading analogy and metaphor. The important thing from an economic point of view is that competition is conducive to efficiency. And we need obviously a definition of efficiency – which I shan't make, although I could, if pressed. Unfair competition or undesirable competition is something which looks like being competitive but which is not conducive to efficiency. And some of the things that are done within the EU in the name of competition and a level playing field I believe fall into the category of things which are obstructive of the achievement of efficiency and not conducive to it.

Participant: What do you mean by efficiency in this case?

Flemming: Typically it means producing, say, electricity at the minimum resource cost. And I'm perfectly happy for that to take in as many environmental things into the concept of the resources that are being used up as you like. It isn't an anti-environmental proposition. But it does, for instance, mean that if people in one part of Europe are more tolerant of a certain type of local pollution then people in another part of Europe then one should expect the economic activities that give rise to that pollutant as a by-product to be concentrated in the area where those people live. And that is not an unnatural and improper advantage. That is efficiency. Because the cost minimisation that competition should deliver would be not only that you use less oil (or whatever it is) but also that you make people, as a by-product, less unhappy than they would otherwise have been. And if the same activity located anywhere else in Europe would make its neighbours more unhappy than this particular tolerant community then that would be a loss of efficiency. The danger with the fair competition and level playing field argument is that it makes people think – perhaps to again extend or to mix the metaphor a bit – in terms of handicap races, in which if there is one horse that would win the race too often you have to load the jockey with additional weights. That is one point.

Another point which I'd like to make. Jip Lenstra referred to the exposed sector<sup>2</sup>. As I understand it the way in which the Kyoto objectives are defined is that if you drive those industries away you do indeed achieve your targets, and there may be some things that you lose: some jobs, and you get some unhappy shareholders or whatever, and that's why you may not do it. But clearly it is almost certain that they would go not only to Spain but also to China and places where they would be quite likely to use inferior technologies as well as taking advantage of laxer regulatory regimes, and non-parties to the Kyoto agreement. It is highly likely that the total emissions of greenhouse gases will actually go up. So it would be a very perverse thing to do. And one of the questions is whether the European stance in the international agreement has recognised that as fully as I believe they should. And my understanding is that the US has been a bit more realistic or hard headed in this respect than the Europeans in saying that they will not go along with some of these things unless the coverage is more nearly global. And that the Europeans have set a lower standard at the level at which they would swing into operation despite the risk of perverse side effects.

Then I have five specific issues in which people seem to have suggested that EU Commission arrangements, regulations and directives are actually an obstacle to the achievement of an environmen-

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<sup>2</sup> 'Exposed sector' refers to companies exposed to foreign competition.

tally sustainable energy policy. It seems to me that if a group such as this or the consultative bodies that we represent were to make a common front in this connection then we might hope to have some impact.

The first of those is again something that emerged from Jip Lenstra's presentation. My understanding is that the concept of CO<sub>2</sub> being a pollutant does feature in some of the EU legislation. And it would clearly be desirable in the context of our present discussion if CO<sub>2</sub> was recognised within the EU framework as being a pollutant. Jip Lenstra said it is in the Netherlands but it is not, as it were, in Brussels. And that is something for which we might press. Therefore within all the Integrated Pollution Prevention and Control (IPPC) regulations you would actually build in energy efficiency, fuel substitution and even CO<sub>2</sub> sequestration. That would have to come into the IPPC and not have to be done separately through other policies.

The rest is simply a list of things which people have referred to.

First, the state aid regime was identified as being a major obstacle. It should be possible to differentiate between 'good' and 'bad' state aid.

Further, getting efficiency into the arrangements for green supplies across frontiers. If we are to have both a sustainable energy policy and a single market in Europe this may be difficult to reconcile with the national devolution of the EU's Kyoto commitments. There may be a problem in trying to have an integrated market because the implication of national quotas is that the shadow prices associated with those quotas are liable to differ in different countries. There is a question of whether you should stick to the original quotas or whether you make some adjustment in the light of the differential prices.

Participant: This is not completely clear to me.

Flemming: Well, there are two things I had in mind. One goes back a little way to a case I referred to. I believe it was a ruling of the European Court that if a country has a policy of paying extra for clean energy then all energy from outside the jurisdiction is to be deemed to be clean because to do otherwise would be to penalise international trade and that is not allowed under the EU directive. Now that is clearly perverse. But the other point that I was making is that the way that the Kyoto agreement was done there was a sharing out of the burden. Now, if you were to have tradable permits, which were tradable only within each nation state, and you had quotas then it is almost certain that they would command different prices in different states. Efficiency requires that the trade off between energy and the environment be the same everywhere and that in turn requires that the price of a unit of CO<sub>2</sub> emitted should be the same throughout the EU (and ideally throughout the world). So there is a question about what you do given that the quota allocation (and since we're meant to be having an integrated market it's hard to see how you have these differential prices – so there's a problem there which I don't think has been sorted out).

Then there's the question that was raised about Euro-labelling and whether there was adequate monitoring of compliance. And on this I'm somewhat of two minds. I'm worried about issues related to the third world. Forest Stewardship. There is a concern that there might be heavy discrimination against the third world. They might be the people who should be exporting some of these things. But they are quite incapable of maintaining, and themselves monitoring. So one really is underlining the divide between North and South. But that may be necessary in that area and there is no excuse for the situation that Jip Lenstra was describing (on how easy it is to get an A-certificate for your washing machine).

Finally, on my list, Catherine Mitchell mentioned that there are EU directives which effectively discourage competitive outsourcing. So some of the benefits of competition may not necessarily come from changing the nature of the ownership of traditional large scale electricity undertakings nor even from changing the market for electricity but for changing the market for, for example, cleaners in the headquarters in electricity supply companies, or the people who do the maintenance contracts. The tradition is that the nationalised monopolies were vertically integrated and largely self contained and did everything themselves. And if you move away from that and have competition for a large number of

their functions they can remain responsible, they can retain their responsibility for policy and, if that's what you want, you can even maintain monopoly. But you can still get many of the efficiency advantages of competition from the way that they organise competition for the constituent activities that go to make up these large vertically organised entities. And I think you were suggesting that there were some things in EU regulation, which actually obstructed that.

Mitchell: What I was saying was that if you look at both the gas and electricity liberalisation regulation it doesn't really move down into distribution companies. The way to full competition and to allow all these things that Walt has talked about to happen is to allow choices to happen. And in order for those choices to happen you have to have a kind of regulation that makes distribution network operators market facilitators. So that they buy and choose the cheapest option. And the cheapest option is for them to become a network manager and to outsource all these things. So, in a sense, yes I am saying that. But I'm saying that this is part of this whole process that competition just isn't being pushed.

Lewis: One other point, which worries me somewhat, is the Kyoto obligation at EU level and the sharing out among member states. I understand that the legal basis for sharing out among EU member states is rather uncertain. And therefore the obligations are perhaps are not as firm as they should be for member states to achieve their reductions.

Participant: That will be solved upon ratification of the Kyoto Protocol.

Lewis: But I think that the EU has some problems concerning the legal basis for ratification. I think there is some uncertainty there that needs to be sorted out.

Turkenburg: If COP6 is not a success then probably Kyoto will not be a success anymore either.

Lewis: Well if the Kyoto agreement would collapse then we would be into a new situation but this would arise under any further international agreement as well. There is no real basis for monitoring or indeed for applying sanctions against member states that do not actually meet their obligations.

Turkenburg: Any other points?

Harley: I'm thinking about the origins of the meeting. I wonder if this group will progress in the future if it would be useful to have some sort of debate on the science upon which the policy mechanisms are based.

Participant: Is there any disagreement within this group on the science?

Participant: Which bits of the science did you have in mind?

Harley: I'm thinking that if policy measures are going to be given to the EU or to the CSD then it would be useful to have some science underpinning of the policy measures that would be given. Given that these messages would be coming from a consortium of European environmental organisations: what are the environmental issues that we as a group are tackling? What do we perceive the long-term impacts of climate change to be on our respective businesses (on nature conservation, on wildlife conservation, on the human environment) and therefore why are we espousing these sorts of policy tools to deal with them. I just wonder if we need that kind of background setting against which to set out a way forward.

Turkenburg: More than what the UN Intergovernmental Panel on Climate Change is already delivering?

Harley: I'm not sure that their environmental messages are that focussed. There are big environmental messages about climate change being a big issue that needs to be tackled; there are ways of doing that through mitigation and adaptation. But the specific detail of how it will affect individual countries and parts of individual countries within the European Union isn't clear and it's work that is ongoing. My own organisation is engaged in some fairly fundamental baseline research into climate change im-

pacts on wildlife and natural processes and I would imagine that other governmental advisory organisations in Europe are engaged in similar sorts of research that would underpin the policy messages that we would want to give to the Commission or to a UN body.

Turkenburg: That is a rather different focus from the discussion we've had so far.

Flemming: It is certainly true that before addressing the policy issues and instruments the Royal Commission felt it appropriate to summarise and didn't do anything original. Depending on what we would want to do we may want to preface any statement by some reference to the IPCC or whatever. But I'm not sure that it's disputed either among national groups or between us and any Brussels agency.

Lewis: There is one implication of what Mike [Harley] was saying which might be of policy significance for the EU and that is that there may be implications for the Habitats and Species Directive. If the impact on wildlife or on coastlines are going to be very significant. But that is a rather different focus. It may be a point which is worth pursuing but whether it can be successfully combined with the other issues we were looking at in the same group I'm not sure.

Harley: I think that that would be tackled through a different mechanism, which is already in train, certainly from the UK's perspective. It is a personal concern of mine that in delivering policy messages that a sound scientific justification for those messages is very important.

Turkenburg: Are there any other suggestions or remarks on the outcome of this workshop and on suggestions for the future?

Participant: I would like more exchange of experience on the success and the deficiency of the process of liberalisation within the different countries. Perhaps each country could just give a short introduction of the national system and then describe experiences and what is good and what is bad with the system and then we could compare and have a discussion on proposals. Then we could say, for example, in the UK this is pretty good, and in Germany this is problematic. Then we could look at the plans in the different systems and compare. This would be very interesting for all the national councils and also for the EU too. Just to make a proposal of how a liberalised market could be.

Flemming: I would be unhappy about that unless it were restricted in some clear way to the environmental aspects.

Participant: Yes. Just restricted to the environment. Not the whole liberalisation question.

Participant: Would that be an idea for a next meeting?

Participant: Everyone has different experiences. There could be quite a precise discussion on that.

Lewis: I wonder whether that might be extended. I'm not sure how far people have had it in mind under other headings but the growth of emissions trading schemes and the environmental impact of those is something that is developing quite rapidly and as well as looking at liberalisation of energy markets we might also perhaps keep in touch and exchange information and analysis about that.

Flemming: I'm always a little worried when people suggest that emissions trading is somehow an alternative. It has to be a derivative from something else. There are a number of companies that have set themselves or negotiated some undertaking to restrict their emissions and then if they're multi-facility they have an internal trading system. I'm not sure how much experience there is outside that.

Participant: I heard that seven major companies had formed a coalition and inside this coalition emission trading will happen.

Flemming: That is entirely logical because if each of them imposes their own internal regime and the price differs, as it probably will, then instead of adding together their self imposed quota's, they could add them together, subtract 5%, trade with one another, and everybody can benefit.

Flipphi: Jip Lenstra also mentioned that we're starting in the Netherlands with a system to trade nitrogen oxide. So there is some experience coming along in the environmental field.

Turkenburg: Are there any other ideas?

Participant: Another question could be: In almost every European country you have a phasing out of nuclear power plants. In several countries nuclear power is used in a significant amount. We should face the question how we should replace this energy production without getting into trouble with climate change. Certainly in Germany it is 13% and in UK it's 5%. How much is it in Europe as a whole?

Participant: I believe it's around 30%.

Participant: But we can't replace 30% by renewable energy. It's just impossible. And the phasing out will take place within the next 15 years. So we will have trouble meeting the climate goals. Perhaps we should have a short discussion on this question.

Turkenburg: To discuss whether, or under what conditions, nuclear could be considered a sustainable energy source?

Participant: But in the context of a liberalised market they become too expensive.

Flemming: This is right. The disappearance of nuclear in the UK is not in response to political action as in Sweden or in Germany. The government has not said 'we won't build any'. But the cost situation that has emerged after liberalisation is one in which they are not seen as being viable.

Turkenburg: Could one imagine new nuclear technology that could handle that issue of cost?

Flemming: One could, but what is much more likely, and this is my knee jerk reaction, if you have a carbon tax then that would transform the relative position of nuclear power.

Mitchell: I think that there would be a huge outcry against nuclear. I don't think that just because we now have liberalisation that we should necessarily think that in ten years time the government won't be prepared to intervene to support nuclear power in order to have a carbon free form of generation. I think that every form of energy should be treated in the same way. But I don't think that is the case with nuclear.

Flemming: That is also Jip Lenstra's view and the Royal Commission's view, I should say, is that there should indeed be a ban until there is a solution to the waste problem.

Turkenburg: I would like to place energy in the context of sustainable development and not only in the context of CO<sub>2</sub> emissions.

Participant: It seems to me that we've covered a wide range of topics. And there are other issues (such as to do with transport) which we haven't touched on. I'm just trying to think what might be the criteria by which we might decide to focus this group down. Is there a parallel process at the European level that we might try to hit? And if so does it relate primarily to liberalisation or are there other issues.

Participant: Most of the topics we've mentioned had quite a close relationship to liberalisation.

Turkenburg: I would say that the main question should be how do we achieve a sustainable energy system. Liberalisation is taking place already. The question is what kind of policies are needed at the national and at the European level, making use of the potential of liberalisation. Should we be discussing on frameworks for dealing with instruments and concrete measures? Some things might be helpful

in some countries but not in other countries. If you need consensus then you might wait for years, as we've seen with the ecotax. These questions are in my opinion important.

Concerning the next meeting. Will there be a next meeting? There seems to be enough material for another meeting. I would be in favour of organising one on more or less the same subject. Maybe more focussed on what is going on in the different countries. The question is who is able and willing to organise that and in more general terms what does that mean for the institutionalisation of this working group. Who will be the chairman in future? Or should that be organised meeting by meeting? I would like to hear some opinion from the UK especially on this subject.

Flemming: We would be willing to host and organise a further meeting.

Participant: The main topic could be sustainable energy. At the next meeting we could just choose one or two topics. And then at the next meeting another topic.

Flemming: I would hope that we would, if anything, sharpen the focus. In fact the principle focus of this meeting was sustainable energy and liberalisation. I would be reluctant to see it widened from that.

Flipphi: The five points that John [Flemming] made seem to be good points on which to focus our work. Let's elaborate on those, I'd say.

Turkenburg: Perhaps we could leave it in your hands to refine the focus.

Lewis: And still with a strong Dutch input, we would hope.

Turkenburg: Do we need a chair for this working group?

Lewis: I think we should keep it fairly informal for the moment.

Lewis: I would like to express thanks to the VROM-council for organising this meeting, producing such a useful exchange of views covering such a wide area – in some respects it is a very timely exchange drawing on developments like the World Energy Assessment – and for arranging for the working group to be so well fed and indeed housed!

**GENERAL APPLAUSE!**

## Annex I – List of Participants

<b>Wim Turkenburg</b>	Chair / Dutch Council on Housing, Spatial Planning and the Environment (VROM-Raad)
<b>Marc Depoortere</b>	Federal Council for Environment and Sustainable Development (FRDO-CFDD), Belgium
<b>Alain Maraisse</b>	Walloon Council for Environment and Sustainable Development (CWEDD), Belgium
<b>Tomas Velghe</b>	Environment and Nature Council of Flanders (Mina-Raad), Belgium
<b>Pirkko Selin</b>	Finnish Council for Natural Resources (FCNR)
<b>Michael Schmalholz</b>	German Council of Environmental Advisors (SRU)
<b>Ronald Flipphi</b>	Dutch Council on Housing, Spatial Planning and the Environment (VROM-Raad)
<b>Mike Harley</b>	English Nature, UK
<b>John Flemming</b>	Royal Commission on Environmental Pollution (RCEP), UK
<b>David Lewis</b>	Royal Commission on Environmental Pollution (RCEP), UK
<b>Ingeborg Niestroy</b>	Focal Point of EEAC
<b>Kornelis Blok</b>	Reviewer / Utrecht University & Ecofys
<b>Jip Lenstra</b>	Reviewer / Netherlands' Ministry on Housing, Spatial Planning and the Environment
<b>Cathrine Mitchell</b>	Reviewer / Warwick Business School, UK
<b>Walt Patterson</b>	Reviewer / Royal Institute of International Affairs, UK



## Annex II – Sources of Information

### Further Reading

American Public Power Association, Electricity Utility Basics, Washington, D.C., 1999

European Commission, Report of the European Climate Change Program, June 2001. Available from <http://europa.eu.int/comm/environment/climat/eccp.htm>

Greenpeace International, The Liberalisation of Europe's Electricity Markets – is the environment paying the price for cheap power?, Amsterdam, 2000

Heinrich Böll Foundation, Electricity Restructuring and the Environment – a US German Dialogue, Washington, D.C., 2000

International Energy Agency, Electricity Market Reform, an IEA handbook, 1999

Matthes, F. and Timpe, C., Sustainability and the Future of European Electricity Policy, Heinrich Böll Foundation, 2000

Patterson, W., Transforming Electricity, Earthscan, 1999

Pew Center on Global Climate Change, The European Union and Global Climate Change, June 2000

SAVE Programme, Completing the Market for Least-Cost Energy Services: strengthening energy efficiency in the changing European Electricity and Gas Markets, September 2000

UK Department of Trade and Industry, Social, Environmental and Security of Supply Policies in a Competitive Energy Market, May 2001

Worldwide Fund for Nature (WWF) Background Paper, Electricity Liberalisation – a disaster for clean energy, March 2000

### Relevant information on the Internet

There is a vast amount of information in the area of climate change, sustainable energy, and energy sector liberalisation on the Internet. Below is a sample of relevant sites.

**Climate Network Europe:** <http://www.climnet.org>

**Commission on Sustainable Development:** <http://www.un.org/esa/sustdev/csd.htm>

**Eurelectric: The Union of the Electricity Industry:** <http://www.eurelectric.org/Public/content/>

**European Commission Environment Directorate:**  
[http://europa.eu.int/comm/dgs/environment/index\\_en.htm](http://europa.eu.int/comm/dgs/environment/index_en.htm)

**European Commission Transport and Energy Directorate:**  
[http://europa.eu.int/comm/dgs/energy\\_transport/index\\_en.html](http://europa.eu.int/comm/dgs/energy_transport/index_en.html)

**European Environment Advisory Councils:** <http://www.eeac-network.org/>

**European Integrated Pollution Prevention and Control Bureau:** <http://eippcb.jrc.es/>

**Financial Times Energy:** <http://www.ftenergy.com>

**Framework Convention on Climate Change Homepage:** <http://www.unfccc.de/>

**International Energy Agency Homepage:** <http://www.iea.org/>

**The European Pollutant Emission Register:** <http://europa.eu.int/comm/environment/ipcc/eper.htm>

**The European Union Network for the Implementation and Enforcement of Environmental Law (IMPEL):** <http://europa.eu.int/comm/environment/impel/index.htm>

**World Energy Assessment:** <http://www.undp.org/seed/eap/activities/wea/>

**World Energy Council:** <http://www.worldenergy.org/wec-geis/>

## Annex III – Background papers

This annex contains the following background papers:

Turkenburg, W.C., *World Energy Assessment: Energy and the Challenge of Sustainability – Key Messages*, UNDP, New York / Utrecht University, Utrecht (2000).

Blok, K. and D. Phylipsen, *Carbon Dioxide Emission reduction in the European Union: Options and policies*, Ecofys, Utrecht (2000).

Mitchell, C., *Removing Barriers to Sustainable Energy form Regulation of Liberalised Energy Markets – the UK as a case study*, Centre for Management Under Regulation, Warwick Business School, University of Warwick, Coventry (2000).

Patterson, W., *Energy 21: Making the World Work*, Institute of Energy Melchett Medal Lecture, London Planetarium (2000).



*World Energy Assessment: Energy and the Challenge of Sustainability*  
*Key Messages*

Professor Wim C. Turkenburg  
Dept. of Science Technology and Society, Utrecht University  
Padualaan 14, 3584 CH Utrecht, The Netherlands,  
w.c.turkenburg@chem.uu.nl

*Energy, when produced and used wisely, can play a pivotal role improving the lives of people today and simultaneously protecting the prospects of future generations. This balance is embodied in the idea of 'sustainable development', a goal firmly committed to by the United Nations and its Member States. Although the energy technologies and resources are available with which to achieve sustainable development, this goal will go unrealized unless fundamental changes are made in the production, distribution and use of energy. Specific changes needed are: higher levels of energy efficiency, a greater contribution of modern renewables to the fuel mix, accelerated development and deployment of advanced technologies, and enabling policy frameworks to support such changes. .*

**Social equity issues and environmental impacts are the two most critical energy-linked threats to sustainability**

Secure supplies of affordable energy services are a pre-requisite to, and an essential ingredient of, economic growth and human development. However, critical problems – the most serious being equity issues and environmental impacts – are linked to current patterns of energy production, distribution and use.

- ***Two billion people struggle to meet their basic needs without access to affordable and adequate energy services.*** A third of the world's people lack access to electricity with which to satisfy basic household needs and support livelihoods. The world's oldest energy technology, the cooking fire, remains the most widespread fuel-using technology today. A reliance on traditional fuels and technologies, because of associated time demands and localized air pollution, is a hardship that keeps a large fraction of humanity – particularly women – locked into cycles of poverty, ill-health and deprivation.
- ***Energy-linked emissions pollute and degrade the environment at the local, regional and global levels.*** Compromised health, resulting in some 3 million premature deaths per year, equivalent to 5-6 percent of global mortality, dominates local impacts associated with energy use. Energy activities account for about 85 percent of anthropogenic emissions of sulphur dioxide, a major contributor to local air pollution as well as regional acidification. About 78 percent of human-caused carbon dioxide emissions are linked to fuel combustion. These emissions are a major factor in global warming, which represents an unprecedented threat to humanity.

## Our reliance on fossil fuels

**Fossil fuels are now and will continue to be an important part of the overall fuel mix; the challenge is to use them in cleaner, safer and more efficient ways.** *The fossil resource base is at least 600 times current fossil fuel use -- oil and gas reserves are expected to last well into this century, and coal will be abundant for centuries to come. Thus, fuel scarcity will not be a major driver of change in energy systems. Even the most ecologically-driven of the scenarios considered in the report shows petroleum and coal products supplying more than half of energy demand in the year 2050. Unless the substantial environmental impacts linked to fossil fuels are addressed soon, global warming will accelerate and local and regional pollution will continue. Emerging technologies show great promise for utilizing fossil fuels in cleaner and safer ways, but policy support will be needed to encourage their rapid development and deployment.*

## Opportunities afforded by more efficient use of energy

**The possibilities offered by more efficient use of energy are tremendous, since overall global energy efficiency is estimated at 37 percent maximum.** In other words, in conversion processes from raw material to useful energy, at least 63 percent of energy is dissipated, mostly as wasted heat. Many energy efficiency gains have already been realized, especially in centralized processes, which have helped loosen the historically tight link between economic development and energy consumption. In this century, the average conversion efficiency of power stations rose from around 3 percent to more than 50 percent for today's combined-cycle gas-fired power stations. The energy inputs to Western European industry have remained relatively constant for the past 20 years, while output grew by 2 percent per year. A large unrealized potential for greater energy efficiency exists at the point of end-use, for example, through more efficient vehicles, appliances, and buildings. The report finds that gains in energy efficiency of 25-35 percent are cost-effectively achievable in industrialized countries over the next 20 years, with higher potentials (30-45 percent) achievable in developing and transitional economies. In both cases, the higher percentages assume the introduction of effective policy measures to encourage energy conservation.

## Renewable energy

**Although renewable energy flows to Earth are three orders of magnitude higher than total global energy consumption, harnessing these flows to useful forms of energy is complicated.** As a result, 'new' renewables (which include modern forms of biomass, as well as geothermal energy, small hydropower, wind, solar, and marine energy) contribute about 2 percent of global energy, of which nearly 80% comes from biomass. The total contribution from renewables (including traditional biomass and large hydro power) is at present about 14% of global energy supply. While the installed solar photovoltaics and wind energy capacities are growing at about 30 percent per year, it may be decades before they represent a large contribution to the energy mix. In the second half of the 21<sup>st</sup> century the total contribution of renewables may be 20 – 50%. Future prospects are dependent on an enabling policy environment. Today the ability of renewables

to compete in the marketplace is hampered by pervasive (and often perverse) subsidies to fossil energy. Factoring in some of the environmental and social costs borne by society at large into the price of energy would be a huge stimulus for the renewables market. More widespread use of renewables, in turn, would mean expanded energy services, with relatively low environmental impacts.

### **Advanced technologies**

***Increased development, deployment and diffusion of new energy technologies is critical in any scenario of success.*** The direction and rate of technological change can have the same magnitude of influence on future emissions as population growth, economic development and energy consumption taken together. However, current investments in research and development in both the public and private sectors are inadequate to meet the challenges ahead. The energy innovation chain, from research and development through demonstration projects, deployment and diffusion, is sometimes a decades-long process, and progress can be stalled at any point along way. Continued technological advances are needed in all aspects of the energy system, especially in renewables, energy-efficiency, and fossil fuel utilization. Advanced nuclear energy technologies could play a role in de-carbonising the world energy system in the next 50 years, but only if public concerns about reactor safety, proliferation, and waste disposal can be satisfied. Promising advanced fossil fuel technologies include superclean 'syngas' derived from coal or natural gas for the near term, fuel cells over the medium-term, and large-scale recapturing and storage of carbon dioxide over the longer term. In some respects, developing countries with little installed capacity, are well-positioned to become leaders in introducing innovative technologies, leapfrogging up the technology curve.

### **Finding ways to widen access to adequate energy services**

***Targeted strategies are needed to address the needs of the two billion people with inadequate access to energy services – most of whom live in rural areas of developing countries.*** The lives and productivity of this large group could be enormously improved over the short term with relatively small inputs of energy. For instance, the cooking needs of those not served by modern fuels correspond to about 1 percent of global commercial energy consumption, or 3 percent of global oil consumption. Where extension of electricity grids is not economically feasible, decentralized solutions, including diesel and biomass systems, wind and solar power, are viable options that also offer opportunities for local control. Innovative approaches and financing mechanisms, tailored to local conditions, will be needed to bring modern forms of energy to rural areas, just as rural electrification in many now-industrialized countries was accomplished with government support in order to achieve social and economic objectives.

## **Investing in sustainable energy**

***There is no need to choose between economic growth and environmental protection: investing in substantially cleaner, safer forms of energy now will avoid higher costs later.***

Investment in sustainable energy is not occurring rapidly enough, especially in the developing countries, where demand for energy is most acute. Official development assistance fell by about 20 percent (in real terms) during the 1990s, and represents a shrinking fraction of net resource flows. Foreign direct investment has continued to grow worldwide, but tends not to reach the least developed countries. Building institutional and technical capacity in these countries are prerequisites for improving capital flows, including investments in energy. Clearly the ingenuity and dynamism of the private sector will be critical to meeting the challenges ahead. However, market forces alone will not meet the needs of the most vulnerable groups, protect the environment and ensure energy security. Far-sighted policies are needed to address these issues.

## **Policy matters**

***The economic, social and environmental goals of sustainable development as expressed in the United Nations summits of the 1990s cannot be achieved unless energy is produced, distributed and utilized in fundamentally different ways in the future.*** Energy scenarios suggest that sustainable energy futures that can support a prosperous, equitable and environmentally sound world are indeed possible, but that ambitious policy measures, initiated in the near term, will be required to achieve them. Complementary efforts at the local, national, regional and international levels are called for. Some promising policy options include:

- Removal of subsidies to conventional fuels (except when there are no other viable approaches to bring modern energy to unserved populations)
- Rational pricing approaches that reflect social and environmental costs associated with various forms of energy use
- Complementing market approaches with regulatory measures to protect public benefits
- Encouraging technological advance at every stage of the energy innovation chain
- Supporting technological leapfrogging in developing countries

## **The urgency of our situation**

**Unless wise decisions are made in the next few decades, many opportunities to change our energy course may be lost.** Because energy systems and infrastructure are capital intensive and long-lived, and much capacity will be installed in the coming decades, a limited window of opportunity is now open in which to get energy right. Thus choices about the world's future energy systems are relatively wide open now, but by 2020 many investment decisions will have been made that will affect the world for years to come. The current window of opportunity is particularly significant where much infrastructure has yet to be installed, offering the possibility of a rapid introduction of new, environmentally sound technologies. Once infrastructure is in place, a

phase of mostly replacement investments begins. Changes can be made in this phase, but they take much longer to affect average system performance. Thus, if sound decisions are not made during the next few decades, we will be locked into those choices, and certain development opportunities might not be achievable later.

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See also on the web: <http://www.undp.org/seed/eap/activities/wea>

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Professor Wim C. Turkenburg is:

- Member of the Editorial Board of the World Energy Assessment;
- Convening Lead Author of the chapter on 'Renewable Energy Technologies' of the World Energy Assessment;
- Vice-Chairman of the UN Committee on Energy and Natural Resources for Development (UN-CENRD);
- Chairman of the Sub-committee on Energy of the UN-CENRD;
- Scientific Director of the Utrecht Center for Energy Research (Utrecht, the Netherlands).



# Carbon Dioxide Emission Reduction in the European Union: Options and Policies

Kornelis Blok<sup>3</sup> and Dian Phylipsen  
Ecofys  
P.O. Box 8408  
3503 RK Utrecht  
The Netherlands

Project M70002  
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## Summary and conclusions

Carbon dioxide emissions make up nearly 80% of greenhouse gas emissions in the European Union. Emissions are expected to rise in a business-as-usual development. In order to reach the commitments agreed upon in Kyoto it is necessary to implement policies and measures aiming to reduce these emissions. In this paper an overview is given of the potential of such policies and measures and the present stage of their development.

The total emission reduction potential of policies and measures available in the EU is more than sufficient to reach the commitments.

Much attention is paid to the development and promotion of renewable energy sources, both at the national and Community level. However, the effort is not yet enough to reach the ambitious renewable energy targets. Other areas where substantial Community efforts exist are the energy efficiency of passenger cars and electric appliances. An agreement between the European Commission and the associations of car manufacturers will probably lead to emission limitations in passenger transport. In areas like energy efficiency in heavy industry and combined generation of heat and power some countries have implemented successful policies. However, progress on a EU wide level is limited.

Overall, the degree of policy implementation is not yet sufficient to reach the commitments set out in the Kyoto Protocol.

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<sup>3</sup> Also with: Dept. of Science, Technology and Society, Utrecht University, Padualaan 14, NL-3584 CH Utrecht

## 1. Introduction

In the Kyoto-Protocol the European Union Member States have jointly committed themselves to a reduction of their greenhouse gas<sup>4</sup> emissions by 8% in the year 2010 compared to those in 1990.

Carbon dioxide emissions make up nearly 80% of total greenhouse gas emissions in the European Union. In a business-as-usual development, it is expected that carbon dioxide emissions will grow, maybe with 7 to 10% in the period 1990-2010. Emissions of non-CO<sub>2</sub> greenhouse gases are expected to decline, by approx. 10%. Hence, total greenhouse gas emissions are expected to rise by 3-5%. The "gap" between the business-as-usual development and the Kyoto target is about 500 Mtonnes of CO<sub>2</sub>-equivalent.

It is clear that limitation or reduction of emissions of CO<sub>2</sub> should play an important role in reducing the total amount of greenhouse gas emissions.

This paper intends to give an overview of the options that are available for greenhouse gas emission reduction and the policies that can be applied to attain such emission reductions, with special emphasis on so-called common and co-ordinated policies and measures.

In the European Union discussions much value is attached to these common and co-ordinated policies and measures (CCPMs). CCPMs are policies and measures that are implemented at the EU level, in contrast to policies and measures that are implemented at the national level. Roughly speaking, one could say that common policies are policies that are the same for all Member States (e.g. detailed EU directives, negotiated agreements between the European Commission and international industry associations). Co-ordinated policies are those policies that are primarily implemented on the national level, but with a substantial level of harmonisation between Member States taking place at the EU level. In March 1997 the EU Environment Council identified twelve areas for which common and co-ordinated policies should be adopted [March Council, 1997].

This paper first of all gives an overview of estimated policy potentials for greenhouse gas emission reduction in the various areas. Next, the focus will be on important CO<sub>2</sub> emission reduction options/policies: renewable energy programs, combined heat and power generation (CHP), energy efficiency improvement of electrical appliances, fuel efficiency improvement of passenger cars, energy efficiency improvement in the heavy industry and fuel taxation.

In this paper, the scope is limited to measures taken within the EU. Under the Kyoto-Protocol it is allowed to realise (part of) the commitments in other countries through emission trading, joint implementation and the Clean Development Mechanism.

Furthermore, we limit ourselves to the most important greenhouse gas, CO<sub>2</sub>. Emission reduction options for the other gases generally are relatively larger.

Finally, we do not pay attention to policies with respect to the thermal integrity of buildings as this has predominantly been an area for national policies.

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<sup>4</sup> Here and further on in this paper with greenhouse gases only those gases that are subject to the Kyoto Protocol are meant (carbon dioxide, methane, nitrous oxide, HFCs, PFCs and SF<sub>6</sub>).

## 2. Emission reduction options

Table 1 provides an overview of the results of the following studies regarding greenhouse gas emission reduction potentials:

- A study released by WWF, 'Policies and measures to reduce CO<sub>2</sub> emissions by efficiency and renewables' [Blok et al., 1996];
- 'The Expert Group's work on EU Common and Co-ordinated Policies and Measures' [Phylipsen et al., 1997];
- The European Commission Staff Working Paper 'Climate change - analysis of proposed EU emission reduction objectives for Kyoto' [EC, 1997].
- A Communication from the European Commission "Preparing for Implementation of the Kyoto-Protocol" [EC, 1999].

All studies present the possible effect of policies and measures, rather than a technical or economic potential. The emission reduction in each of these scenarios is related to a reference scenario with little or no intervention directed at the reduction of CO<sub>2</sub> emissions.

The study for WWF concludes that a package of policies and measures for the European Union could lead to a reduction of CO<sub>2</sub> emissions of 14% in the year 2005 compared to 1990 (in a business-as-usual development these emissions would increase by 7%).

The work of the so-called Expert Group on Climate<sup>5</sup> showed that, if implemented ambitiously, common and co-ordinated policies and measures could be sufficient to achieve a 8 to 15% reduction of carbon dioxide emissions in 2010, compared to 1990 [Blok and Phylipsen, 1997]. This work formed the basis for the negotiation position of the European Union towards Kyoto: a 15% reduction of greenhouse gas emissions for all Annex-I countries.

The European Commission came to similar conclusion in 1997 [EC, 1997]. The 1999 Communication came to the Conclusion that achievement of the Kyoto target is feasible.

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<sup>5</sup> A sub-group to the so-called Ad Hoc Group on Climate, the negotiation forum on climate policy in the European Union.

**Table 1.** Overview of policies and measures and their expected emission reduction potential in 2005 according to the WWF study [Blok et al., 1996] and for 2010 according to the Expert Group report [Phylipsen et al., 1997], the European Commission Staff Working Paper [EC, 1997] and the Communication “Preparing for Implementation of the Kyoto-Protocol” [EC, 1999]. All emission reductions indicate what can be reached in comparison to a reference level and are expressed in Mtonnes CO<sub>2</sub>-eq.

Total greenhouse gas emissions (six-gas basket) in the EU in 1990 were 4218 Mtonnes<sup>6</sup> (of which 3324 Mtonnes is carbon dioxide)<sup>7</sup>.

The gap between the reference development and the Kyoto target amounts to approx. 500 Mtonnes per annum in the first budget period (2008-2012).

	WWF study (2005)	Expert Group (2010)	European Commission 1997 (2010)	European Commission 1999 (2010)
Renewable energy	90	up to 200	200	110
Combined generation of heat and power	46	110 - 220	100	57
Increased effic. of power plants	-	n.a.	50	115
Fuel switching	5 <sup>8</sup>	-	50	
Energy efficiency electric appliances	95	55 - 90	100	140
Energy efficiency buildings (heat)	117			
Energy efficiency passenger cars	41	80 - 120	100	150
Other measures in transportation	55	up to 30	80 <sup>9</sup>	
Energy efficiency heavy industry	107	70 - 130	100 <sup>10</sup>	50
Energy efficiency in light industry	57		20	
Material efficiency improvement / changes in consumption patterns	45	n.a.	n.a.	
Energy taxation	-	40	50 <sup>11</sup>	
Total	653	355-830	800	622

n.a. = not assessed.

<sup>6</sup> This includes 1990 emissions for CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O, and 1995 emissions for the fluorinated gases.

<sup>7</sup> 4163 Mt CO<sub>2</sub>-eq. for CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O [UNFCCC, 2000], 55 Mt CO<sub>2</sub>-eq. for fluorinated gases from [Phylipsen et al., 1997]

<sup>8</sup> Fuel switch in households. Fuel switching in electricity production is not included in the reduction package as already a substantial amount of fuel switching in this sector is included in the reference scenario.

<sup>9</sup> Of which 50 Mtonnes due to intermodal shifts.

<sup>10</sup> Includes refineries

<sup>11</sup> Not included in total because of inclusion in specific sectors.

### 3. Renewable energy

In 1997 the European Commission published a White Paper on Renewable Energy [EC, 1997d]. The target is a doubling of the share of renewable energy sources in the European Union from the current level of 6% to 12% in the year 2010 (Eurostat Convention; in term of saved primary energy the latter share is 15%). According to this communication, such a doubling will lead to a CO<sub>2</sub> emission reduction of 400 Mtonnes, or 250 Mtonnes compared to a business-as-usual development. This doubling could - for example - be reached as indicated in Table 2.

*Table 2. Current and projected contribution of the various renewable energy sources [EC, 1997d]. The total projected energy demand is 68,000 PJ (so-called Pre-Kyoto scenario).*

Renewable energy source	Current application (~1997)	Estimated application in 2010	Contribution in terms of substituted primary energy in 2010
Wind	2.5 GW	40 GW	740
Hydro	92 GW	105 GW	3270
Photovoltaics	0.03 GW <sub>p</sub>	3 GW <sub>p</sub>	30
Biomass - electricity	22.5 TWh (approx. 4 GW)	230 TWh (approx. 38 GW)	~ 2300
Biomass - heat/fuels	1590 PJ	3140 PJ	~ 3400
Geothermal - electric	0.5 GW	1 GW	60
Geothermal - heat	1.3 GW <sub>th</sub>	5 GW <sub>th</sub>	40
Solar thermal collectors	6.5 million m <sup>2</sup>	100 million m <sup>2</sup>	590
TOTAL			10,430

The costs of renewable energy sources can be substantial. For the medium term, electricity production costs will typically be on the order of 0.04 - 0.08 Euro/kWh for wind energy; 0.02 - 0.15 Euro/kWh for biomass; and 0.4 - 0.8 Euro/kWh for photovoltaic solar energy [WEC, 1993; ESD, 1996; EC, 2000a]. At present, costs of energy from renewable sources are generally higher than the typical electricity market prices in the EU, which are on the order of 0.02 - 0.04 Euro/kWh. At present the costs of per tonne of CO<sub>2</sub> avoided are up to 50 - 100 Euro for electricity production from renewable energy sources.

The following policies to stimulate the implementation of renewable energy are quoted in the White Paper, e.g.:

- Internal market measures (fair access for renewables to the electricity market, fiscal and financial measures, a new bioenergy initiative for transport, heat and electricity, and improving building regulations).
- Research, technological development and demonstration.
- Regional policy (support to regional and local projects).
- Activities within the framework of the common agricultural and rural development policy.
- Launching of a "campaign for take-off".

The policies presented in the White Paper are important for the further development of renewable energy in the European Union. They will form the necessary boundary conditions

within which renewable energy can develop. However, it is questionable whether they form a sufficient stimulus for the actual development of renewable energy, given the fact that renewable energy will remain more expensive than fossil energy sources for the coming years.

Special attention should be paid to the "Campaign for Take-Off". The idea of this campaign is to realize 10 GW of wind energy, 10 GW<sub>th</sub> of biomass, 1 GW<sub>p</sub> of PV and 1,5 GW renewable sources for 100 isolated communities. Realizing these values in the coming years would mean not only realization of an important part of the total target foreseen for 2010, but also cause an important boost in technological development and industrial activities. For the Campaign 6.8 billion Euro per annum is needed; of which at present only 2.6 billion Euro is covered (by the European Commission and the Member States). The additional effort of about 4 billion Euro will be partly covered by the Commission's Directorate-General for Transport and Energy, but additional funding is required from other sources, like the structural funds. No commitments have been made from these sides. Also, it is not yet established to what extent other parties, i.e. national governments and private industry will contribute. Therefore, it is doubtful that the Campaign for Take-off will have the necessary impact.

Recently the 'renewable energy directive' was accepted by the Council of Ministers. This draft directive provides indicative national targets for renewable energy and obliges all countries to introduce a system of renewable energy certificates. The national targets accepted as annex to the directive, at present are no more than indicative non-binding targets.

A system of certificates, as prescribed in the draft-directive, is important for the marketing of 'green energy', but it could also form the cornerstone for the introduction of a 'renewable energy obligation'. These can be modeled making use of the experience with the non-fossil fuel obligation in the UK or the green-label scheme in the Netherlands. In these schemes a certain fraction of renewable energy application in total energy demand is compulsory. The actual implementation is left to market forces as much as possible. In a liberalizing energy market such type of instruments could be appropriate. The only region in the EU with binding targets, being accompanied with penalties, is the Flemish Region. However, such approaches are considered in other countries as well.

The schemes of high feed-in tariffs have proven to be successful in an early stage of market development, and have been the basis for a successful industrial development. Such schemes are in place in a number of countries, notably Germany and Spain. In the European policy making context they are competing with competitive systems such as the green certificate systems, which are more in line with the liberalizing market practices. However, experiences with competitive systems are too limited to take conclusions on their effectiveness to develop the renewable energy market. Much will depend on the extent to which member states introduce binding quota. The expected voluntary market is far from being large enough in comparison to the policy targets.

#### **4. Combined generation of heat and power**

Combined generation of heat and power (CHP) is a technique that reduces the primary energy consumption compared to separate generation of heat and power. The CO<sub>2</sub> savings from 1 kWh electricity production by CHP vary from 250 g CO<sub>2</sub> (replacing conventional power plants) to 120 g CO<sub>2</sub> (replacing combined cycle power plants).

The ultimate CHP potential is estimated to be 40-50% of total EU power production [Hendriks et al., 1995; Phylipsen et al., 1997]. The actual realised penetration of CHP in the EU in 1990 was about 9% of total generated electricity.

Currently, there has been a very heterogeneous development of CHP in the Member States. This is valid for the policies applied and the implementation rate obtained. In countries like Denmark, Finland and the Netherlands the share of CHP in 1994 was above 30% of domestic power production, while the share of CHP in all other countries, except Austria, are close to or under 10%. The European average amounts to 9 to 10%.

In October 1997 the European Commission published a communication strategy to promote combined heat and power (CHP) and to dismantle barriers to its development [EC, 1997c]. In this Communication the European Commission postulates that '*CHP is one of the very few technologies which can offer a significant short or medium term contribution to the energy efficiency issue in the European Union*'.

The Commission estimated a *maximum* reduction potential of 300 Mtonnes in 2010 (under the Conventional Wisdom scenario). The aim of the Commission is a doubling of the current share of CHP from 9% to 18% of the total gross electricity generation by the year 2010. This equals 100 Mtonnes of avoided CO<sub>2</sub> emissions in 2010 [EC, 1997c]. If CHP is to cover 18% of total electricity supply in 2010, this would imply an annual growth of about 5000 MW<sub>e</sub>, or half of all new European power capacity. In some member states almost all new capacity would have to be CHP.

Currently, the main development relevant for CHP in the EU is the liberalisation of the electricity market that is resulting in a harsh competition environment for CHP. Up till recently, it was expected that a well-carried out liberalisation process would be in favour of CHP as it is a cost-effective way to generate electricity and heat, especially for large industrial installations and large plants in the service sector (e.g. hospitals).

However, due to surplus capacity the electricity market is stagnating currently. Due to the resulting low electricity prices even these more attractive CHP applications cannot compete on the liberalised market. For other, applications the situation is even more difficult, e.g. for most new applications of district heating, small-scale applications in the service sector and the residential sector [De Beer et al., 1994].

Good access to electricity grids and fair tariffs are important conditions for CHP, and these may come with liberalising markets. However, they definitely are not sufficient to ensure the large-scale implementation warranted under the Community CHP strategy.

In addition strong incentive policies are required, such as:

- Directives. In the framework of the revision of the Large Combustion Plant Directive, in July 1998 the European Commission sent a proposal to the Council and the Parliament for discussion. Article 7 of this proposal encourages the use of CHP and sets the obligation for the operator to explore the possibilities of locating the plant on a site with heat demand. Another option, which may play a role in the somewhat longer term, is the Integrated Pollution Prevention and Control Directive (adopted in September 1996). This framework directive may serve as an appropriate vehicle to further the application of energy-efficient technologies i.e. CHP.
- Other regulation. Especially for (large-scale) district heating projects high initial capital investments are required with low return on investment rates. Additional regulation may therefore be put in place. Danish policy may serve as an example of such regulation (the Electricity Supply Law from 1976, Heat Supply Law from 1979), which starting point is

to promote CHP to the highest possible degree. In the Danish system heat supply monopolies owned by the consumers may be founded, which have the right to supply heat at the lowest price possible. More recently France put into operation the “Air act” which regulates that new buildings should have the possibilities to be connected to all energy carriers, including heat.

- Also energy and CO<sub>2</sub> taxation can play a role in stimulating CHP. Note that the present taxation proposal by the European Commission is not suitable to stimulate CHP (due to the low level of taxation and the ratio of taxation on electricity and natural gas).

## 5. Energy efficiency improvement of appliances

Electricity consumption in the domestic and tertiary/commercial<sup>12</sup> sectors in the European Union is estimated at about 2200 PJ<sub>e</sub>/yr and 1440 PJ<sub>e</sub>/yr respectively [Bertoldi, 1996]. The efficiency of newly marketed electric appliances has improved considerably over the years. Typically, the best equipment sold, uses about 50% less energy than the average stock [Nørgård, 1989; Enquete Kommission, 1995].

According to the Expert Group report [Phylipsen et al., 1997] energy efficiency improvement potentials of 30-60% exist for most electrical appliances, often based on minimum life cycle costs models. Taking into account economic and implementation constraints, the Expert Group estimates the electricity savings to amount to 540 PJ<sub>e</sub>, resulting in an emission reduction of 55-90 Mt CO<sub>2</sub> in 2010, compared to a business-as-usual development. Here, energy efficiency improvement investments are considered to be economically feasible, if the pay-back period is shorter than 3-5 years.

Several policies are already in place, including R&D programs, mandatory energy consumption labeling and minimum energy efficiency standards for refrigerators and freezers (EC-directive, effective as of 1999). Labels have already been introduced for refrigerators and freezers in the European Union in January 1995 and for washing machines and tumble dryers in April 1996 [Bertoldi, 1996]. Recently, also labels have been adopted for dishwashers and ballast lamp circuits. New labeling is planned for central heating boilers, air-conditioners, ovens and water heaters; existing labels for refrigerators/freezers and washing machines are being revised.

A regulatory minimum efficiency standard has been adopted in 1996 for refrigerators, requiring an energy efficiency improvement of new equipment of 15% by 1999. The European Commission's objective to reach an additional 25% energy efficiency improvement by 2002 has been rejected by the EU Parliament and Council. Subsequently, the focus shifted from mandatory efficiency standards to voluntary standards, in the form of negotiated agreements. Negotiated agreements have been made for TV/VCRs and washing machines. For TV/VCRs the target is to phase out all equipment with a standby mode electricity consumption higher than 10 W by 2000 and to have a sales-weighted average standby consumption of less than 6 W. The target, formulated in the negotiated agreement on washing machines, is to phase out equipment with energy labels in the lower D, E, F and G ranges by 2000.

The European Commission is presently working on (voluntary or mandatory) minimum efficiency standards for domestic electric storage water heaters and on voluntary standards for electric motors. For ballast-lamp circuits the Commission is working on mandatory minimum efficiency standards. This is done at the request of ballast lamp circuits manufacturers to also

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<sup>12</sup> Here defined as office and retail space [Bertoldi, 1996a]

cover the high share of imported products, which would not be covered by a negotiated agreement.

The estimated effect of the minimum efficiency standard adopted for refrigerators (over and above autonomous developments) is expected to be negligible due to the low efficiency improvement objective and the fact that it has come into effect only in 1999, while the base year is 1990<sup>13</sup> [Gusbin, 1995; Blok and Phylipsen, 1996]. The effect of labeling by itself is limited. The negotiated agreement on TV/VCRs is estimated to result in electricity savings of 3.2 TWh in 2005 in the EU as a whole compared to a business-as-usual development (equivalent to 1.2 Mt CO<sub>2</sub>).

The effect of the negotiated agreement on washers is difficult to estimate. It is likely that the D, E, F and G label models will be replaced by C label models. The effect of this strongly depends on whether a dynamic approach is used to determine the boundaries between labels. In case the absolute values of the boundaries of categories A, B and C are maintained, the specific energy consumption (per kg of laundry) of the equipment sold will decrease with less than 1% [GEA, 1995]. The effect on energy consumption (i.e. the decline of specific energy consumption of the average equipment used) will even be smaller. In case the absolute values of the boundaries are adjusted according to their definition (e.g. class A is 55% more efficient than the average model) the effect of eliminating D, E, F and G label models can be larger. According to GEA (1995) this could result in energy savings of 4-8% of washing machine energy consumption in 1994. CO<sub>2</sub> emission reduction would be 0.5-0.7 Mt.

If efficiency improvement targets turn out to be as low as in the case of refrigerators, the value of mandatory efficiency standards is limited. Reinforcement of the instrument of minimum efficiency standards is possible in case minimum efficiency standards (either mandatory or voluntary) are formulated as suggested in the Commission Staff Working Paper (dynamic efficiency standards, based on minimum life cycle cost analysis) their contribution to CO<sub>2</sub> emission reduction might be substantial. In Japan such a dynamic approach is already implemented (the so-called top-runner approach).

On top of these policies that bring *existing* technology into the market, the development and introduction of *new* efficient appliances is necessary. Policies that could help in achieving this are R&D programs, golden-carrot programs and technology procurement programs (also announced in a recent Communication of the Commission on energy efficiency [EC,2000b]).

## 6. Fuel economy improvement of passenger cars

In June 1996 the Council of Ministers of the EU adopted the principle that in the year 2005 or 2010 new passenger cars should have a specific fuel consumption of 4.5 and 5.0 litre per 100 km for diesel and gasoline cars respectively [EC, 1996c]. This is considered equivalent to 120 g CO<sub>2</sub>/km level (the present average level in the European Union is about 185 g/km). Depending on the target year, the effect of realisation of this development will be a CO<sub>2</sub> emission reduction of 80 - 120 Mtonnes [Phylipsen et al., 1997].

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<sup>13</sup> It was decided that the standard will come into effect four years after adoption of the Directive. However the base year was fixed in 1990. Therefore, the later the Directive is adopted, the smaller the gap between the 15% improvement target and the autonomous efficiency improvement that has already been achieved in the year the standard becomes effective.

At this moment the main policy instrument is a negotiated agreement with the European car manufacturers (ACEA). In 1998, the car manufacturers and the European Commission have agreed on a target of an average specific CO<sub>2</sub> emission for new cars of 140 g/km in the year 2008 [EC, 1998a].

The adoption of the 140 g/km target for 2008 by ACEA is a substantial step forward compared to the present situation, but still means an important set-back compared to the initial targets of the European Commission of 120 g/km in 2005 or 2010. The outcome of the ACEA agreement is dependent on the time path, towards 2008, but CO<sub>2</sub> emission reductions will likely be in the order of 60 - 70 Mtonnes. First results of the monitoring system that was implemented in association with the agreement suggest that the 'trend' of constant specific fuel consumption that existed since 1986 is now changing in a downward direction.

Strong additional policies, e.g. fiscal policies, are required if the original targets are to be achieved. Development of such additional policies is still in an early stage.

Policies in related areas are set out in a Communication on Transport and CO<sub>2</sub> [EC, 1998]. The communication identifies various options for reducing CO<sub>2</sub> emissions, like the actions on passenger car fuel economy, fair and efficient pricing, completion of the internal market in rail transport and the integration of various transport modes. No new policies have been put forward that have an effect in the year 2010. R&D has been announced to develop long-term options for reducing transport CO<sub>2</sub> emissions. Especially missing are policies to improve the energy efficiency of freight transport.

## **7. Energy efficiency improvement in the heavy industry**

Branches like the iron and steel industry, refineries, basic chemical producers and the pulp and paper industry are energy-intensive and are often referred to as heavy industry. Historical energy efficiency improvement rates differ by sector, by country and over time. Several studies mention improvement rates of 1-2%/yr [Howarth and Schipper, 1991; Peterson and Miller, 1986; Farla et al., 1997; Worrell et al., 1997].

The Expert group report estimates the remaining technical efficiency improvement potential at 20-40% [Phylipsen et al., 1997]. Economically feasible energy efficiency improvement rates are estimated to range from 1.5-2%/yr (pay-back period < 4 years), but can be as high as 3.4%/yr, including non-energy benefits. This is consistent with improvement rates observed in voluntary agreements closed with the heavy industry in the EU, 1.5-2.2%/yr [Phylipsen et al., 1997]. In general the Expert Group considers energy efficiency improvement rates of 1.5 - 2.0%/yr (incl. CHP) to be feasible. Such improvements will lead to a CO<sub>2</sub> emission reduction of 70 - 110 Mtonnes compared to a business-as-usual development<sup>14</sup>.

In the European Commission Staff working paper an economic energy efficiency improvement rate of 2%/yr is suggested. Bottom-up models indicate reduction potentials of 110-130 Mt CO<sub>2</sub> in the heavy industry. According to the Commission this represents the upper range of reduction potential, and it suggests a potential of 80 Mt CO<sub>2</sub> as being more realistic. Net

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<sup>14</sup> In which the improvement will be only 0.5 - 1.0% per year

CO<sub>2</sub> emission reduction costs are generally expected to be negative at the current energy prices [EC, 1997].

A policy instrument that draws much attention is the voluntary agreement. Experience with this instrument has been obtained in, among others, Denmark, France, Germany and the Netherlands. The Dutch voluntary agreements seem to be reasonably on schedule [Ministry of Economic Affairs, 1995; Utrecht University, 1997, Ministry of Economic Affairs, 2000]. Voluntary agreements also exist in Germany, France and Denmark; the impression is that in general the effectiveness of such agreements strongly depends on the degree to which supporting government policies are in place.

Alternatives for negotiated agreements are EU guidelines or directives, e.g. in the form of best-available-technology performance descriptions or minimum efficiency standards, e.g. included in the Council Directive in Integrated Pollution Prevention and Control - BAT or the Large Combustion Plant Directive.

The effectiveness of the European Commission energy tax proposal for the heavy industry strongly depends on the exemptions that can or must be made according to the future energy tax Directive. In earlier proposals heavy industry was exempted from energy taxes. A possibility could be to make exemptions conditional. Conditions for exemption could be that companies enter into a negotiated agreement, that they achieved minimum energy efficiency improvement criteria, or that they participate in an emission trading scheme such as in the UK. Agreements should be monitored and sanctioning should be possible in case targets are not met.

## **8. Increase of minimum tax levels for energy products**

Reviews of existing studies on the effects of strong taxes - of the order of \$10-\$30/bbl - show that the potential effects of fiscal instruments on CO<sub>2</sub> emissions beyond 2000 is rather large, ranging from 11% in 30 years (350 Mt CO<sub>2</sub> emission reduction) to 20% in 20 years (630 Mt CO<sub>2</sub>) [EC, 1996b; Burniaux et al., 1992; Capros et al., 1996]. Evidence on the effect of smaller levels of taxes is limited at present. Energy taxation will lead to a reduction of emissions in many sectors, and part of the estimated reduction may overlap with emission reductions estimated for other measures (e.g. voluntary agreements, labelling).

The European Commission has proposed to gradually increase the minimum duties on non-automotive energy carriers to 0.7 Euro/GJ (equivalent to \$30 - 50 per tonne of carbon) [EC, 1997b]. According to a Commission working staff paper the present Commission proposal for a directive to raise minimum excise duties for energy products is expected to result in a CO<sub>2</sub> emission reduction of 50 Mtonnes in 2010 compared with the development in the pre-Kyoto scenario [EC, 1997]<sup>15</sup>. This is less than 2% of emissions.

Although only limited emission reductions can be achieved by the energy tax itself, energy and carbon taxes may be important to support other policies (e.g. to limit rebound effects). This support can be enhanced by excluding unconditional exemptions from taxes for certain industry sectors. An exemption could for instance only be granted if a company enters into a

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<sup>15</sup> Studies on the 1992 Commission proposal on energy taxation suggested a much larger effect of 350 Mt CO<sub>2</sub> to be achievable [EC, 1997].

negotiated agreement on energy efficiency improvement or if they achieve a certain improvement target.

## **9. Overview**

In Table 3 an overview is given of status of implementation of the policies and measures discussed (situation end 1998). It is shown that for most of the measures implementation is still limited: either it is limited to national measures, or to a limited part of the potential, or limited to the weaker types of policy measures. On the basis of the level of implementation by the end of 1998, only a limited part of the potential of policies and measures will be realised.

It may of course be that some progress has been attained since then on the national level (the progress at the European Union level definitely is limited). However, a recent analysis of the progress for six EU Member States (France, Germany, the Netherlands, Spain, Sweden and the UK) also showed that at least four of the countries have not yet implemented sufficient policies and measures to reach their targets for the year 2010.

The conclusion is that up to now a number of adequate policies is implemented, often only in a number of countries, but that the overall stage of implementation of these policies is not yet sufficient to reach the Kyoto target for the European Union.

Table 3. Overview of policies and measures discussed in this report.

Policies and measures	Potential effect (Mtonnes CO <sub>2</sub> emission reduction)	Required policies	Present stage of implementation	Preliminary estimate of the expected effect at present stage of implementation (Mtonnes CO <sub>2</sub> emission reduction) Situation end 1998
Renewable energy	200	Renewable energy obligation Budget for campaign for take-off	White Paper National policies in many countries	Limited (difficult to quantify, maybe up to 50 Mtonnes)
Combined generation of heat and power	100	Agreements on CHP obligations Directives	Liberalisation Harmonisation of tariffs National policies in some countries	Maybe effective for industrial CHP (~ 25 Mtonnes)
Energy efficiency of appliances	50	Dynamic efficiency standards	Labelling Weak standards or agreements	Limited (less than 10 Mtonnes)
Fuel economy improvement of passenger cars	100	Ambitious agreements or fuel economy standards	Agreement on part of the target	60 – 70 Mtonnes
Energy efficiency improvement in heavy industry	100	Voluntary agreements, including targets and monitoring (EU guidelines)	Voluntary agreements in some countries (various ambition levels)	Part of potential, e.g. 20 – 40 Mtonnes
Energy taxation	50	High uniform taxation level	Under negotiation in the EU Implemented in some countries	Very limited
Others	200			
Total	800			Approx. 100 – 200

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# **Removing Barriers to Sustainable Energy from Regulation of Liberalised Energy Markets - the UK as a case study**

Paper given by Dr. Catherine Mitchell, Centre for Management Under Regulation, Warwick Business School, University of Warwick, Coventry, UK, CV4 7 AL,  
e-mail: catherine.mitchell@warwick.ac.uk

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## **1. Introduction**

Most papers, when discussing the implications of liberalisation on sustainable energy policies, examine the degree to which current policies in Member States (MS) are able to survive the legislative changes of liberalisation. This paper does not examine this area. It explains the underlying regulatory drivers placed on electricity companies as a result of the liberalisation process and the implications of this for sustainable energy. It then argues that Britain will endeavor to transfer to Europe the recent regulatory principles established via the Utilities Act, 2000. These regulatory principles endeavour not only to make energy markets more competitive but, uniquely, to also move competition down to the distribution network level. This would represent another step towards competitive markets which most MS have not so far taken since the EU Directives on Gas and Electricity effectively create a framework for competition in Europe rather than enforce it.

This paper argues that the introduction of liberalisation to energy industries can be beneficial or non-beneficial to sustainable energy, depending on the energy system being displaced or installed. However, liberalisation is being enforced across Europe as a result of various Directives. In this sense, there is no option for MS but to establish a liberalised framework for energy. Given this situation, this paper argues that it is vital for sustainable energy development that MS establish a liberalisation of the type which ensures competition down to, and including, the distribution level. Only in this way will sustainable energy prosper.

This is because most sustainable energy options occur at (or within) the distribution network. If those networks are not regulated to facilitate competition in generation and supply by removing barriers to distributed generation, then the options and services offered by sustainable energy are unlikely to be valued. Unless regulation of energy markets values these services that distributed generation and demand side management bring to operating and managing the distribution network, those services will remain unpriced, under-valued and under-used.

The Utilities Act, 2000 has imposed a requirement on distribution network operators (DNOs) to facilitate competition in generation and supply. The UK Government has undertaken a review to establish to what degree this competition exists and what barriers exist for distributed generation. The review has made major recommendations for change to the regulatory process. It is unclear at this stage how many of those recommendations will occur. Nevertheless, in this area, UK liberalisation and its regulation offers a radical and very beneficial example of how liberalisation, through its determination to open up markets, can remove regulatory barriers to sustainable energy.

This paper is not suggesting that other MS copy the UK liberalisation model in its entirety<sup>16</sup>. It does suggest however that MS should 'pick and mix' the constituents of its liberalisation package. This paper also argues that liberalisation which does not regulate for competition in distribution networks is likely to be the worst of all worlds for sustainable energy. In this situation, not only are the previously supportive mechanisms likely to go but the underlying incentives within the regulation of the liberalised market are likely to favour centralised power and act as barriers to sustainable energy.

This paper:

- provides an overview of liberalisation within Europe and the ways it can be measured;
- describes the UK's experience of the relationship between liberalisation and the environment;
- evaluates the drivers for certain characteristics of liberalisation within Europe;
- discusses the benefits and disbenefits for sustainable energy which arise from liberalisation.

## **2. A Brief Update of Liberalisation within Europe**

The European Union has various Directives in place relating to liberalisation of the Energy markets. The EU required that all Member States (MS) should adopt legislation which implemented the provisions of the Electricity Directive by March 1999. All MS have now done so, although France and Belgium have yet to adopt the necessary secondary legislation. The European Commission estimates that 65% of the consumer market for electricity in the EU is now open<sup>17</sup>

The provisions of the Gas Directive were to have been adopted by August 2000. Even so, the Commission estimates that 78% of the consumer market for gas is now open for competition.

Both Directives set the framework for opening markets. Nevertheless, there is a considerable amount of work required to create the conditions for competition to apply throughout both industries. This work is being undertaken by Electricity and Gas Regulatory Forums held every 6 months in Florence and Madrid respectively.

Towards the end of 1999, the UK and Dutch Governments jointly commissioned work on competition indicators to monitor the development of competition in EU markets<sup>18</sup>. The basis

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<sup>16</sup> It also provides an example of the imposition of a serious barrier to sustainable energy - notably the new electricity trading arrangements (NETA).

<sup>17</sup> DTI, 2000, The Energy Report, Chapter 2, The Stationary Office, London or [www.dti.gov.uk/energy](http://www.dti.gov.uk/energy).

<sup>18</sup> Department of Trade and Industry, UK and Ministry of Economic Affairs, Netherlands, 2000, Energy Liberalisation Indicators in Europe, October, available from [www.dti.gov.uk/energy](http://www.dti.gov.uk/energy), undertaken by OXERA of Oxford, England.

of the work is to use energy liberalisation indicators to provide a simple analysis of the overall trends in each MS. The indicators are designed to follow progress in implementing the EU liberalisation directives, to track the fundamental development of market competition and regulation and to allow the performance of different countries to be compared.

The Commission intends to follow up the project with its own study. Once suitable indicators have been developed, they should show where barriers to competition remain so that action can be taken to remove them. At the Lisbon Special European Council Meeting in March 2000, Heads of Government agreed that gas and electricity liberalisation should be accelerated with the ultimate objective being full market opening. The Commission was asked to come forward with proposals to be presented to the Special European Council in Stockholm in March 2001.

The Commission is planning to propose two new Directives on electricity and gas in the near future which will include, as a minimum,

- provisions on a final date for full liberalisation for both markets
- greater unbundling of competitive and monopoly activities
- more transparent terms of access to grids and pipelines.

Thus, there are two driving forces for liberalisation in Europe. Firstly, the first set of Directives themselves. However, as fundamentally ‘framework’ directives, they can be enforced very differently within MSs. Secondly, there are the countries which have invested in liberalisation, namely the UK and the Netherlands, which are pushing the European Commission very strongly for a standardised type of liberalisation and regulation across Europe to be institutionalised in new Directives and measured via Indicators.

### **3. Measuring Liberalisation**

There are a number of ways that liberalisation can be measured once its characteristics are delineated<sup>19</sup>. One division is between upstream activities (gas supply and electricity generation) and downstream (access to grid for new entrants and retail competition). Thus, quantitative indicators of liberalised upstream activities might be the extent of compliance with the Directive; the market share of the largest generator/wholesaler; the market share of the three largest generators/wholesaler; and the existence of wholesale markets. There could also be qualitative indicators. For example, the extent of new entry into generation; the effectiveness of wholesale trading and capacity constraints on interconnectors. Similar indicators would exist for downstream except that it would be numbers of suppliers rather than generators.

Another division could be between competitive and non-competitive network areas. Furthermore, the boundary of competition can differ markedly in a non-competitive area. Indicators of liberalisation could be legal separation of businesses, unbundling of services and network access. Distribution networks are often described as natural monopolies. However, many of the functions of running the distribution network can be competitively run. There is an ‘irreducible core’ of monopoly but where its boundaries are is an increasingly important question of regulation<sup>20</sup>.

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<sup>19</sup> *ibid*

<sup>20</sup> Utility Week, Interview with Chris Bolt, 18 January 2000.

Ensuring competition in generation and supply requires access to transmission and distribution networks. Liberalisation of distribution networks is complex but since this is the area that sustainable energy is most closely linked to it is also the area of liberalisation which has the greatest effect on sustainable energy.

A further indication of liberalisation within the non-competitive electricity market could be the extent of regulatory influence. This is a sensitive area for those who consider that environmental and social goals should be inter-linked with economic goals right from the beginning. Nevertheless, qualitative indicators of liberalisation may be the impact of state subsidies, levels of social obligations and regulatory independence.

There are two problems with this area. Firstly, how to 'score' liberalisation<sup>21</sup>. Secondly, how to achieve a balance between economic, environmental and social goals. Some commentators may argue, as the UK/Dutch study did, that economic indicators should be separated from social and environmental indicators. Social and environmental obligations would be 'scored' as if they undermined economic liberalisation. This paper argues against such a view. It supports a transparency of market functions so that economic incentives and obligations are clearly differentiated and costed. However, it would argue that provided obligations work with the market and do not effect any one group more than another, liberalisation should be regulated to meet economic, social and environmental goals.

Table 1 sets out the range of liberalisation scores found by the UK/Dutch Government study of electricity markets. Table 2 sets out a the equivalent table for gas liberalisation.

#### **4. Implications of Indicators for Liberalisation in Europe**

As can be seen in Table 1, there is a considerable difference of liberalisation scores for the European electricity markets between the UK, Holland, the average (UK, Holland, France, Germany, Italy, Norway and Spain) and the minimum. Because of the recent timing of liberalisation of gas markets in Europe, Table 2 only compares the UK with Holland but again there is a considerable difference in scores. Table 3 examines liberalisation of the gs market over time in the UK. This shows that competition is gradually occurring but it has taken a long time to arrive.

The implications of the study for Europe, is that the UK and Holland will push to standardise liberalisation and its competitive effects in Europe. For some countries, this willd emand considerable changes. The EC appears to support the principle since it has also undertaken its own study. What changes, if any, this will lead to in Europe is unknown. What is clear is that thre will be a body of countries which will be pushing for increasing standardisation and benchmarking of energy liberalisation.

#### **5. Competition within the Energy Distribution Networks**

The UK and Netherlands government's study of liberalisation indicators did not examine the extent to which distribution networks are liberalised nor did it examine the relationship between distribution and transmission sectors. This is a major flaw of the study since it ignores a large and important area from which to assess liberalisation. A recent Department of Trade

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<sup>21</sup> see ref 3 for methodology

and Industry, Department of Environment, Transport and Regions and Energy Regulator (OFGEM) Working Group in the UK<sup>22</sup> has shown that the current regulation of distribution networks undermines competition amongst generators and places barriers to the take-up of distribution generation.

Distribution networks have in the past been viewed as natural monopolies in that the sunk cost of the pipes and wires were such that it precluded the building of two or more competitive networks. However, it is becoming increasingly clear that the strategic and the operational functions of the distribution network can be separated. The License conditions can rest on the strategic body while most of the operational functions can be put out to competitive tender. If the incentive on the network operator is to run the network at least cost while meeting certain performance measurements, it should be in the business interests of the DNO to facilitate market transactions between actors or to choose least cost ways of running the system while at the same time meeting performance measurements. Currently, this is not generally the case.

Provided that the performance measurements were correct, the separation of the License holder from operational functions could benefit sustainable energy. This is because, in theory, a network operator which is incentivised to run its network at least overall cost to the customer while meeting certain performance measurements (for example, amounts of distributed generation, reducing losses, providing energy services and so on) would always consider distributed generation or demand side services as an option of providing a service. Currently, network operators do not consider sustainable energy options because those services tend to be excluded (unpriced) within the regulatory process. Moreover, distribution services tend to be provided by the transmission network and paid for by customers. DNOs have no incentive therefore to set up markets to value distributed generation services. Thus, separation of the License holder from operating functions (to some degree although to what degree is still open to question) is likely to benefit sustainable energy since they are more likely to enjoy the opportunity to provide the services.

However, if performance based regulation on the different functions of the network is inappropriate or if the penalties for not meeting those performance measurements are incorrect (in particular too low), then the move towards an 'irreducible core' of monopoly functions on both transmission and distribution networks could result in poor quality service for customers. Just how far the 'natural monopoly' can shrink to its 'irreducible core' is a central question of regulation. The tragic case of the Hatfield train crash in Britain has highlighted how theoretical economic gains can transfer into tragedy if appropriate performance measurements are absent. Nevertheless, this paper would argue that a shrinking of the natural monopoly of the distribution network as it is now generally defined would benefit sustainable energy provided the correct performance measurements were in place.

This paper would therefore argue that a true indicator of liberalisation within an electricity system is the extent to which regulation of distribution networks:

- facilitates competition in generation and supply
- incentivises DNOs to act as market facilitators thereby valuing services provided by distributed generation and demand side management

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<sup>22</sup> DTI/DETR/OFGEM Working Group Report on Distribution Network Issues, January 2001, available on [www.dti.gov.uk/energy/wgeg](http://www.dti.gov.uk/energy/wgeg)

- does not act as a barrier to distributed generation and demand side management measures

Market facilitation is the means of ensuring suppliers, customers, generators, network operators and new entrants are able to ask for, obtain or provide network services they require at least cost whilst meeting appropriate performance requirements. In order to do this, regulation has to remove inappropriate price signals. Price signals should be cost-reflective, they should not promote certain decisions. In this sense, they should be 'neutral'. The underlying regulatory incentives would not favour a technology or service (whether from transmission or distribution), nor demand or supply measures, but would encourage the provision of choice and service to all actors at least overall cost while meeting certain performance measurements.

## **6. UK Experience of Liberalisation and Environment**

The UK privatised and liberalised its market in 1990. It re-regulated the energy industry in 2000 with the Utilities Act. There have been large changes within the electricity market over the last decade. The changing point was the election of a Labour Government in 1997 which put in place seventeen reviews to do with Energy. These reviews led to many changes, the most important being the Utilities Act, 2000.

A change in direction also included attitudes to the environment. At the end of 1999, OFGEM, the joint gas and electricity industry regulator appointed a Director of Social and Environmental Affairs for the first time. A Director is a senior, third level position (after Director General and Deputy Director General).

At the same time, November 1999, the Department of Trade and Industry issued a consultation on Electricity Network Issues. This led to a joint DTI/DETR/OFGEM Working Group on Embedded Generation Issues which took place throughout 2000. This has led to the publication of a forward thinking report which sets out in details the barriers that embedded generation has embodied in the current energy regulation and recommendations for change to overcome it. This is discussed in more detail below.

In early 2000, the DTI issued Environmental Guidance to the Regulator. This clarified what environmental tasks the Regulator should undertake in two ways. Firstly, within the Electricity Act of 1990, the Regulator had a number of primary and secondary obligations placed upon him or her. The primary obligation was to promote competition while the secondary obligations were to protect customers and the environment. However, if there was conflict between the primary and secondary obligation, the primary obligation was to be undertaken. In practice, this meant that competition was pursued. The second clarification concerned decisions by Regulators which would be paid for by customers. Under the Electricity Act, the Regulators had argued that any decisions concerning extra cost was not appropriate for them to make and that such decisions should come from the Government. The 2000 Guidance therefore endeavored to set out what environmental policies should be pursued by OFGEM.

OFGEM also began a project called the Information and Incentives Project (IIP) in 1999. This project examined how DNOs might be incentivised to meet certain performance targets. This is a first step towards performance based regulation (PBR). Up until this point, no DNO revenue was related to performance. It was assumed that the RPI-X regulation of minimising costs would also lead to the most suitable performance. Thus, for the first time regulation in the UK has begun to specify a certain performance. The IIP project is due to begin in April

2002. From that point to the next price control review, the DNO has to meet a certain performance. If they do not meet this performance, up to 2% of its allowable revenue may be taken from them as a penalty. The IIP is concerned with a small fraction of revenue. It is however an important step towards PBR and also towards incorporating environmental goals into performance criteria.

Finally, in July 2000 OFGEM issued a DRAFT Environment Action Plan. This is to lead to a 5-Year Environment Action Plan.

## **7. The DTI/OFGEM Working Group on Embedded Generation (WGEG)**

The WGEG investigated throughout the year 2000 and set out in detail how the incentives embodied in the current regulation of electricity act as a barrier to the take-up of sustainable energy. This is because the underlying price incentives provide an economic rationale for transporting centralised electricity to customers. The WGEG sets out a number of recommendations to overcome these inappropriate price signals. The goal of the recommendations is to establish a level playing field within distribution regulation so that barriers to distributed generation are removed. This would be regulation which intends to favour no actor or option but to represent cost-reflective price signals so that actors are able to make ‘real’ choices.

The WGEG UK regulatory analysis established that there are three fundamental areas which undermine distributed generation in the UK. These are, firstly, the underlying price incentives within UK distribution network price controls; secondly, the technical standards that DNOs are required to follow; and thirdly, the charging mechanism for use of, and connection to, the network. Together, these three drivers create a distribution network design culture within DNOs which excludes distributed generation from the design process. These findings are discussed below:

### *Underlying Incentives Within the Distribution Price Control Process*

The key incentives and management drivers within the electricity system on DNOs are:

- a focus on capital asset expenditure (because it creates future revenue)
- an incentive to minimise operational expenditure (which undermines doing things differently, innovation or undertaking activities which are heavily weighted towards operational expenditure)
- the netting out of losses which derive from distributed generation from the network loss calculation (thereby negating value of reduced losses from distributed generation)
- cost pass-throughs (for example, the provision of reactive power services by the National Grid Company and paid for by customers which negates any incentives on DNOs to set up distribution network markets which may be able to provide the service more cheaply)
- RPI-X regulation which is a blunt instrument to reduce costs rather than to provide incentives to meet performance standards

DNOs act economically rationally as a result of these incentives by designing a ‘passive’ network and transporting centralised power through to customers. It would not be in their economic interest to promote distributed generation.

Not only do the key incentives represent a barrier to distributed generation but they also:

- do not meet a ‘least overall cost to the network’ criteria

- do not meet ‘the facilitation of competition in generation and supply’ provision within the Distribution Licenses
- reduce choice for customers (and other energy actors such as generators and suppliers).

### *Network Design Culture and Technical Standards*

The design culture of distribution networks has developed as a result of:

- the underlying distribution price control incentives;
- the technical standards that DNOs are required to adhere to;
- the charging mechanisms of the network (discussed below);
- and a momentum of the ‘right way to do things’, still in existence, from a time of rapid commissioning of large power plants attached to the national grid in the 60s through to 80s.

The result is that networks are designed to be ‘passive’ which means that once a customer, whether demand or generation, is connected, the DNO does not have to consider it again unless a fault occurs. The networks are also designed for the electricity flow to be top-down, from centralised, power plants to customers. Connection of distributed generation is often viewed as de-stabilizing that one-way flow and passivity.

### *Charging Principles*

Charges for use of the distribution network and connection to it are regulated by OFGEM. These charging principles reflect the current design of the network. In the UK, generators pay ‘deep’ connection charges, in other words all costs related to the network which result from their connection. This raises a number of difficulties for distributed generation, not least the high up-front costs but it also disengages DNOs from having any incentive to connect distributed generation. They earn no money from distributed generators once they are connected.

The charging mechanism needs to be altered:

- so that it facilitate competition in generation
- so that the costs of connection are transparent to generators
- so that connection occurs as a result of publicly available information about future network opportunities
- so that it incorporates some incentive for DNOs to connect distributed generation.

### *Conclusion of the Findings of the WGEG*

The WGEG found that the combination of these underlying barriers means that it is not in the interests of DNOs to promote distributed generation or to design a network which could more easily incorporate distributed generation and value benefits that distributed generation might bring to the system.

All inappropriate incentives and technical should be removed if DNOs are to operate and manage the electricity systems in such a way that distributed generation can be connected. The key recommendations to achieve this are to remove the current underlying incentives by:

- reduce focus on capital asset expenditure

- be neutral to capital or operational expenditure
- make DNOs responsible for losses in their regions and incentivise them to reduce losses by any means thereby valuing the impact distributed generation has on losses (either negative or positive)
- replace technical standards which act as a barrier to network design and operation with ones suitable for distributed generation
- establish transparent charging principles which facilitate competition in generation
- remove all cost pass-throughs so that network service markets may develop
- ensure transparency of network information
- move to a greater proportion of DNO revenue related to performance based regulation

## 8. Conclusion

Liberalisation of electricity networks in Europe is still in the early stages and attitudes to it differ widely between Member States. It has been widely documented that liberalisation can undermine sustainable energy if previous mechanisms of promotion are undermined. However, because of the Gas and Electricity Directives all countries will have to enforce liberalisation to some degree. This paper has argued that the UK will promote its view of liberalisation within the European Commission and that it already has done so through the development of indicators of liberalisation.

The UK view of liberalisation has some positive merits for sustainable energy, namely its efforts to ensure regulation which promotes competition within distribution networks.

So far, most MS in Europe have not endeavored to ensure competition within distribution networks. Unless regulation of energy markets values the services that distributed generation and demand side management bring to operating and managing the distribution network, those services will remain unpriced, under-valued and under-used.

If sustainable energy is to prosper in liberalised markets, the regulation of those markets must be neutral. MS are able, as a result of the Renewables Directive, to promote renewables in whatever they wish, provided it passes State Aid Guidelines, for 10 years once the Directive comes into force<sup>23</sup>. Sustainable energy may develop in this way. However, unless regulation of the energy markets removes the barriers to distributed generation, sustainable energy can never really prosper in any long-term sense since they will always come up against them.

An in-depth study of the UK regulatory system has found that barriers do exist to sustainable energy development and steps are underway in the UK to get rid of those barriers incorporated into the regulation. It is essential that all MS also ensure that the underlying regulatory incentives which underpin liberalisation do not act as a barrier to sustainable energy. This paper recommends that all MS undertake a similar study to that undertaken by DTI/DETR/OFGEM Working Group so that regulatory barriers which underpin the move towards a liberalised system are removed.

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<sup>23</sup> EC Renewables Directive, May 2000.

Table 1 Range of Liberalisation Scores for European Electricity Markets

	<b>Holland</b>	<b>UK</b>	<b>Average</b>	<b>Minimum</b>
<i>Competitive Area</i>				
Upstream & Wholesale	6.2	9.0	5.8	1.7
Downstream and Customer	5.2	7.5	5.0	1.7
<b>Overall Indicator</b>	5.7	8.3	5.4	1.7
<i>Non-Competitive Area</i>				
Network Access	7.8	9.0	7.4	4.8
Regulatory Influence	6.7	6.7	4.8	1.7
<b>Overall Indicator</b>	7.5	8.4	6.7	4.0

Source: Department of Trade and Industry, UK and Ministry of Economic Affairs, Netherlands, 2000, Energy Liberalisation Indicators in Europe, October, available from [www.dti.gov.uk/energy](http://www.dti.gov.uk/energy)

Table 2 Liberalisation Indicators for Gas

	<b>Holland</b>	<b>UK</b>
<i>Competitive area</i>		
Upstream and Wholesale	2.9	8.4
Downstream and customer benefits	3.2	8.8
<b>Overall</b>	<b>3.0</b>	<b>8.6</b>
<i>Non-competitive area</i>		
Network Access	4.8	10
Regulatory Influence	8.3	6.7
<b>Overall</b>	5.6	9.2

Source: Department of Trade and Industry, UK and Ministry of Economic Affairs, Netherlands, 2000, Energy Liberalisation Indicators in Europe, October, available from [www.dti.gov.uk/energy](http://www.dti.gov.uk/energy)

Table 3 Liberalisation Indicators for UK Gas

	<b>1985</b>	<b>1990</b>	<b>1995</b>	<b>2000</b>
<i>Competitive Areas</i>				
Upstream and Wholesale	2.9	3.9	7.4	8.4
Downstream and customers	1.8	2.0	5.2	8.8
<b>Overall</b>	<b>2.3</b>	<b>2.9</b>	<b>6.3</b>	<b>8.6</b>
<i>Non-competitive areas</i>				
Network access	0	0	6.8	10.0
Regulatory Influence	5.0	6.7	8.3	6.7
<b>Overall</b>	<b>1.3</b>	<b>1.7</b>	<b>7.1</b>	<b>9.2</b>

Source: Department of Trade and Industry, UK and Ministry of Economic Affairs, Netherlands, 2000, Energy Liberalisation Indicators in Europe, October, available from [www.dti.gov.uk/energy](http://www.dti.gov.uk/energy)

Table 4 EC Targets for Renewables

	<b>Renewables-E1997 (%)</b>	<b>Renewables-E 2010 (%)</b>
Austria	72.7	78.1
Belgium	1.1	6.0
Denmark	8.7	29
Finland	24.7	35.0
France	15	21
Germany	4.5	12.5
Greece	8.6	20.1
Ireland	3.6	13.2
Italy	16	25
Luxembourg	2.1	5.7
Netherlands	3.5	12
Portugal	38.5	45.6
Spain	19.9	29.4
Sweden	49.1	60

Source: EC Renewables Directive



## **Energy 21: Making The World Work**

By Walt Patterson

The time has come for me to reveal an embarrassing secret. Some twenty years ago, at the end of the 1970s, I wrote a book. I gave it the title *Energy and Purpose*. By 'purpose' I meant 'what we humans want from energy, and how we try to get it'. A reputable publisher gave me a modest advance. I worked on the book for two years, eventually accumulating about 100 000 words of text. But the longer I worked on it the less I liked it. I finally had to confess to myself that I didn't know what I was talking about. I didn't understand enough about energy and purpose to say anything I considered useful or persuasive. I gave the publisher back the advance, piled the typescript in a cardboard box and stashed it in my archive, along with the unpublished novel, the unpublished textbook and the unproduced musical.

This evening I propose to return to the scene of my failure two decades ago, to talk again about energy and purpose - what we humans want from energy, whether we can get it and if so how. I have an alarming sense of *deja vu*, knowing I have been here before, and wondering whether I can do any better this time. I also have less than an hour, and less than 6000 words. Wish me luck.

Why talk about energy and purpose? The short answer is that we're making a mess of it. The world isn't working well enough. More than two billion people - one-third of humanity - have no access to the kinds of energy benefits we here tonight take for granted; and the proportion of 'energy have-nots' is increasing, not decreasing. Worse still, the key fuels and energy technologies of the 'energy haves', like us - fossil fuels, nuclear power, large dams - all face problems that may become insuperable. If that doesn't worry you, I'm wasting your time here this evening. I hope I'm not wasting your time.

What do YOU want from energy? You probably never gave the matter a moment's thought. That's as it should be. Almost everything you get from energy you get without even noticing. It doesn't involve a meter; you don't get billed for it. You get surroundings whose temperature mostly stays within limits your body can tolerate. You get sunlight processed by green leaves, that store up the solar energy in a form you can eventually eat, for your muscles to use. As a byproduct from the green leaves you get the oxygen you breathe to process the food; and so on. You are immersed in - and indeed you are a part of - natural energy systems of astonishing complexity and variety; and you take them all for granted.

You are also, however, immersed in energy processes that you yourself, and other people, initiate and control - what we can call human energy systems. Some you take for granted as completely as you take natural energy systems for granted. I'll bet you can't remember the last time you turned on a light. Some human energy systems you notice, at least some of the time - particularly when they fail. When you turn the key

in the ignition, or flip the light switch, and nothing happens, you notice. You also notice when you get a bill. That may be part of the problem. In the last three decades we have come to think of energy as something you get a bill for. Tonight I propose to argue that this should change.

Let's start with this word 'energy'. When you think of energy, you probably think of oil, coal, natural gas, electricity. I don't. By training, I'm a hard scientist. I used to call myself a lapsed nuclear physicist. I am also, as my family and friends will testify, a pedant. I'm obsessively fussy about language. The language we now use to talk about energy drives me crazy. It's wrong, wrong, wrong. If we can't even describe the issues and options correctly we'll never get the policy right.

How many times have you heard some energy specialist refer to 'energy production' or 'energy consumption'? These people are supposed to be experts. Haven't they heard of the First Law of Thermodynamics, the law of conservation of energy? NO ONE produces energy. NO ONE consumes energy. The amount of energy in THE WHOLE UNIVERSE remains the same. That's what makes energy such a valuable and important concept for understanding how the world works. We don't have to conserve energy. Nature does it for us.

Why, then, do we talk this way? The answer is simple. When we talk about energy production, energy consumption and energy conservation, we don't mean 'energy'. We mean 'energy carriers' - that is, fuels and electricity. The confusion dates back only about three decades. Until the early 1970s governments had 'fuel policy'. They had Ministries of Fuel, or perhaps of Fuel and Power - 'power' meaning electricity. Then, in October 1973, the Organization of Petroleum Exporting Countries suddenly quadrupled the world price of oil, and plunged the world into a panic. Governments everywhere launched a frenzied search for a 'substitute' for oil. Within weeks all the different fuels, plus electricity, were swept together and called 'energy', as if they were all potential substitutes for one another, all more or less interchangeable. 'Fuel policy' became 'energy policy'. Governments exhorted their citizens to 'conserve energy'. Ministries of Fuel became Departments of Energy. Oil companies, coal companies, gas companies and electricity companies all became 'energy companies'. Here in the UK the Institute of Fuel became the Institute of Energy.

So what? Everyone knows that specialists talking about 'energy' really mean 'energy carriers' - oil, coal, natural gas, electricity. Lumping them all together and calling them 'energy' is just a convenient shorthand. Does this quirk of language really matter, except to pedants like me?

I think it does. It distorts our understanding of what we are actually doing with energy; and here I mean 'energy', not 'fuels and electricity'. Worse still, this misleading language obscures crucial options we now have - ways for us to use energy much better.

Note that I'm talking about 'using' energy. That's what we do with energy. We don't consume it, we use it. Humans have been using energy on purpose since long before the beginning of recorded history. Our human ancestors began using energy by intervening intentionally in natural energy flows, or what I like to call 'ambient energy' -

energy that is there for us to use, with no meter and no bills to pay. The first ‘energy technologies’ that our human ancestors hit upon were clothing and shelter. In cold weather clothing reduces the loss of heat energy from your body; in hot weather it protects you from too much solar energy. Shelter provides an enclosed space, reducing energy flows and keeping the temperature inside more stable than that outside; inside the shelter you are more comfortable.

You may not usually think of clothing and shelter as energy technologies. But if you really want to understand how we humans use energy, clothing and shelter are fundamental. Note, too, that clothing and shelter are physical materials. You don’t measure or pay for the energy flows involved; the clothing and the shelter manage the energy flows for you. Keep that in mind. It’s important.

Humans were probably manipulating ambient energy in these basic but fundamental ways long before they learned to control fire and use fuel. Fire and the fuel to feed it opened many new possibilities. Nevertheless, intervening in ambient energy remained an important aspect of using energy on purpose. In many parts of the world, for instance, humans developed increasingly subtle and ingenious ways to design the energy technologies we call buildings. They selected materials and erected structures to use the ambient energy of sunlight, moving air and human bodies for comfort, light and ventilation. They also developed technologies including sails, windmills and watermills, to use the ambient energy of wind and water for human purposes.

Ambient energy is all around us, whether or not we explicitly want to use it. Fuel, by contrast, is a material containing energy that we can release on purpose, when and where we want to use it. The word ‘fuel’ comes from old French ‘fowaille’, which comes in turn from low Latin ‘focale’ and Latin ‘focus’, meaning ‘fireplace’. Etymologically, a fuel is ‘material for a fireplace’. Historically, a fuel is a material you can burn, to release its stored energy as heat. This creates a local high temperature, in which you can cook food, fire ceramics and smelt metals. But the real potential of fuel emerged only less than three centuries ago, with the invention of the steam engine.

The steam engine could convert the heat energy from a burning fuel into mechanical energy - a source of controlled force and motion much more powerful than human or animal muscles, and more predictable than wind or water. The steam engine tipped the balance. Since the advent of the steam engine, giving us this potent additional way to use fuel energy, we have gradually forgotten about using ambient energy. Instead we have concentrated our attention on fuel energy - usable energy stored in a form that can be stockpiled, transported, and released in concentrated form, when and where we want to use it.

Note one important corollary. Fuel energy is comparatively easy to measure and quantify - so many tons of firewood or coal, barrels of oil, cubic metres of natural gas. Because it can be stored, it can be possessed - someone can take title to it and own it. It can therefore be bought and sold. Nobody can buy or sell ambient energy, because nobody owns it - not yet, at any rate. Keep the distinction between ambient energy and fuel energy in mind. It’s important.

The steam engine, and all the numberless energy technologies that have come after it, also demonstrate another key point. At its simplest, fuel energy can be released directly from the fuel and used as it comes - say from a bonfire. However, precisely because it is being released intentionally, for a human purpose, fuel energy is usually released in the context of some sort of physical hardware - an energy technology designed to control and direct the conversion of the fuel energy.

For example, my wife and I are building a little house on a remote hillside on a Greek island. The house is heavily insulated - roof, walls, windows and floor - in order to take maximum advantage of the ambient energy, whatever the temperature outside, to keep us cool in summer and warm in winter. In northern Greece, however, winters can be pretty cold. Rather than lighting a bonfire on the kitchen floor we have a black potbellied stove. It is essentially a metal canister with a lid, a small front door into which we put the fuel, and a pipe to channel the smoke of the fire out the back of the house. We burn dead heather branches from the hillside, scrap planks from the builders, cardboard packaging, essentially anything combustible. It converts the energy from the fuel into radiant heat energy that saturates the structural material of the house. If it's cold outside, a short burst of heat from the stove fine-tunes the temperature inside, and keeps us cosy for hours. Of course a lot of the heat from the stove escapes out the chimney, and the emissions would probably get us into trouble in London. As an energy technology our potbellied stove could scarcely be more basic. But we have fallen in love with it.

Our potbellied stove, however, illustrates another significant aspect of human energy use. Precisely because the stove is such basic energy technology, it can use the most basic fuel - whatever we can lay our hands on to burn. The only processing the fuel requires is to break or cut it into pieces small enough to put in the stove. Although we bought and paid for the energy technologies we use - the house itself, and the stove in the kitchen - we don't have to buy the fuel. We can gather and cut it up ourselves. It costs us our own time and effort, but doesn't take any expertise.

In that respect, our stove is no longer a typical energy technology, at least in this part of the world. Over the past three centuries, the interaction between fuels and energy technologies has become ever more specialized. A particular technology requires a particular fuel, and vice versa. The specifications of both the technology and the fuel have become steadily more stringent. Your car engine probably demands not petroleum, not even plain 'petrol', but unleaded premium petrol. As my wife and I now know, a cooker designed for natural gas will not work safely on bottled propane; and so on.

That's the main reason why looking for a 'substitute for oil' in the 1970s was misconceived. You can't change the fuel without changing the energy technology that uses it. Preparing, delivering and supplying fuels appropriate for their corresponding energy technologies now requires not only high levels of expertise, but elaborate organization of all the necessary skills and competences, with all that that implies. You can't collect the fuel on a hillside. Just as you buy and pay for the energy technology, you also have to buy and pay for the fuel. The companies you buy the fuel from used to be similarly specialized - oil companies, coal companies, gas companies. That, however, is now changing rapidly - as we shall see.

Within the past century, the human use of energy in much of the world has come to depend not merely on separate individual fuels and technologies, but on entire intricate human energy systems, complex and interconnected. To fulfil our many purposes these human energy systems use a combination of ambient energy and fuel energy not merely in individual energy technologies but in a vast human energy infrastructure. Enormous aggregations of buildings are expanding into megacities. The buildings are filled with other energy technologies, and linked by roads, pipes, cables and other interacting connections, extending human energy processes not only across entire continents but even bridging the oceans.

As well as natural energy systems, we now have a human energy infrastructure that also covers the planet. Much of this human energy infrastructure delivers the energy services we all want - comfort, cooked food, illumination, motive power, information handling and so on. However, a substantial part of this infrastructure is now devoted to collecting, preparing and delivering fuel energy to run the rest of the infrastructure. Making substantial changes to the delivery infrastructure can take as long as making substantial changes to the energy-service infrastructure, and cost at least as much.

Among the specialized and complex energy systems we have created, perhaps the most specialized are those that function with an energy carrier quite different from fuel. I mean of course electricity. No matter what you may hear from politicians and others, electricity is not a fuel. A fuel is a physical substance. You can store it until you want to use it or sell it. Electricity, in the form in which we use it, cannot be stored. Electricity is not a physical substance; it is a physical phenomenon, happening simultaneously throughout an entire interconnected system; it has to be generated more or less exactly as it is being used. Fuels and electricity also differ in another fundamental way. A fuel such as natural gas comes out of a hole in the ground at a particular place. If you want to use it somewhere else you have to carry it there. Electricity, by contrast, you can generate anywhere, at a price. Just ask the person with the hissing headphones sitting next to you on the bus.

Because electricity can't be stored, whenever you use it you have to have the entire system in place and operating. The person with the headphones, for example, is carrying the whole system. Back in the 1870s, the first systems for electric light were likewise local; generator, cables, and lamps were all on the same site. Some generators used ambient energy, with a water wheel; others used fuel, with a steam engine. The arrangement was reassuringly expensive; only the wealthiest and most ostentatious could afford electric light. At the beginning of the 1880s, however, Thomas Edison had a bright idea. He scaled up the entire system, to reduce the unit cost of lighting individual lamps; and he enlisted subscribers on sites all around his central generating station on Pearl Street in lower Manhattan, charging them according to how many lamps they used. Edison was selling electric light - what his customers actually wanted. To keep the cost of the electric light as low as possible Edison had to optimize the entire system - generator, cables and lamps.

Soon thereafter, however, came a critical change in the arrangements - the introduction of the electricity meter. From that time on, Edison, his contemporaries and their successors were no longer selling electric light; they were selling electricity, by the

metered unit. The advent of the electricity meter had an additional consequence. If you are selling electric light, you want the whole system producing the light to be as efficient and cost-effective as possible. If, on the other hand, you are selling units of electricity as measured by an electricity meter, someone using less efficient lamps has to buy more electricity from you to get the same level of illumination. From the point of view of you, the seller, inefficiency on your customer's premises is good for your business. This perverse incentive has underpinned the electricity business for a century.

The introduction of the electricity meter made electricity analogous to fuel in one key respect. If you used electricity from a central-station system you bought the electricity by the unit, just like fuel. In other respects, however, electricity evolved as a distinct and specialized form of energy carrier. As an energy carrier electricity proved extraordinarily versatile. It could even be used to collect and convert for use ambient energy from concentrated sources – even as dramatically concentrated as Niagara Falls. But electricity demanded highly skilled specialists to design the interconnected system and operate it continuously in real time, responding immediately whenever some electricity user threw a switch. It also involved what eventually became staggering amounts of capital investment in the electricity infrastructure itself. Nevertheless Edison's crucial idea, of scaling up the system to lower the cost of the services it could provide, succeeded magnificently. In my book *Transforming Electricity* I declared that 'Electricity systems may be the most spectacularly successful technology of the twentieth century. They work so well that those who most rely on them hardly notice them'.

Remember, however, that you can generate electricity anywhere, at a price. The whole point of traditional central-station electricity systems following Edison is to lower the cost of delivering electric light and the many other services electricity technologies provide. But electricity by itself is useless. Electricity just carries energy; the energy has to be converted into a useful form by an energy technology such as a lamp, a motor or a computer. When it is being used, the energy technology involved - lamp, motor, computer - becomes a functioning part of the electricity system. In this respect electricity as an energy carrier is fundamentally different from any fuel. The whole system - generators, networks and end-use technologies or 'loads' - is part of the human energy infrastructure, operating continuously in real time. You can keep a stack of wood, a pile of coal, a tank of oil or even a canister of compressed natural gas on site, ready to use when you wish. But if you want to use electricity from a traditional system the whole system - that vast array of capital assets - has to be operating with you, in real time.

In that respect, oddly enough, using electricity has a lot in common with using ambient energy, and the link is going to get steadily closer. Like electricity, ambient energy is delivered continuously. Ambient energy can't be stored, except as low-grade heat. To use ambient energy on purpose, you need physical assets - a building, a water turbine, a wind turbine, a photovoltaic panel - that is, physical infrastructure. For some purposes, such as comfort - probably the single most important human purpose for using energy - if you make the physical infrastructure good enough, ambient energy may well suffice, with no resort to fuel energy. In much of the world, however, we have accumulated a built infrastructure whose performance with ambient energy all

too often seems wilfully poor, making fuel energy essential if we are to get the comfort we want. When I first arrived in Britain from Winnipeg in Canada forty years ago, I could not believe the buildings in Britain. The heat inside barely slowed down before it escaped outdoors.

We also settle for poor performance from the energy technologies inside and around the buildings. When I arrived in London I lived in a bedsitter in Bayswater. The bath was in a sort of greenhouse over the front door. The boiler was in the basement. The hot water pipe from the boiler ran up the exterior wall. Not only was it not lagged, it was painted black – the best colour for radiators. As you can imagine, the water running into the tub was barely tepid. I couldn't understand why they bothered.

That may sound like an extreme example, but it's not. Countless reports and analyses have underlined the inadequate performance of lighting, motive power and other energy technologies in many parts of the world, and deplored the missed opportunities for so-called 'energy efficiency' - another expression I have come to avoid. Many reasons have been suggested. I'm sure you've all read the meticulous and detailed lists of 'barriers to energy efficiency' that have been pouring out since the 1970s, and they are all true. But the single underlying reason why our human energy infrastructure does not perform better is that most of us can't be bothered. We have other things to think about. If we are ever going to make the sweeping improvements in human energy use long since readily available, if we are ever going to make the world work better, someone has to want to - someone who can make it happen.

By now you're probably thinking 'What about costs? How can he talk so long without mentioning costs?' Let's talk about costs. Energy itself costs nothing. However, if you want to use ambient energy you have to design and fabricate the technology to do so. If you want to use fuel energy you have to produce and process the fuel, and deliver it to where it is to be used; and you have to design and fabricate the technology to use the fuel. Once you get beyond the mud hut and the bonfire, all these activities have become variously part of a financial economy, carried out in transactions mediated by money. The skills, competences, responsibilities and risks involved have been divided up and apportioned out in ways that once appeared to make sense, but now look profoundly unsatisfactory, because of what they have done to human energy infrastructure.

Consider, for instance, the two parts of this infrastructure I mentioned earlier. One part delivers the energy services we want. The other part delivers the fuels and electricity to run the first part. Both parts represent investments in physical assets. Because the fuels and electricity are to be sold by the unit to users, the investment in all of this part of the infrastructure generally receives favourable tax treatment, as business investment. An investment, say, to increase the generating capacity of an electricity system, is allowed against tax; whereas investments in, say, more efficient refrigerators to make extra generation unnecessary are not. This one single anomaly, replicated across all the energy infrastructure, skews the pattern severely, in favour of more investment in delivering fuels and electricity, and less investment in delivering better energy services. Tax regimes thus tend to encourage investment in infrastructure that makes money, rather than in infrastructure that delivers the energy services we citizens want.

Using ambient energy does not make money – not at the moment. But fuel energy can be stored and sold, by the unit. What costs money is not the energy, but storing it, carrying it to where it is to be used and converting it. We use fuels and electricity to have energy available where, when and in what form we want; and we pay for the privilege. Policy people call this ‘commercial energy’, as if paying for it makes it better. Commentators scrutinize the prices of fuels and electricity, and analyze their movements minutely. However, in our modern interconnected society the prices of fuels and electricity by the unit have long been essentially artificial, shaped by preferential tax regimes, subsidies and cross-subsidies, cartels and outright monopolies, as in the case of electricity networks. With this in mind the highly respected chairman of Ireland’s Electricity Supply Board, Patrick Moriarty, once remarked succinctly ‘The price of electricity is what the government wants it to be’. Much the same can be said of fuels. Except for short-term advantage, price is not a good enough criterion.

If we were stuck with these traditional arrangements for using energy on purpose, concentrating on selling fuels and electricity by the unit at more or less arbitrary prices, we would have little chance of making the world work better. Fortunately, however, within the past five years or so something remarkable has begun to happen. I don’t really understand it yet, and I’m not alone. But if I’m reading it right we may at last be starting to move in the right direction.

I noted earlier that if we really want to change human energy infrastructure to make it work better, someone has to want to - someone with the clout to make it happen. Well, now someone wants to - and not just a single someone but a rapidly lengthening catalogue of some of the biggest players in the game. As some of us foresaw, the apparently modest and constrained measures originally billed merely as ‘privatization and restructuring’ of traditional electricity industries in the UK and elsewhere have acquired a headlong momentum, far beyond the expectations of those who set the changes in motion just over a decade ago. The speed of change is already breathtaking, and accelerating.

Companies whose business used to be centred entirely on supplying fuel or electricity by the unit are now evolving in many different directions, at breakneck speed. In the mid-1980s, for instance, Enron was a low-profile operator of natural gas pipelines in the US. In the intervening fifteen years it has ramified into an independent electricity generator with assets all over the world, a international water company, and most recently an almost hyperactive global trader via the internet. In the autumn of 1999 Enron and the major industrial firm Owens Corning signed a contract for more than one billion dollars, according to which Enron will manage all of Owens Corning’s energy requirements for ten years - not just fuels and electricity but plant upgrades, maintenance, a complete energy service package.

Less than a year ago the world’s largest engineering company, ABB, was one of the handful of huge companies manufacturing large-scale generating equipment for traditional electricity systems. Then, in the autumn of last year, ABB sold off all its nuclear activities; and at the end of March this year ABB also sold off all the rest of its large-scale power generation interests. Two weeks ago today, on 8 June, ABB’s chief executive and top management held a dramatic press conference in London and on the

Internet, announcing a new company-wide strategy focusing on solutions and services for much more decentralized electricity systems. ABB is launching a whole portfolio of innovative on-site and local generating technologies, including microturbines, fuel cells and a new design of wind generator, plus all the innovative network technologies and controls the new systems will require. The company is offering not just the technologies but complete service packages, including finance, operation and management.

Meanwhile the German companies RWE and VEW, as they gradually merge, are publishing full-page ads in the *Financial Times* in which the new company calls itself an 'energy infrastructure company'. TXU Europe announces a new programme it calls 'Staywarm' in which it will sell agreed levels of comfort to low-income households, at a fixed price, not according to units of electricity. ScottishPower, too, is upgrading the homes of low-income neighbourhoods in Glasgow, on a similar basis. Vattenfall in Sweden is promoting the 'Smart House', with its own on-site generation. In Brussels last month the European Commission and Eurelectric, the union of electricity industries, held a high-level conference entitled 'From Electricity Supply to Energy Services'. Our hosts tonight, PowerGen, are now offering not just units of electricity but 'energy solutions', as you'll see from the programme pack this evening.

These are only a handful of examples; I could cite many more. Do you see a pattern emerging? These major companies are redefining the business they are in, and the relationship they want to have with their customers. Their focus is shifting steadily away from selling fuel and electricity by the unit. Instead they are offering to sell the energy services that their customers actually require, bringing both expertise and financial resources to bear on the energy service infrastructure itself. These big players can overcome the 'hassle factor', the 'can't be bothered' factor that keeps the rest of us from making energy work better; and they can do so for sound commercial reasons.

How this is going to work out in practice no one yet knows. But here are some possibilities you might like to ponder. In the sort of world we may be moving towards, big companies will do the short-term trading, not only in fuels and electricity but also in all the requisite energy hardware. This is happening already; the internet is humming with deal-making of every kind. But relations between companies and energy users will be on the basis of service contracts – contracts to supply whatever comfort, illumination, motive power, information handling or other energy services customers desire, at fixed contract prices over stated periods of time. For energy users, units of fuel and electricity will disappear from the picture.

Big companies will out-source a vast amount of their on-site activities; they will need plenty of staff and contract employees to install, maintain, service and upgrade energy technologies for their customers. They will also enter alliances, to bring together skills and competence hitherto separate and disconnected, from architects and designers through to electronics, control and network specialists, pooling their expertise and sharing responsibility to get the whole service system right. Financial links with customers need not include outright sale of hardware; leasing and other contractual arrangements may be more appropriate when technology is evolving so rapidly.

Governments, in turn, will have to revise and reshape company law to foster these activities, and to ensure that big players deal fairly with each other, with employees, with smaller players and with customers. Energy service contracts, even those with individual householders, will have to be enforceable in law, with penalties for failure. Governments will also have to reorganize tax regimes and fiscal structures. They must shift the balance away from expanding fuel and electricity delivery infrastructure, in favour of upgrading the energy service infrastructure. Governments will set an example and prime the pump for energy service business, by calling for tenders and contracting for their own requirements, especially for their own extensive stock of buildings. Governments will have to take explicit responsibility to make energy services available to the poorest and most vulnerable in society, by tenders and contracts for services, paid for out of government social service budgets.

For years we've been talking about 'sustainable energy'. In my more hopeful moments I think we may at last be seeing the initial stages of the evolution that will get us there – not just those of us among the 'energy haves', but also the two billion people who are still waiting. In the course of this new century we may even manage to make human energy systems work like natural systems, continually delivering the services we want while most of us don't even notice. Can human energy systems converge toward natural energy systems? I find the vision appealing and exhilarating.

I know all too well that energy is only one of the fundamental issues that challenge us. But if we don't get energy right the other issues will be insoluble. Last year I tackled what proved to be the most difficult piece of writing I've ever done. It was a millennium essay, written for the Royal Institute of International Affairs, published at the end of last November. I called it *Running The Planet*. As this modest title indicates, the essay was an attempt to reassess the fundamentals of human life on earth, from first principles. As you might imagine, I lay awake night after night for many months, wrestling with it. I don't intend to summarize the analysis; if you're interested we've included some copies with the programme material here this evening, and you can also download the essay from the Royal Institute web site. But *Running The Planet* proved to be a distillation of my own world-view. Since writing it I have found that I read newspapers and watch the TV news in a very different way.

One key aspect that emerged is my profound conviction that we humans cannot long survive as a species, on this interconnected planet we share, unless we can rectify the gaping disparities that divide us. As I said in *Running The Planet* 'The co-existence of opulent luxury and desperate poverty, sometimes within the same urban area, is not a recipe for stability'. Nor can we keep borrowing from our descendants.

If we are to meet this challenge, we have to get energy right. We have to make the world work better, and I think we can. But I must close with the closing lines of *Running The Planet*:

'No one knows all the answers. We may not even be asking the right questions. We're all in this together, and we'll need all the help we can get.'

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