The Royal Academy of Engineering

Euro-CASE

How can the EU meet its 2020 Renewables Targets?

Proceedings of the first annual Euro-CASE Conference

3 November 2008

The Royal Academy of Engineering

Euro-CASE

How can the EU meet its 2020 Renewables Targets?

Proceedings of the first annual Euro-CASE Conference

3 November 2008

ISBN: 1-903496-45-4

May 2009

Published by
The Royal Academy of Engineering
3 Carlton House Terrace
London
SW1Y 5DG

Tel: 020 7766 0600 Fax: 020 7930 1549
www.raeng.org.uk

Copies of this report are available online at
http://www.raeng.org.uk/links/international/eurocase

Registered Charity Number: 293074

energy technologies institute

Research Councils UK Energy Programme For a Low Carbon Future

Euro-CASE

The European Council of Applied Sciences and Engineering (Euro-CASE) is an independent, non-profit organisation of national academies of engineering from 21 European countries. Together the Academies count over 6000 of the continent's most senior engineers among their members. Euro-CASE's mission is to pursue, encourage and maintain excellence in the fields of engineering, applied sciences and technology and to promote their science, art and practice for the benefits of the citizens of Europe. More information on Euro-CASE is available at **www.euro-case.org**

Its most prominent policy forum is an annual conference, hosted in turn by member academies, where Europe's leading engineers gather to debate the engineering aspects of an issue of vital importance to the future of the continent.

On 3 November 2008, The Royal Academy of Engineering hosted the first annual Euro-CASE conference at its London headquarters on the topic of the European Union's 2020 renewable energy targets. The conference examined the engineering challenges associated with the targets, and asked: what policies, technologies and incentives need to be put in place within the next decade to ensure that they are met?

The conference set out to:

- Examine the technical and policy barriers to achieving the 2020 targets across the principal renewables technologies and propose appropriate solutions
- Facilitate the exchange of best practice in the promotion of renewable energy across Europe
- Create European networks of experts in the key renewables technologies
- Promote the role of engineers and engineering in delivering the 2020 targets.

Academy President Lord Browne FREng FRS chaired the conference, and EU Energy Commissioner Andris Piebalgs delivered the keynote speech.

Contents

2008 Euro-CASE Annual Conference
How can the EU meet its 2020 Renewables Targets?

Executive Summary

The following is a summary of the key messages delivered at the 2008 Euro-CASE annual conference.

Background

In December 2008, the EU adopted its *20:20:20* package— an ambitious plan to dramatically reduce its carbon output by 20% over the coming decade. It is important both for the global struggle to reduce greenhouse gas emissions and Europe's position at the forefront of these efforts that this package is successful.

One of the most far reaching elements of the package is the commitment to meet 20% of Europe's total energy needs from renewable sources by 2020. In order to achieve this goal, each EU member state has been allocated its own binding target for renewable energy by 2020. These targets are intended to be challenging, both for member states who have not yet invested heavily in renewable energy, and for those where renewables already play a large part in the national energy mix.

Policy Recommendations

If the 2020 renewables targets are to be met, member states should immediately take action to create a level playing field for all energy sources. This can be done by pricing in the externalities of CO_2 emissions, removing regulatory barriers to low carbon energy sources, and dismantling fossil fuel subsidies.

Planning and incentives regimes need to be simplified. Governments should devote particular attention to adapting planning and administrative procedures to new energy sources, including developing 'one stop shops' for planning and licensing. Targeted transitional incentives should be used to promote faster innovation in energy technologies. The lack of appropriate EU and national incentives in several key areas, including heating and cooling from renewable sources, needs to be addressed.

Once a fair incentive framework is in place, the power of the market should be harnessed to deliver favourable outcomes. The best way to achieve this is to set clear, stable and predictable rules, with penalties for non-compliance.

The greatest obstacle to achieving these targets is a lack of political will. Tough decisions will be needed, particularly in reconciling environmental and economic imperatives, and in balancing climate change mitigation needs with local ecological concerns. While politicians are keen to appear in favour of renewable energy, they are not yet preparing the public for the difficult choices that will have to be made.

Priorities for Investment

To ensure that the most appropriate policies are put in place, increased engineering input is needed at every stage of European and national energy policy development. If Europe is to profit from a new generation of green jobs, more investment is also needed in engineering education, particularly in the niche skills necessary for renewable energy generation.

While the 2020 targets can be reached using currently available infrastructure and technology, fundamental technological and structural change is needed if Europe is to meet even more ambitious targets of halving total greenhouse gas emissions by 2050. Research is particularly required in the area of storage technologies and grid adaptation. Ways must be found to aggregate public and private research on strategic energy needs carried out across the EU, either through increased co-ordination at EU level or the development of novel policy vehicles like the UK's Energy Technology Institute.

A European Energy Grid is no longer a speculative aspiration but an achievable goal. If Europe is to have a grid in place by 2050, work needs to begin now on a range associated political, regulatory and engineering issues. In the shorter term, governments should develop principles of systems thinking about national energy infrastructures, and their pan-European dependencies.

Carbon savings from increased deployment of renewables will only achieve their desired impact if they are complemented by strong investment in demand reduction policies and technologies. Greater political priority must be given to the binding energy efficiency targets set out in the *20:20:20* legislation.

A breakdown of the key priorities across the major renewable energy technologies now follows.

Wind Energy

To reach levels required to meet the 2020 targets, the EU as a whole will have to reach the same wind energy density that currently pertains in Denmark– a challenging but not impossible target. While supply chain bottlenecks persist in the supply of cables, specialist offshore wind installation vehicles, and key turbine components, these should be overcome as increased manufacturing capacity comes on line within and outside the EU. By far the greatest constraints to development lie in planning and approval processes and grid access and adaptation. There are also skills bottlenecks- development of offshore wind, for example, will require a large cohort of engineers with the skills to operate in a marine environment.

For offshore wind, the key challenge is not greater efficiency but reduced cost. The priorities are to adapt turbine technology, which has largely been designed for onshore installations, to offshore conditions, and to reduce the cost of installation and foundations. The UK's Energy Technology Institute, which allows government and large energy firms to pool resources on large-scale strategic energy research projects, could serve as a model for states wishing to aggregate and add value to industry research.

Solar Energy

Concentrated solar power could be competitive with fossil fuel power plants by 2017 or 2018. Demonstration plants are in operation which provide around the clock solar energy through thermal storage, or hybridisation with a fossil fuel source. Research needs in the short to medium term include new designs for collectors, receivers and tubes.

For photovoltaic solar the short term research priority is to resolve crucial materials shortfalls— if growth persists at current rates, the photovoltaic industry will be the world's largest consumer of silver by 2020. Longer term research needs also focus on materials for semi-conductor, conductor and encapsulation technologies.

For all kinds of solar power, the more serious challenges are structural— there can be a step change in solar power throughout Europe, but in order to achieve this, major grid upgrades, increased grid access, more interconnections, and more open energy markets are needed. In those countries where they have been applied, feed-in tariffs have not just been good for jobs in solar, but good for solar energy as a whole— as extra capacity is added, the cost of solar falls, and it moves closer to grid parity. However, the German experience shows that a good supply of well trained semiconductor engineers is at least as vital to a strong solar industry as an appropriate incentives framework.

Hydro, Wave and Tidal Energy

Hydro, wave and tidal energy all carry environmental impacts. In conventional large scale hydro power, local ecological impacts are addressed on a case-by-case basis with pragmatic engineering interventions; however, for tidal and wave power proposals, there is a need to balance local ecological considerations, which may be encoded in EU regulations such as the Habitats Directive, against the overall benefits of climate change mitigation.

Wave technology has not developed as far as envisaged during the last thirty years, and still needs considerable investment to overcome planning, grid access and environmental obstacles. In order to provide certainty to investors, government needs to develop a clear, long-term policy framework for financial support, while the industry needs to develop a professional perspective. That means approved standards, an agreed basic device or concept, increased research on cost reduction and strong networks and stakeholder engagement. Under realistic assumptions, installed European capacity could reach 750MW by 2020.

Biomass, Biofuels and Biogas

The target within the *20:20:20* package for 10% biofuels in the transport sector by 2020 has drawn strong criticism from environmental groups. However, supporters note that there are exceptional characteristics to the market for biofuels. In the short to medium term, other renewables are likely to make little contribution to the energy demands of transport. It must also be remembered that for some countries, geographically ill placed for other renewable energy sources, biofuels and biomass are very important for meeting their renewables targets and achieving energy security. Scapegoating biofuels on sustainability grounds risks closing off an important sustainable energy option and impeding the development of a second generation of non-food biofuels. The EU's real responsibility is not to move away from biofuels but to promote international acceptance of biofuel sustainability criteria, which it has led the world in developing.

Improvements in feedstock breeding and the synthesis of lignin and cellulose are showing the way to a second generation of non-food biofuels; at the same time we now have the basic genetic knowledge to create tailor made GM trees for biofuels and green chemicals. There are strong synergies with traditional EU industries such as sugar and paper production, and development of new biofuels must make good use of existing agricultural, research and industrial capacity.

Conclusion

There is a need for global leadership in the tough negotiations on a successor treaty to Kyoto. The EU, with its status as first mover on climate change, its practical experience of managing carbon markets, and its historical legacy of intergovernmental compromise, is ideally placed to take this leadership role— if it can show that it is serious about dramatically reducing its own CO_2 output. The *20:20:20* targets set out a comprehensive framework for reducing the EU's CO_2 emissions by 20% over the next decade. If the policy and investment recommendations outlined above are adopted, the consensus among leading European engineers is that Europe has the technical expertise and manufacturing capacity to meet 20% of all energy needs from renewable energy sources by 2020.

Opening speech and welcome by Lord Browne FREng FRS

President, The Royal Academy of Engineering

Commissioner, ladies and gentlemen, good morning.

I'd like to welcome you all to the Royal Academy of Engineering for the inaugural conference of the European Council of Applied Sciences and Engineering.

We meet during a remarkable period of change and uncertainty.

The immediate policy priority across the world must be to unfreeze the financial markets. However, this must not be done at the expense of longer term but no less pressing goals.

Some people view anxiety about climate change as a luxury afforded only to prosperous societies – as 'a rich man's problem'.

This is a mistaken analysis. Catastrophic climate change would affect us all – especially the world's poorest.

Action on climate change is not merely a hedge against future environmental problems: it's a defence against the risk of social and economic upheaval on an unprecedented scale

The scientific arguments for immediate action on climate change are compelling. But in making our case to the public, we shouldn't be afraid to reach beyond the scientific facts to the implications for society.

Because, at the most basic human level, we are trying to safeguard peace in our children's and grandchildren's generations.

Next year, world leaders will meet in Copenhagen to draw up a successor to the Kyoto treaty. The challenge to preserve peace and stability should be uppermost in their minds.

Politics are particularly difficult at the international level, but there are important precedents for action.

In 1944, statesmen from many different countries met at Bretton Woods, New Hampshire to stave off global economic collapse following the strains of the Second World War.

They created institutions which underwrote a period of growth and prosperity in most parts of the world lasting sixty years or more.

The EU had similar origins.

The establishment of the European Coal and Steel Community in 1951 was rooted in a vision that economic solidarity was the best way to countervail the forces of nationalism and militarism that had wrought so much destruction in Europe.

Now, nearly sixty years later, the successors to EU founders Jean Monnet and Robert Schumann have been confronted with another threat to peace and stability – climate change.

Their response came in an historic agreement in March 2007, fleshed out in January 2008 in the Commission's Climate Action and Renewables Package – a package which, as we speak, is in the final stages of negotiation, with legislation expected in the next few months.

One of the most far-reaching aspects of the package is the commitment to meet 20% of Europe's total energy needs from renewable sources by 2020.

Today's conference will look at the renewables target from an engineering perspective.

Global Perspectives

But first, a word needs to be said about the broader context in which the package is appearing.

We are living through probably the greatest period of change and uncertainty in energy I've witnessed in my career so far.

Change is occurring in just about every conceivable dimension, but I'd like to single out three: the energy mix, players and politics.

Having been fairly static over the past three decades, the energy mix is becoming increasingly diversified over time.

All energy sources – high-carbon and low-carbon – have been growing in recent years in response to rising demand.

But low-carbon energy sources have been growing much faster: solar power at around 40%, wind and biofuels at 30%.

Diversification is happening for two principal reasons:

- First, high oil, gas and coal prices, which have been passed through to the costs of the two sources of delivered energy: electricity and transportation fuels
- And second, rapid cost reductions in low-carbon technologies as they have scaled up. Costs have come down around 20% every time their capacity has doubled.

As a result of these factors, gas, coal, nuclear, and renewable electricity sources will soon be competitive with each other – an outcome being accelerated by carbon pricing.

Transport fuels are currently 95% reliant on oil. But diversification is happening here too, most significantly through the introduction of biofuels, which this year will provide the single biggest increase in liquid fuels production outside of OPEC.

At the same time, high energy prices, coupled with climate change and energy security concerns, are leading to significant improvements in energy efficiency. US gasoline demand may already be in long term decline, in large part because the US car fleet is becoming more efficient.

It is, as always, very difficult to predict the future direction of the oil price – still the most important pricing benchmark in energy.

Oil, as with all commodities, is a highly cyclical business.

But it's a fact that oil extraction costs have risen dramatically in recent years – and are likely to rise further as production migrates to ever-more technically challenging places.

This factor alone suggests that we are unlikely to see a dramatic, long-term fall in the oil price in the foreseeable future.

Dramatic changes are also taking place along the second dimension I'd like to talk about – energy market players.

In oil and gas, national oil companies are increasingly calling the shots. These companies now control as much as 80 percent of known reserves.

In renewable and alternative energy, there are 1,500 'clean tech' funds, backing a panoply of solar, wind, wave, tidal and biomass technologies.

There are also a plethora of new players: ranging from fund-backed start-ups, to software companies investing in energy efficiency, to agribusinesses backing new biofuel technologies.

We don't yet know which approaches will be most successful. Who will be the first player to create a renewable energy 'major'? How quickly will regional businesses emerge in European renewables, or global businesses in biofuels?

The final dimension of change is the enhanced role of governments throughout the energy sector.

Governments are reverting to historical precedent by becoming more interventionist. And the energy market is no exception.

The increasing geographic concentration of supplies, and their dislocation with key consuming nations, is leading to political interventions in energy markets on both the supply and demand side as energy security concerns mount.

At the same time, climate change concerns are leading to a proliferation of fiscal and regulatory policies designed to promote energy efficiency and alternative energy supplies.

Some people argue that governments should go even further.

They see 'green Keynesianism' – large-scale government spending on low-carbon projects – as a means to pump prime economies during the impending economic downturn.

So we are in the midst of a great deal of change. And when so much is new, unclear and uncertain it can be difficult to see the path ahead.

At times like this, societies look to principles to help them navigate.

Principles for Government

As Europe's politicians, businesspeople, NGOs, scientists and engineers grapple with the energy and climate package, I'd like to suggest four such principles during my remaining remarks today.

The first is: establish a level playing field in energy.

The most important step is 'pricing in' the externality of carbon dioxide emissions – a cost which would otherwise not be recognized by the market.

That means a basket of measures tailored to different sectors, including fiscal policies and regulations. There is no silver bullet.

Cap and trade schemes have emerged as the preferred approach to reap carbon savings from large stationary emitters.

The EU has led the world on this front. But the EU's Emissions Trading Scheme is in danger of stalling.

To make a real difference, it's essential that the lion share of its carbon permits are auctioned rather than given away for free.

Establishing a level playing field will also require removing barriers that are hindering the deployment of low-carbon energy sources – for example grid regulations designed around the needs of high-carbon incumbents and cumbersome planning laws. The average renewable power plant in Europe has to gain approval from 9.5 authorities before it can be built.

Obstacles to the regional trading of power within Europe, and the global trade of biofuels, must also be removed.

Finally, a critical step in establishing a true level playing field is dismantling subsidies on fossil fuel based energy sources. A little known fact is that, globally speaking, such subsidies total more than $200bn a year globally, compared with $33bn for renewables and nuclear.

The second key principle I'd like to mention is the importance of promoting accelerated technological innovation in energy.

As we know from other sectors of the economy, new technologies require carefully targeted, transitional incentives to accelerate their development and deployment.

Again, there is no silver bullet. A basket of feed-in-tariffs, mandates and capital grants will be needed – depending on the nature and maturity of the technology and on the broader policy context.

A particularly large challenge is getting incentives right for carbon capture and storage.

This absolutely critical technology is currently stuck on the starting block because of lack of policy support.

It seems to me the key next step is to fund a number of CCS demonstration projects – something explicitly recognised in the EU package.

The most effective way to do this would be for governments to give out capital grants to promising projects, while at the same time assuring the long term competitive position of CCS by including it in the EU emissions trading scheme.

Of course disbursing the grants required – perhaps totaling a billion euros each – will be very difficult politically, especially in strongly representative democracies.

Earmarking a portion of revenues from auctioning carbon permits is emerging as a favoured approach. Whichever mechanism is chosen, it should balance the need for alacrity with the need for transparency and fairness.

As well as carefully targeted incentives, collaborative technology networks across Europe will be essential to compliment national efforts.

The role of the Strategic Energy Technology Plan and the newly established European Institute of Innovation and Technology will be crucial in this regard.

The third principle is to harness the power of the market, but to do so in the right way.

Markets are the most effective delivery units available to society, but they must be properly regulated.

In my view, 'Green Keynesianism' is not the right answer.

Rather, policymakers should set clear, stable and predictable rules coupled with penalties for breaking the rules. Then, the market – private enterprise – should be left to deliver the outcomes required within the rules that are laid down.

That's why the EU's 2020 targets are so important.

This is an example of clear, stable and predictable policy. And the market is already responding. For example, the pull of the targets is largely responsible for the progress made in offshore wind, in this country and others bordering the North Sea, over the past few years.

Reneging or dismantling the targets that have been announced, or making them indicative rather than binding, would in my view be a big mistake. It would damage the investing environment in renewables in Europe for a generation.

One place where there is particular risk of this happening is biofuels.

I believe biofuels can and should play a critical role in global efforts to combat climate change and enhance energy security.

But their potential is being hampered by alarmism and misunderstanding.

Concerns about bad biofuels are justified. But the right way to distinguish between the good and the bad is through clear, stable and predictable CO_2 and sustainability standards rather than by making sweeping, negative policy changes.

The fourth and final principle I'd like to talk about this morning is the importance of global leadership.

Reducing greenhouse gas emissions to a safe level will be impossible without a global agreement at Copenhagen next year.

Equity issues have emerged as the greatest stumbling blocks in those talks: how the costs of cutting carbon should be shared between developed countries – source of most carbon emissions to date – and developing countries – source of most emissions in the future.

I believe Europe could make a tremendous difference here.

As a global first mover on climate change targets, the EU has the credibility to be a leader in international negotiations.

As the first region to have adopted an international carbon trading system, it also has the practical experience.

And Europe has important political experience. It is used to operating in a world of overlapping sovereignty, to striking a balance between supranational institutions and Member State governments.

Such experience will be critical. Because I believe addressing climate change will be impossible without enhanced international climate institutions: able to manage, monitor and verify national and regional efforts.

So I continue to see Europe at the vanguard of global efforts to address climate change, despite the pessimism we've heard in some quarters in recent weeks.

As the world faces up to the challenge of stabilizing CO_2 concentration in the atmosphere, our watchword must be solidarity – a term that is fundamental to the vision of the European Union and also highly appropriate for today's gathering of scientists and policymakers from many different countries.

During our discussions today, we should remember the words of one of Europe's founding fathers, Jean Monnet. He said that his main objective in life was, and I quote: "to make men work together, to show them that beyond their differences and geographical boundaries there lies a common interest"

It's my sincere hope that our current generation of leaders also takes heed of these words.

Thank you very much.

Keynote Speech

The Commission's vision for renewables

Andris Piebalgs, EU Energy Commissioner

Introduction

Good morning and thank you for this chance to set the scene for today's conference and recommend to you the "climate-energy" package proposed by the Commission earlier this year. It is a package that I believe is bold and ambitious, reasonable and balanced – and today I will expand on why this is the case.

Where will the renewable energy come from?

In January 2008 the Commission proposed a package of Directives that would implement its *20:20:20* targets: 20% renewable energy, 20% greenhouse gas emissions reductions, and 20% improvement in energy efficiency – all to be achieved in 2020. The Commission's analysis showed that these 20% targets are feasible on all fronts. But I'm going to focus on the renewable energy target. I must also add that, as part of the 20% renewable energy target, there is a 10% target for renewable energy in transport: this had already been agreed by the EU's Heads of Government. Clearly, the expansion of renewable energy will have to accelerate significantly across Europe, and not least in the UK. But it can be done.

Our analysis suggests how Europe might get there. We estimate that as much as 34% of electricity will be produced from renewable energy sources, of which 12% will probably come from wind. We will see strong growth from Combined Heat and Power installations using biomass. Solar, as we will hear later, will play its role – and we expect the costs of solar energy to decline by 50% by 2020[1] . Renewables in the heating sector could double to around 18%, using more biomass, efficient CHP and household heating. Renewables in the transport sector could also expand quite significantly by 2020, using both biofuels and electricity in vehicles. The technology-specific sessions later today will explore the prospects of these individual technologies and how they will contribute economically, as well as environmentally, towards reaching the renewables target.

Country examples

My job is not to tell the UK how to meet its target. But I would like to use the opportunity today to tell you some of the good things we see in other Member States.

Spain

We hear about the variability of wind energy. Well, wind electricity in Spain provides about 10% of electricity on an average day, and on 18 April this year (a Friday – not a weekend) the contribution of wind reached 32% of Spain's power needs. Spain has managed to integrate wind energy into its network through a better grid management strategy (including forecasting) and investment in equipment. Spain is also pioneering the use of solar thermal power generation at the Abengoa plant near Seville.

France

France has a tidal energy project at Rance that has been supplying renewable electricity into the French national grid since 1967. Although modest in size, at 500 GWh a year – it does have the virtue of actually existing. Furthermore, it produces electricity at a cost of approximately 12 Euro-cents per KWh. I should mention here that I recently visited the Severn Estuary to learn for myself what options were being examined for harnessing tidal power here in the UK.

Portugal

Portugal too wants to invest more in marine energy, and has announced plans for 1 GW of capacity to be put in place within the next decade. Last September, Portugal inaugurated the world's first "wave farm", consisting of three wave energy converters, developed by the Scottish company Pelamis Wave Power. This "wave farm" has an installed capacity

1. Solar PV

of 2.25MW, enough to meet the average electricity demand of more than 1,500 Portuguese homes. A second phase of the project is now planned to increase the installed capacity from 2.25MW to 21MW using a further 25 Pelamis machines.

Denmark

Let us not forget that one of the ways of helping to meet the renewable energy targets is to reduce total energy use – in which case, the same amount of renewable energy production makes a higher proportion of the total. For example, about 75% of Denmark's district heating is produced in combined heat and power plants that generate both heat and electricity simultaneously, and 40% of this is without any CO_2 emissions at all, thanks mainly to the use of biomass. Basically, this CHP technology raises a 40% rate of efficiency to 90%, and so less fossil fuel is used and less CO_2 produced. This illustrates nicely how the different targets (RES, GHG and energy-efficiency) are all linked.

Latvia

Finally, a word about "the country I know best". I give this example because sometimes options are sitting there waiting to be discovered. Latvia has enormous under-exploited biomass potential. About 55% of the surface area of the country is covered by forests. A recent study presented to me suggests that between 33% and 60% of Latvia's total energy consumption could potentially be met by indigenous biomass. Coupled with hydro-power, this suggests that Latvia could potentially be almost carbon-free for its power and heating needs.

The Directive

Following extensive discussions with stakeholders, we came forward with the legislative package in January 2008. Here, we strived to address all the problems that the renewable energy sector faces today:

First, there needs to be a stable policy regime: legally binding targets for each Member State would be fixed – differentiated according to their specific circumstances. These targets would set the goals. We also require Member States to prepare "National Action Plans" which spell out how they will reach the targets: we don't prescribe sectoral shares for electricity, or heating and cooling, but Member States will have to assess and determine for themselves where the growth will come from. They will also have to explain what the shares will be and what instruments will be used to ensure the targets are reached. In the meantime, the Directive sets an "indicative" trajectory that Member States will be expected to meet in order to show that they are "on track".

Second, there is need for flexibility in order to reach the targets in a cost-effective way. So, in addition to the flexibility of setting their own sectoral targets, Member States are free to decide on the instruments and measures to be used: it could be the on-going use of obligations on suppliers (such as with biofuels today), renewable energy obligations, or so-called "ROCs" in the UK context – in the electricity sector – perhaps together with feed-in tariffs for novel or small scale technologies. It could include more support for household biomass heating or solar hot water systems… these are ideas that are being aired in the UK. Flexibility is also allowed between Member States. Member States may choose to undertake collaborative bilateral or multilateral projects, or transfer an over-achievement by one Member State to compensate for an under-achievement by another. All these options for flexibility lead to greater cost-effectiveness in meeting the targets.

We also modify the existing regime for electricity to ensure that electricity imported from third countries can count towards Member States' renewable energy targets: so Member States can invest in cheaper renewable energy sources within the EU and in neighbouring countries, helping to build biomass power plants in Albania or the Ukraine, for example, or solar plants in north Africa. These can be much more profitable investments, and so both parties benefit: we get cheaper renewable energy to count towards the target; they get new sustainable energy infrastructure.

Third, improvements need to be made to the administrative and planning regimes. As Commissioner I have found that there is not one Member State of the 27 where people are satisfied with the planning regime for renewable energy. There is not one Member State out of 27 where the administrative arrangements and procedures could not be simpler and clearer. The Directive aims to tackle this, and in so doing, have a direct impact on reducing the costs industry faces in developing renewables.

Fourth, we need to focus more attention on electricity grid access for renewable electricity: we already have a legal framework for this, but it doesn't appear to be strong enough, or its implementation adequate enough. Green electricity is going to have to grow substantially in order for us to reach our targets, and any aversion to decentralised or distributed generation, or concerns about intermittency, have to be overcome – as they have been overcome in some countries (I already mentioned Spain).

Finally, given the wide debate on biofuels, our Proposal establishes tough but effective criteria to ensure that the biofuels used in Europe generate real greenhouse gas reductions and other benefits – and indeed, lead the world in establishing strict criteria for biofuels sustainability.

So this is our Proposal. There are a range of obstacles facing the development of renewable energy in all Member States, and we have tried to address each of them. Since we published the proposed law in January, it has been working its way through the European legislative process. Discussions are now intensifying between the EU's 27 Energy Ministers in Council and Members of the European Parliament. Throughout all of this, I have continued to meet with Ministers myself – including UK Ministers John Hutton and Ed Miliband – to hear their concerns and to try and help address them.

We very much hope that the Council and European Parliament will agree this new framework by the end of this year.

As already mentioned, the renewables Directive is just part of the package. Our efforts to improve the Emissions Trading System and to cut greenhouse gas emissions by 20% will clearly work in tandem.

Improving energy efficiency is still the most cost-effective means of reducing emissions – we already do a lot in this area – emissions standards for cars (currently being strengthened), labelling regimes, eco-design minimum efficiency standards, and energy efficiency codes for buildings. Action is being taken on all these fronts and will be strengthened in the coming year. In a matter of days, the Commission will publish its second Strategic Energy Review together with our plans for revising and improving key elements of our energy efficiency legislative framework.

So the Commission believes it has put forward a coherent package that will help all of us in Europe meet our energy and climate change goals – and importantly, help persuade other regions of the world to act.

Costs

Let me now touch on the economic aspects of the energy and climate package and of the renewables proposal in particular. To begin with, I should note that our analysis of the package suggests that the short term net financial and economic costs of the package will be very modest. There is clearly a direct cost of the policy, but it is relatively minor, and we believe that there is a clear medium-term gain.

For the UK, we estimate the costs as being up to about 0.41% of GDP, or a little under £1 billion a year by 2020. This compares favourably with the billions of pounds used in the UK's banking rescue package. Even compared with the normal "business as usual" energy investments that are needed to replace aging power plants and infrastructure, the quantities are relatively small and the overall gains clearly significant and worthwhile.

Economic crisis

All of which brings me to my final point: there are those who are saying that we can no longer afford such a package.

In response, I would say that there are a range of safeguards already in the package to address the issues: energy intensive industries and internationally exposed sectors can be protected - we have a framework for that. The auction revenues raised by auctioning in the Emissions Trading Scheme will provide a huge source of revenues that governments can use to soften the economic burdens. I would even say that EU companies face less uncertainty in terms of carbon constraint that many of their competitors in the US, in Japan, or in other industrialised countries. But more importantly, it is time to realise that we don't have a long-term choice about developing a low carbon economy. Climate change, vulnerability to high fossil fuel prices and energy security mean that we must not let current market turmoil distract us.

Conclusion

So my message today is that we have a very clear vision of how the renewable energy targets will be met – and I welcome the UK Government's fleshing out of its own ideas in the consultation document launched by the Prime Minister last June.

The sessions later this morning will explore the technologies that will help us meet our objectives and the ways in which the growth of renewable energy can be encouraged. These are important issues and I wish you a successful conference.

Thank you for listening.

Wind Energy

Wind Energy

Is there sufficient EU wind energy industrial capacity to meet the 2020 targets?

Dr David Lindley OBE FREng
Director
Pelamis Wave Power Ltd
UK

Meeting the European targets will require a massive increase in installed wind turbine capacity. Expansion of manufacturing should be able to meet this demand, given stable markets secured by long-term support mechanisms. However, there are other constraints on growth, which must be dealt with, including planning delays, grid access, cable supply and – for offshore wind – availability of specialist installation vessels.

The requirement

It has been estimated in a recent report by Douglas Westwood Limited to the UK Government that, if the EU target of producing 20% of electricity from renewables by 2020 is to be met, approximately 320,000 MW of onshore wind turbines and 24,000 MW of offshore turbines will be needed in Europe.

At the end of 2007, total worldwide wind turbine capacity was approximately 94,000 MW, of which about 57,000 MW was in Europe. New installation amounted to approximately 20,000 MW worldwide in 2007, with 8,300 MW in Europe.

Installation rates in emerging markets such as France and Poland have been growing rapidly and the Deutsches Windenergie-Institut forecasts that European installed capacity will increase to 130,000 MW by 2012, a growth of approximately 14,500 MW per annum. Maintaining that rate to 2020 would yield a total European capacity of about 250,000 MW. This falls short of the required target by about 70,000 MW.

The same report forecasts that worldwide wind energy installations will grow to 287,000 MW by 2012.

Capacity

Wind Energy use Worldwide as of 31.12.07

Country	Total installations End 2007, MW	Power installed in 2007,MW	Forecast until 2012, MW
USA	16,879	5,244	60,379
Canada	1,845	386	10,045
South and Middle America	667	185	5,467
India	7,845	1,617	22,845
P.R.China	5,875	3,287	42,375
Japan	1,681	229	3,731
Other Asian countries	487	147	4,162
Australia and New Zealand	1,293	327	4,093
North Africa	468	83	3,193
Middle East	101	0	561
GUS	27	3	1,557
Other countries	11	0	41
Total Europe	56,766	8,287	129,491
Total Worldwide	93,945	19,795	287,940

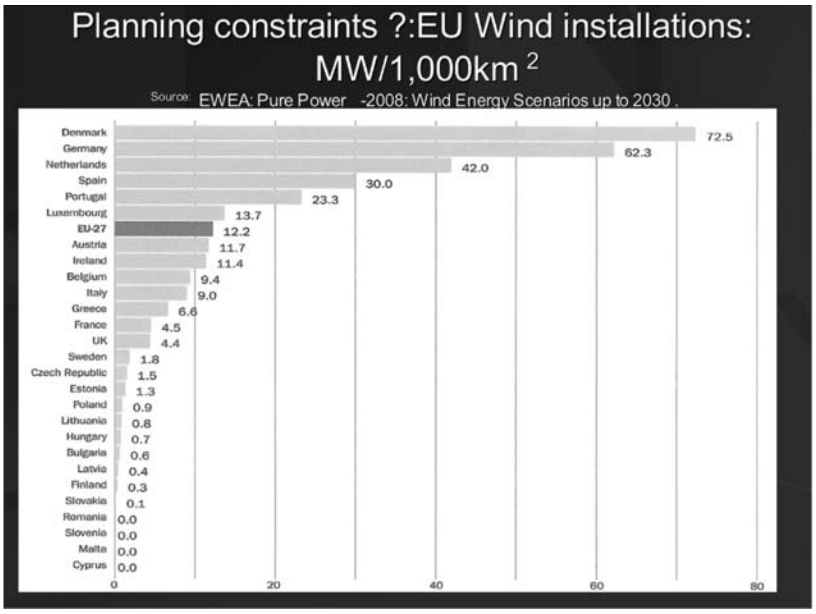
UK studies published in 2008 foresaw practical constraints in meeting UK wind power targets. There are indications of growing lead times across the industry, especially for supply of blades, bearings and generators. The strong market has also driven turbine prices up by up to 30% over the last 2 years and this has already had an effect on the financial viability of some low wind speed sites. However, the indications are that global production can be increased by new and existing turbine manufacturers already investing in new capacity.

There are 127 wind turbine manufacturing sites in 16 countries. Of this total, 26 are in Spain, 23 in Germany, 12 in Denmark, 8 elsewhere in Europe (including 2 in the UK), 14 in the USA, 9 in India, and 29 in China. The larger manufacturers such as Vestas and Gamesa each maintain about 30 sites across the globe and provide the largest proportion of components for their turbines themselves. They have expanded production to meet market growth. Market leader Vestas has facilities in seven EU countries and in addition, owns a nacelle assembly facility in China, a rotor blade manufacturing facility in Australia and a production facility in India.

Although in the last 2 to 3 years demand for turbines has led to increased delivery times, it has also increased investment in manufacturing capacity. For example, Siemens, which provides a complete turbine including the blades, nacelle, hub and tower, plans to triple output, from 1,500 MW in 2007 to 4,500 MW in 2011. In the few years since Siemens bought the Danish manufacturer Bonus, it has increased the number of employees involved in its wind energy business from approximately 700 to more than 3,500.

The number of manufacturers in China has also increased rapidly. Some of these have acquired technology through joint ventures with European and other manufacturers. Some Chinese manufacturers such as Goldwind and Sinovel will soon be ready to export turbines. The very strong market for wind turbines also continues to attract new players and investors.

Other constraints



The most likely constraints on annual installation rates will arise from planning and grid access issues for onshore turbines. Offshore installations will face similar constraints, as well as additional cost versus risk considerations. EU Governments must also maintain stable, long-term financial support to attract private sector investment.

Planning is a big issue in many parts of Europe, particularly in Britain. The planning process in Britain can take several years and be very costly with a very uncertain outcome. If you look at how many megawatts have been installed per 1,000 km^2 of the country, Denmark has the highest density with 72.5 MW for every 1,000 km^2, whereas the average for Europe is about 12 or 13; the UK average is only 4 MW per 1,000 km^2.

What happens if you try to achieve the EU 2020 targets? The total area of the EU is 4.3 million km^2. The current wind energy installed capacity is around 57 GW, equal to about 13 MW per 1,000Km^2 . Achieving the EU target will require a density of 74 MW per 1,000Km^2 - or equal to the Danish figure. So it's not impossible.

Just as an example, the target for wind energy for the UK set by the Renewable Advisory Board is 18 GW by 2020 on land, which would require a density equal to that already achieved in Denmark, in addition to 13 GW offshore to give a total installed capacity of 31GW. The planning system in the United Kingdom already has about 8,500 MW of projects in the pipeline which have not yet obtained consent. Some of them have been there since the year 2000.

Offshore wind farm construction is also limited by the number of specialist installation vessels. There are only two such vessels that could be dedicated to UK waters and this limits installation to about 350 MW/year (equivalent to about 100 offshore turbines), significantly below the rate needed to meet UK targets. To meet this another five vessels are probably needed.

Cable supply is an additional constraint. High voltage AC and DC cables from existing manufacturers are booked up for the next five years. About 1,500 km of high voltage AC and 7,300 km of high voltage DC subsea cable will be required to meet a target of about 30 GW of offshore wind generation, according to a report from Sinclair Knight Merz to the UK Government. This is significantly greater than the current rate of supply to the UK offshore wind generation projects under construction and there are no indigenous manufacturers of suitable AC and DC subsea cables.

The same report concludes that in the UK the time taken for processing local planning consents and inconsistency in reasons for refusals result in uncertainty, delay or abandonment of projects. It also indicates that grid infrastructure bottlenecks are a major constraint to deployment.

Supply chain issues

According to a recent report published by the Danish consultants BTM the shortage in supply of key components for wind turbines should be resolved in time to meet a projected global demand for 50,000 MW in 2012. They say that although the supply chain to the international wind power industry is currently subject to severe constraints in certain key components and materials, "the turbine suppliers should be able to meet an annual demand for new installed capacity of 50 GW per year by 2012, but only if there is substantial increase in production capacity and quality improvements in the supply of specific materials". The assessment concludes that, although wind turbine manufacturers have been able to respond to annual growth of 30% since 2004, the supply of key components and materials has struggled to keep up. These include gearboxes, large bearings for gearboxes and the turbine drive train, forged components for the main shaft, gears and bearings and cast iron in the quantities required by the industry.

What can Europe do?

As long as the wind turbine manufacturing and component supply industry is confident that there is a long term market, it is well able to respond by increasing manufacturing capacity and acquiring and training the personnel required. There is clear evidence of this happening in China, the USA, India and the EU.

The European Wind Energy Association (EWEA) has reported that priority access to the grid for renewables is essential if the target is to be met. Renewable energy companies still face discrimination because the electricity market continues to be controlled by power companies with both generation and transmission assets. The EWEA cites delays of up to 6 years from application to connection. Arguments such as "system security" are used as a pretext for prioritising conventional power generators.

The current difficulties in the financial markets are also likely to constrain the rate of development in the next 2 to 5 years. In particular offshore wind projects will be more difficult to finance. Lenders to and investors in offshore projects have already slowed the rate of progress of some projects because of the re-assessment of risks.

Conclusions

Some recent reports suggest that there are real and potential supply constraints for both components and complete turbines and delivery time for a turbine has increased, often to 2 years or more. Existing turbine suppliers have responded by investing (or planning to invest) in increased production capacity and the wind industry consultants, BTM of Denmark, believe that supply side of the industry will be able to produce up to 50,000 MW per annum by 2012.

The real constraints to the implementation of EU 2020 targets are unlikely to arise from the inability of manufacturing industry to increase production capacity (especially given the probable growth of Chinese, Indian, US and EU manufacturers and the growth of new entrants). Other, more likely constraints include:

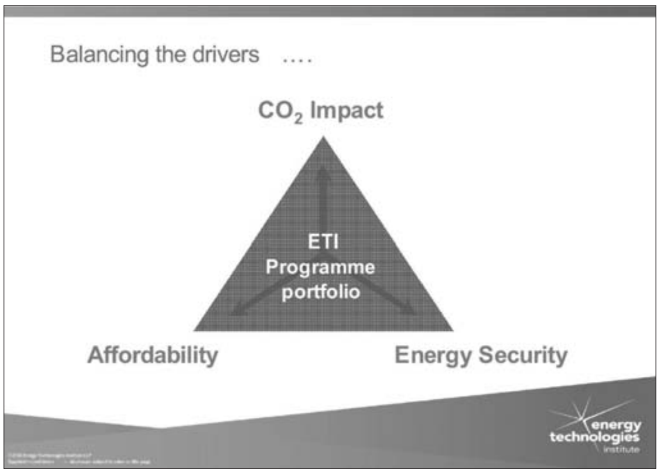
- Difficulties in some EU countries in obtaining planning consents
- Difficulties in accessing the electricity grid and the time it is likely to take to obtain consents and build new electrical grid infrastructure.
- The costs to developers of maintaining a place in the grid access queue in some countries.
- The increased difficulty in raising project debt for all wind energy projects in the current financial climate.
- The particular constraints in the offshore wind farm sector arising from the limited number of offshore installation vessels and associated equipment.
- The increased costs and risks associated with offshore wind farm developments that will inhibit the start of many EU offshore projects.
- The need for sustaining long term support mechanisms throughout EU countries. This will underpin the long term decisions that manufacturers and component suppliers need to make to increase their production capacity. This will lower the perceived risk of investment and project finance provided by the banking sector.

Accelerating deployment of response to the challenge of climate change

Dr David Clarke
Chief Executive
Energy Technologies Institute
UK

The Energy Technologies Institute in the UK focusses on CO_2 impact, energy affordability, and security of supply. Offshore wind has high priority, and promises well on all three criteria. Affordability is the main area where are improvements are still needed. Innovative approaches such as direct drive turbines, superconducting generators, new materials and floating turbines may all contribute to eventual achievement of cost competitive generation.

Energy Technologies Institute



The Energy Technologies Institute (ETI) was launched in January 2008 and it brings together the capabilities of industry and the UK government. Its role is to demonstrate low carbon energy technology systems, and to address issues around energy usage and energy efficiency. It is not about fundamental research, it is about technology demonstration, system demonstration. But if we do that, we will also identify the big barriers which can only be overcome through next generation science and technology development.

From my point of view there are three issues. In any energy project we will be looking at the potential for CO_2 impact, energy affordability, and security of supply. Individual projects will not necessarily address all three, and there will be different combinations.

Offshore-specific wind is our current top priority, but we are also looking at marine projects based on tidal stream and wave power, and then a range of fossil fuel-oriented projects, distributed energy, small-scale generation systems, ways to use waste heat effectively, and carbon capture and storage. Underpinning all of that is the question of systems modelling. A good system model for the energy system, whether it is in the UK, or in Europe or wherever, is essential for making informed decisions.

Improvements in wind power systems to 2020

I will concentrate on offshore wind for the UK. The wind around the UK is second to none from an energy yield point of view. Wind speeds in the North Sea range from 6 to 25 metres per second. Energy yield is proportional to wind speed cubed, so that is significantly better than you would expect from an onshore installation, and clearly it produces no CO_2.

On energy security, the sites we are talking about are all within UK waters. The capacity factor dictated by the irregularity of wind speed is probably better around the UK than anywhere else in Europe – about 30%. As we go further offshore it should become slightly better still – although this would be tempered of course by maintenance issues in deeper water. And that brings us to affordability.

Costs of offshore wind for the UK

Affordability is improving but it is a big, big challenge. Affordability and cost are key issues for 2020: the efficiency of the machine at this point is secondary.

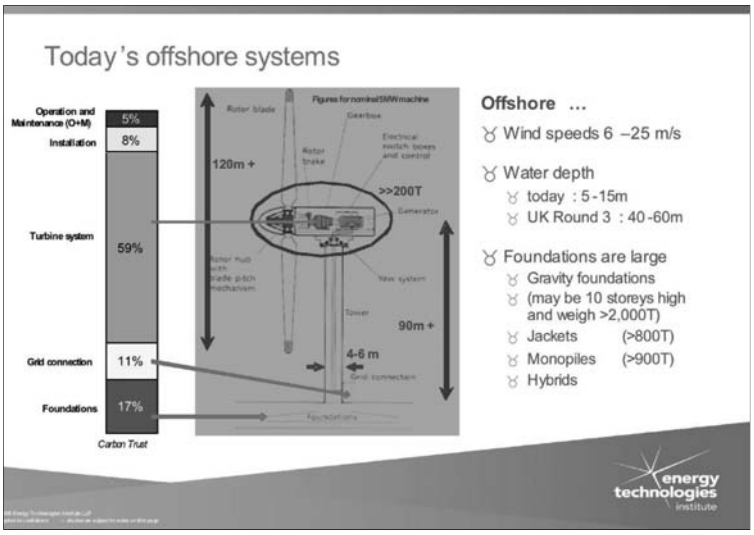
Where are we today? Depending on whose numbers you use you will get a slightly different answer. The recent Carbon Trust analysis put costs at £2.5 million (€3 million*) per MW and 9.4p per kW hour, or £95 (€116) per MW hour for a mid-distance, mid-depth offshore installation.

If you looked at those numbers in early 2007, they were high prices compared to a big central plant. However, by early November 2008 fossil fuel prices had risen to 7.5p per kilowatt hour, so offshore wind does not actually look too bad.

** At November 2008 exchange rate*

But then we need to consider the deployment target of the order of 20 GW. What does that mean? Probably about 3,000 turbines. So for the next 10 years we need to install three to five turbines per week, every single week of the year and you cannot go in every week because of the weather. So is it achievable? I think it is, but it is very difficult. The sites that have been talked about for the forthcoming Round 3 of UK offshore site licenses offer an additional 25 GW of capacity, but the challenge is that 80% of the sea bed is deeper than 40 metres, and is more than 60 miles (96 km) offshore. There is great wind power potential but it is a challenging environment.

Today's offshore systems

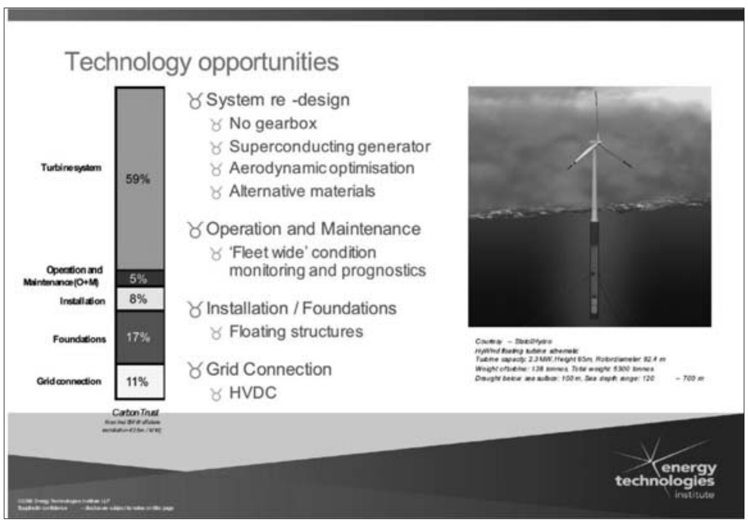


Let's look at today's offshore systems. In a typical installation roughly 60 % of the cost is the turbine itself on top of the tower. You then have grid connection at around 10 %, and foundations at 15-20 %. These are the big ticket items: the turbine, the grid connection and the foundations. Operation and maintenance and installation are relatively small in comparison. Bear in mind the total is £2.5 million (€3 million) per MW, and this is a 5 MW machine.

That looks reasonably straightforward until you look at the machine. Between 200 and 500 tonnes of equipment is being put on top of that tower. The rotor is at least 120 metres across and you are installing it 90 metres above the water. The foundations for today's typical machine can be 10 storeys high and weigh 2,000 tonnes. It is a massive installation.

So If you are going to bring this to the point where it is cost competitive with other systems for 2020, you have to do something about the foundation, logically, and you have to do something about the weight on top to bring the installation cost down.

Technology opportunities



What might you do about some of these things? On the turbine system itself, virtually every single one of the turbines that are in the water at the moment were designed to go onshore.

Current design and development issues include gearbox reliability, weight from an installation point of view, blade life, and blade damage. Can we remove the gearbox? Can we take the gearbox out of the machine completely and go for direct drive? It can be done. Onshore machines are now available without a gearbox, though on a slightly smaller scale than planned offshore installations.

Can you substantially improve the efficiency on the generator or reduce the weight significantly? There are a number of options for that. A superconducting generator superficially sounds like a flight of fancy but Converteam in the UK are developing such a machine with support from the UK government. So there are opportunities around that and the other machines which also have completely different styles of generator that will reduce cost, weight and improve reliability.

Aerodynamic optimisation of the blades also offers opportunities, as do alternative materials. Can we get away from steel? Again General Electric are building a tower out of concrete at the moment to demonstrate that we can, and there are other manufacturers interested in concrete materials.

Operation and maintenance offer opportunities around condition monitoring and prognostics. Vestas is probably the only company at the moment which has the scale of operation for fleet-wide management of their turbines. The others are catching up but they are not quite there yet.

As for foundations, can you build floating wind turbines? Statoil Hydro are demonstrating a machine right now which will be going into the water next year. It rises about 100 metres above the water, and has a draught of 100 metres below the water, built out of concrete. It weighs 5,000 tonnes, and is tethered to the sea bed, but will be essentially fully independent of water depth. Where the deep North Sea installations will be in 60 or 80 metres of water in some cases, they are talking about going into 700 metres of water in some installations in the Atlantic.

Target: cost competitiveness

Given that spread of improvements in foundations, structures, and reliability, could we achieve cost-competitiveness?

In a world where you have to run a coal plant and do something from a cost point of view about CO_2, in the best case you are looking at 6p-7p per kWh. Offshore wind is getting close to that already, and realistically that will come down. As fossil fuel prices increase, it will be even better placed, and that is without factoring in carbon dioxide pricing. So the potential is there.

Wind energy's future in Europe

Mr Erik Kjaer Sorensen
Director
Group Government Relations Department
Vestas Wind Systems A/S
Denmark

In Europe, wind energy is the second-fastest-growing source of newly-installed generation capacity, a growth driven by energy security, climate change and fossil fuel price concerns. Further growth can be encouraged through long-term regulatory and policy stability, fair pricing and an integrated long-term spatial planning and grid planning programme.

The context

I start from the premise that meeting the 2020 targets is driven by energy markets and market forces. Liberalised markets are not the same as unregulated markets of course, and thus energy markets are driven by public policies. For better or worse policy-makers can promote or inhibit, create or destroy, a market's potential to achieve a sustained supply of renewable or any other kind of energy. In many countries public policies are contributing to the impressive expansion of renewable energy.

In Europe, wind energy is the second-fastest-growing source of newly-installed generation capacity, surpassed only by natural gas. Vestas Wind Systems is the world's largest wind turbine manufacturer by market share. One third of all turbines installed globally are Vestas turbines, currently more than 37,000 turbines in 63 countries. What is driving this growth? One key factor is the quest for greater energy security. That requires local sources of energy that free society from dependence on fuel imports, particularly imports from volatile regions. Unpredictable fossil fuel costs are also encouraging countries to diversify their energy supply. This becomes all the more urgent as the demand for energy continues to grow. Climate change is another major factor driving the growth of wind and other sustainable energy sources.

The importance of policy

What can policy-makers do to ensure Europe meets its 2020 targets? The essential factor is long-term market predictability. An obvious start is ensuring that renewable energy is a key part of energy planning. Clear political decisions to promote renewable energy and establish binding renewable targets are essential. National action planning is currently under way in most of the EU countries based on a variety of policies. Long-term regulatory and policy stability enables more accurate predictions for returns on investment, which in turn reduces the risks and the associated costs. Investor confidence is fundamental.

Another important factor is fair pricing. Premiums for renewable energy can level the competition from established subsidised plants. Vestas advocates eliminating all subsidies for energy, but that day has not yet come. There are substantial subsidies elsewhere in the energy sector, but Vestas believe that wind can be highly competitive on a future level playing field.

Another issue is guaranteed access to well-developed electrical grids. This enhances investor confidence by ensuring that if the power is produced it will be bought and fed into the system. As is often the case, streamlined planning and permit processes remove barriers, reduce costs and speed implementation. Something approaching a one-stop shop for all required permits is certainly worth considering.

In Europe, Germany and Spain are two of the more successful countries in terms of promoting renewable energy. Their experiences demonstrate the positive impact of enlightened public policies. Let us also keep in mind that even in the overall EU 2020 context each country has to determine its own path towards meeting its 2020 obligations, via the national action planning process.

In 1991 Germany introduced a renewable energy law and has updated it several times since. The law sets specific targets for renewable energy penetration, most recently 12.5 % by 2010 and 20 % by 2020. (The latter target has now been further revised to 30 % by 2020.) Establishing official targets sets in motion a series of other policies and processes. In Germany, for example, the law guarantees priority grid connections and access for electricity from renewable sources. Further, grid operators and utilities are obliged to buy the renewable electricity at a fair, fixed minimum price – a feed-in tariff. Investors can confidently predict the return on their investment.

The law also provides for differentiated tariffs based on the commercial readiness of different technologies. More mature renewable technologies like wind power receive a lower tariff than less market-ready technologies like solar or tidal, and this encourages the development of new technologies. Further, the law calls for tariff decrements, that is gradually lower tariffs each year over a fixed period. This promotes innovations that lower costs.

Combined, these policies stimulate competitiveness and encourage innovation among different technologies, which contribute to further diversifying the country's energy mix. Additionally the costs of the feed-in tariffs are passed on to consumers, not paid by the State body as a subsidy. This distributes costs across all power consumers, including those in parts of the country that do not produce much renewable energy. This will ensure that no region bears a disproportionate burden to create the benefits that all citizens enjoy.

How significant is the burden on the German consumer? According to a March 2008 government report the higher tariffs paid for renewable energy added about €3 per household per month. It is not a lot.

Turning to Spain, why have wind and other renewable energy sources taken off there? Again politics and policies shape the market. Launched in 1995 and continuously upgraded since then, the key elements in Spain's renewable energy regulations include specific renewable energy targets, most recently 29 % renewable electricity by 2010, and 40 % by 2020. As in Germany, Spain guarantees renewable energy sources will have priority connection and access to grids. The electricity producer can choose to be paid a fixed feed-in tariff or a fixed premium on top of market price. The prices are updated annually in relation to the inflation index. National grid development takes renewable energy specifically into account.

The Spanish and German cases have things in common. Both benefit from clear, long-term policy and regulatory commitment to promote renewable energy, including specific targets, and a guaranteed grid access, guaranteed prices, and a feed-in tariff system. Supply chains, that is the engineering capacity and the industrial capacity required, will build when clear long-term and predictable signals are given.

Of course many public policy frameworks are only part of the story. Let me highlight two other key things needed for meeting the targets: grid infrastructure and spatial planning.

Spatial planning is a tool to plan the use of physical space in a country, region or city. A spatial plan can define for example where there will be roads, industrial areas, power plants or transmission lines, showing also where there are nature conservation areas and other uses of the land. Many countries do not currently carry out comprehensive long-term spatial planning for energy developments, and this leads to an ad hoc allocation of space over the years, which in turn can lead to unnecessary conflicts.

Upgrading the grid

With specific reference to wind energy, Vestas urges governments to identify available wind resources and to take a systematic long-term planning approach to large-scale wind power integration in their energy supplies. This relates directly to grid modernisation. Today's electricity grids were designed many years ago for fossil fuel technologies which have very different characteristics from modern renewable energy technologies. Regardless of these differences, grids in many countries are in urgent need of upgrading. Operating procedure for grids is another area which needs adjustment when large amounts of wind and other fluctuating sources of energy are introduced.

Upgrades to grids are expensive and slow. As countries plan for their energy futures they should plan their grids with renewable energy technologies in mind. This includes extending grids to reach those areas where wind and other renewable power sources are abundant, both on and offshore. Governments would benefit from promptly upgrading their National Grid plans in parallel with a spatial planning process. An integrated approach to siting and grid planning will help in modernising grids. National and regional spatial planning makes it clear in advance where grids must be reinforced and extended over time.

In conclusion, consistent long-term integrated planning is required. It sounds easy; it is not. It is difficult enough on the national level, and all the more so when contemplating the EU-wide action or even the worldwide action that is taken. If achieved, however, the long-term benefits will be very positive. The necessary supply chain will be established when clear, unambiguous and long-term policies are put in place by national governments.

Solar Energy

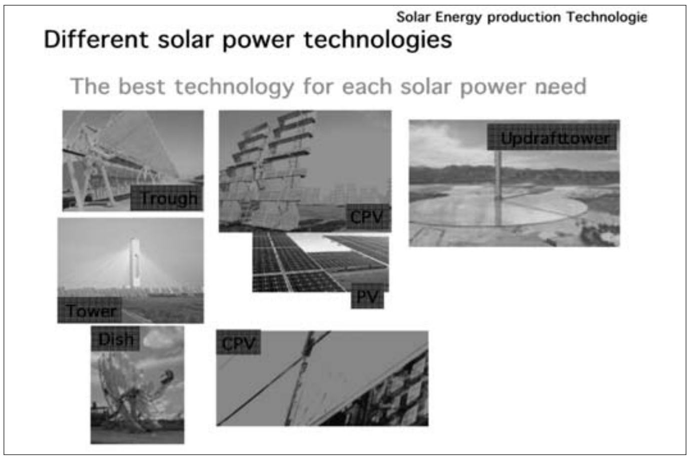
Solar Energy

Solar energy developments in Spain

Professor José Domínguez Abascal
Chief Technology Officer
Abengoa
Spain

Solar thermal power plants are a mature technology. Heat storage (using molten salt) and hybrid operation will improve usability. Solar can be competitive with conventional electricity generation before 2020. Charging for CO2 emission will improve the cost comparison even sooner.

Growth of renewables



There are many different predictions of how renewable energies will grow in the near future, but they have a common theme. We have to increase current levels of renewable energy generation fourfold by 2020, and tenfold by 2050.

There are two reasons. Sometimes we talk too much about the first and not enough about the second. The first is climate change, obviously, but the second is peak oil. In 10 years we will reach peak oil and that means if we need more energy it will have to come from a different source.

Solar energy is an important source in that context. It has enormous potential because it is sustainable, it is clean, and it has low emissions. It is a mature technology. Both photovoltaic solar and concentrated solar power are technologies which can already produce electricity which is almost competitive with electricity from conventional sources. Solar power will be a good substitute for fossil fuels, and if we have adequate policies we are hopeful that we will be able to develop it very competitively in only a few years.

The range of solar technologies

There are a variety of different solar power technologies. The most mature technology is concentrated solar power (CSP) using parabolic troughs to track the sun and concentrate sunlight onto thermally efficient receiver tubes. The heat is then used to generate steam, and converted to electrical energy in the normal way. There are many plants being promoted with this technology in different countries – in Spain, in other European countries, in North Africa and the United States. The energy can also be stored, using molten salt, to even out irregularities in the daily cycle, or the plants can be hybridized with fossil fuel generation.

The second concentrated solar power technology is tower technology, using an array of heliostats focussed on a central receiver on top of a tower.

Alternatively, a dish can concentrate sunlight on a single receptor which contains a heat transfer fluid. This has high levels of efficiency, but there are technical challenges remaining.

Then there are the various photovoltaic technologies, which I will not dwell on here. But photovoltaic cells will develop very quickly and it is clear that all the thin film technologies are getting much cheaper even though there is a long way to go in increasing the efficiency of these kinds of systems.

Finally, there is the solar updraft tower, in which a canopy of glass or Perspex panels is installed around a central tower. Heat from the sun increases the temperature of the air under the canopy. As the air increases in temperature, a natural air flow is induced. This air flow is controlled such that the point of least resistance is via the central tower. Located at the base of the tower are multiple wind electric turbines.

Challenges for solar thermal power plants

There are many technical challenges on the way to making solar power collection and conversion more efficient, and therefore more competitive. We need new designs for collectors, receivers and tubes. More economical collector designs will be available in the short-term with easy-to-implement quality control procedures. Receiver pipes designed to meet different requirements will be available in the medium term – for example non-evacuated low-cost receivers for temperatures below 300 C and semi-evacuated receivers for higher temperatures.

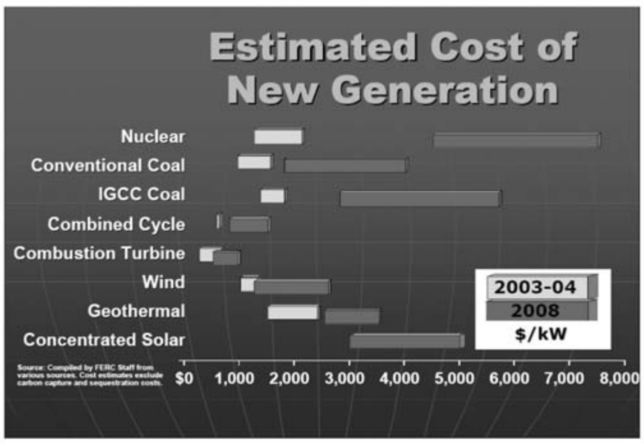
Oil as a heat transfer fluid will be replaced by other working fluids. The best option cannot be found without testing it under real conditions in a pre-commercial solar plant. But I would like to draw attention to the thermal salt system. We are building one plant in Southern Spain with a molten salt system for six to eight hours of energy storage, so this will make it possible to have almost constant production, or at least to produce energy for most of the day. We use existing tower technology and increase operating temperature. That in itself offers an efficiency gain. However, there is some way to go in improving receivers and heliostat technology and the overall efficiency of the plant. The use of two-tank molten-salt storage systems in the mid-to-long-term still strongly depends on pilot plant operation and maintenance results.

The other potentially interesting solution for thermal power plants is the hybrid concept. This is a plant that uses sun when you have sun but uses fossil fuel at other times. The renewable contribution to energy generation can be around 50 % Our company is building a plant like this in Argelia, which is probably the ideal place to do it today, and it is a 50 megawatt design.

On cost comparisons, at the moment we have to invest €4,000 per megawatt in concentrated solar plants. You can see how this compares with other sources in the table.

Energy production

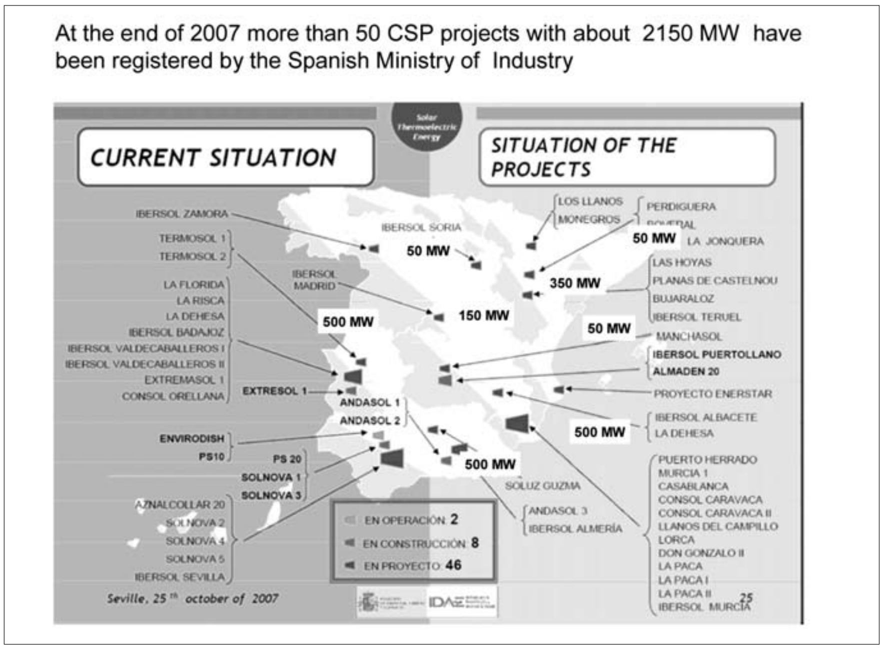
Energy production cost



USA Department of Energy, Federal Energy Regulatory Commission, Item N.: A-3 June 19, 2008.

These costs are the new installation costs but do not include operation and maintenance or fuel. Our projections are that if we do not include the CO_2 emissions and other greenhouse gas effect emissions then we will be competitive with fossil fuels by the year 2017/8 or thereabouts. However if electricity generators are obliged to pay for CO_2 and other emissions the cross-over will occur well before then. In any case, by 2025 we expect to be able to produce solar thermal energy at 40% of today's costs.

In conclusion, CSP introduces solar energy to high-value markets, with high temperature processes providing high capacity and usability. Solar thermal power plants offer a wide portfolio of integration options with heat storage or hybrid operation for massive production of electricity. The first commercial projects are already underway in Spain and elsewhere.

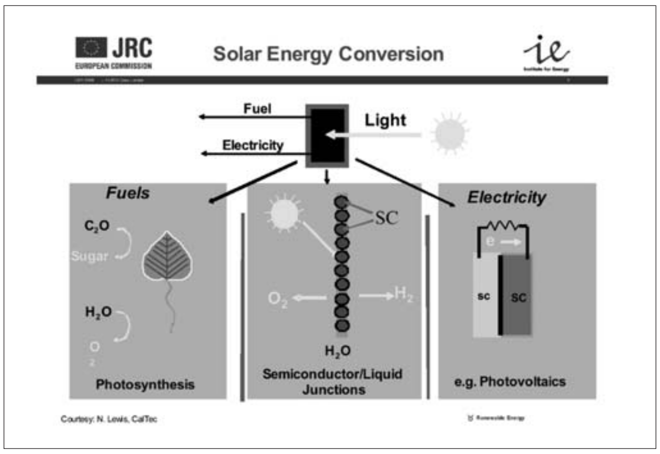


As the map above illustrates, there are 50 projects which now have permission from the Spanish Minister of Industry, which in total will generate more than 2,000 MW. They will be competitive with fossil fuel power plants in a few years.

Production and Market Implementation of Photovoltaics

Dr Arnulf Jaeger-Waldau
Senior Scientist
Institute of Energy
European Commission Joint Research Centre

Decreasing costs driven by technological advances have made photovoltaic solar electricity a very attractive option, particularly in Southern Europe and the Mediterranean. Yet questions remain over whether photovoltaic supply chains can cope with projected growth rates. Research is needed on diverse new materials, mass production and a smart grid. To fully exploit the European potential of renewable energies and PV, a high voltage DC electricity grid will also be needed, and work on this must start now if it is to be in place in the medium to long term.



I am going to introduce one of the most promising technologies for solar energy conversion, and examine how its potential can be realised in Europe. There are basically three pathways for solar energy conversion:

- photosynthesis leading to the production of fuels
- splitting water with the semiconductor liquid junction, generating hydrogen and oxygen
- generating electricity with photovoltaics (PV) and Concentrated Solar Thermal Power (CSP).

It is said that the PV electricity potential of Europe, especially in Northern Europe, is not that large - this is actually untrue. In Southern Britain, for example, what you can harvest over the course of a year is not that much different from Germany. Even the Baltic regions have potential— 700- 900 kilowatt hours can still be generated from a kilowatt system using PV, so it depends on the price you are willing to pay.

In the Mediterranean the figures are of course, much better and the interannual variability of solar resources very small. You can predict how much energy there is to harvest. In the long term, photovoltaic solar is a reliable energy source and fits very well with the markets.

Cost of photovoltaic electricity

On reasonable assumptions for average lifetime, interest rates and performance, current benchmark systems are capable of producing photovoltaic electricity at a cost of 15-18 Euro cents per kWh in the Mediterranean region, which is not far away from the rate that consumers currently pay for electricity. In the South of England the cost is in the range of 27-30 cents which is higher than the current rate but not too far away.

We predict that the cost of generating photovoltaic electricity can decrease below current prices and with current technology development and market expansion, this may be a possibility by the turn of the next decade. So can the supply chain cope?

Worldwide PV production and announced capacity increases

Last year we had production of roughly 4 GW of photovoltaic modules worldwide but published company plans point to a tenfold increase by 2012. This is not unrealistic; a tenfold increase over the next five years is possible but if we go beyond that we have to look at certain constraints of the current supply chain.

A shift in technologies has also increased the potential for photovoltaic. Most of the output is still based on silicon wafers and there has been a tremendous improvement in this technology. For example, in the last five years wafer thickness has roughly halved, from 350 microns to 180 microns. However there is enormous potential to go further. The development of new thin film technology is one of the chances to bring down costs. In addition, Europe is in a very good position because Europe is pursuing all the different technologies to avoid running into a roadblock. This is crucial for large penetration of this technology. We should look at all the options. The European Photovoltaic Industry Association suggests that in Europe by 2020, it's possible to reach 6-12% of all electricity generated by PV. This is at annual growth rates in the range of 28-35%. We are currently experiencing 40-50%.

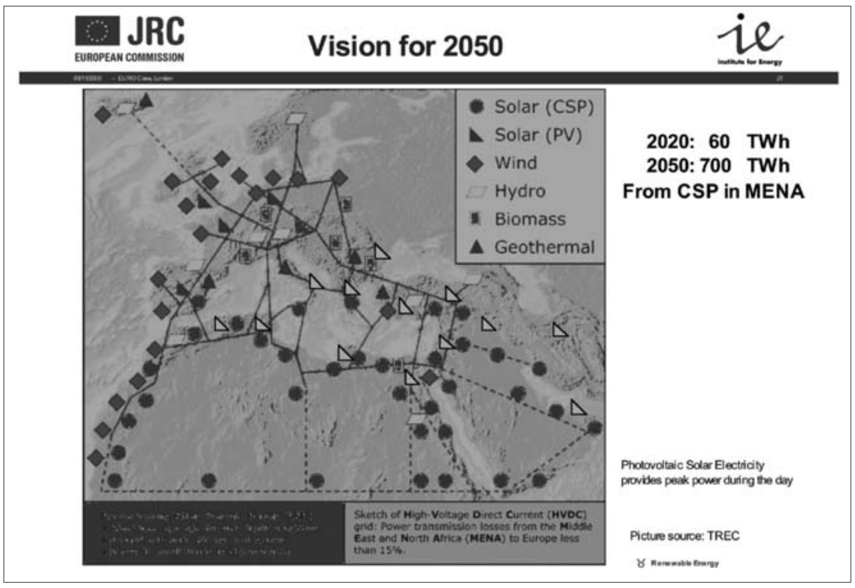
However, there are limitations and bottlenecks. For example, between Southern Italy and Northern Italy, only 2,200 MW can be transported on the current grid system. This means that if we installed 10 GW of photovoltaic in the South, it is inaccessible: we cannot transport the power so the grid will need to be upgraded immediately. Spain is also in a similar situation. If we really want to realise the large potential to use photovoltaics and other solar energy sources in Spain or throughout the Mediterranean, we have to increase grid capacity.

Research needs for photovoltaics

Research is needed for photovoltaics. In the short term we need grid integration and a way to overcome potential shortages of crucial materials, for example silver. If technological development and market growth continues at the current rate, the photovoltaic industry by 2020 would be the largest silver-consuming industry in the world and this will create serious implications for prices. For the medium and long term we need materials, materials, materials. There is a huge challenge for engineers and basic materials scientists to look into alternatives, not just for semi-conductor materials but also for conducting materials and for encapsulation materials, for the next generation PV technologies.

In construction, PV is usually added on. It is not considered in the design of the building. This has to change if solar energy and PV are to be better exploited. Then there is the definition of a 'lifetime'. People say that it is 20 or 30 years but in Ispra we tested modules 20 years ago. We put them out for 20 years then re-tested them and 85% of the modules are still fully functional. So we have no doubt that the lifetime of the modules could easily be in the 30-40 year range. Even after 40 years modules could produce at least 80 per cent of their nominal power if manufactured properly.

Engineering challenges for photovoltaics



To expand this industry there must be mass production. Photovoltaic is just now moving from its infancy in manufacturing to industrial production and we need engineers who can do this. All renewable energy technologies also need grid management with decentralised power, a "smart grid" and storage. There is potential for innovative developments which would increase the attractiveness of PV – for example, ways to integrate PV in buildings and to combine PV modules and electricity storage in the same device. This is another challenge for engineers.

In the medium and long term we need a European high voltage DC backbone for all renewable electricity to transport wind-generated power from the North to the South and solar generated power from the South to the North. There is currently a question concerning maintenance costs of a PV system but it is in general not the module which would be unreliable, but the electronic components.

Regarding access to the grid, there are only a few countries where priority access is given to renewable energy - this has to be changed. Then there is the question of who pays for the connection. Is it society or a single producer? Grid management also needs to be improved.

The map summarises a long-term vision (DESERTEC) developed by a consortium called TREC (Trans-Mediterranean Renewable Energy Cooperation) , asking "What can we do in the long term to combine renewable energy sources in the Mediterranean (mainly solar), along the Atlantic Coast (wind), and also geothermal, bioenergy and hydro, all over Europe?"

To realise this kind of vision there has to be a high voltage backbone, but to achieve this even by 2050 we must start now. In the central Mediterranean region if this high voltage backbone is not created there is no possibility to transport the power which could be generated by renewable energy sources.

In conclusion, photovoltaic electricity in Europe and the Mediterranean is already very attractive, notably at peak times - there is a huge PV potential which is untapped in Southern Europe and the Mediterranean. To realise and reach 12% PV electricity generation by 2020, intensive research and engineering efforts as well as smart grids and high voltage DC electricity grid lines are necessary. We need this infrastructure and if we don't start now it won't be in place by 2020.

Promoting renewable energy in Germany

Professor Frank Behrendt
Acatech Fellow
Energy Innovation Centre
Technische Universität Berlin
Germany

Germany has had legislation in place massively promoting renewable energy since 2000. The main provision is for a feed-in tariff which costs consumers about €3 per household per month. It has helped increase solar photovoltaic installation and production, so that Germany now has a 20% worldwide market share of the worldwide market for PV. Training and supply of skilled workers have been as important in Germany's success support for the market. Further expansion of use of PV in Europe will depend on investment in an improved grid.

The Erneuerbare Energien Gesetz (EEG), the Act granting priority to renewable energy sources in Germany, came into effect in its current form in April 2000. It has two main goals. The first is promotion of renewable energy sources of various kinds to reduce dependency on fossil fuels, mindful of the prospect of peak oil. The second is reduction of greenhouse gases.

Monitoring its impact in different areas has led to revisions. In 2004 the Act was amended by changing some of the incentives. And a further revision will be implemented in 2009. These changes also caused some problems especially in relation to biofuels in Germany. Consequently, there is a clear wish for a more stable and straightforward funding scheme, without the oscillations that we have seen over the last few years.

How the tariffs work

The law does not provide for government subsidy. The additional cost incurred by electricity suppliers for the feed-in tariff is covered by consumers. It amounts to about €3 per household per month. The cost depends on the amount of renewable energies covered by the tariff over the next few years, so it could go up significantly. This also has to be monitored so that we are not pushing this funding scheme to a level which reduces dependency on fossil fuels by making it difficult for some people to pay for electricity.

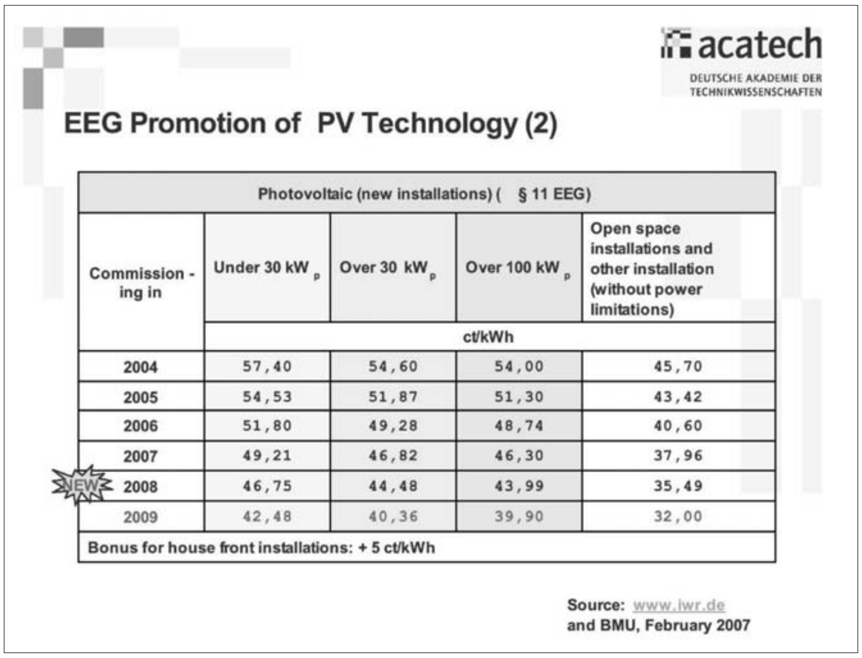
The tariffs are different for specific technologies, and are gradually reduced over time. This tapering has been significantly increased in the 2009 version of the law. The price is normally guaranteed for 20 years after the completion of a qualifying power plant, so that the operators have a secure return. But the amount of funding will go down – depending on the type of renewable energy source - by 5% or more per cent each year to encourage cost reductions. Only energy generated from renewable sources within Germany will be eligible for compensation, so transport of biomass from Spain to Germany, for example, is outside the scope of the scheme.

Solar energy

The EEG promotes the use of photovoltaic (PV) technologies, subject to certain restrictions on time of commissioning and requirements for urban development. Funding is dependent on the amount of power which can be generated at a single site.

The table gives the rates for the years 2004-2009 for three peak-power levels: up to 30 kW, above 30 kW, and above 100 kW. The larger installations normally gain lower levels of funding. There is a bonus for house-front installations. This is intended to promote the integration of photovoltaic elements into the construction of buildings, rather than open site installations which consume a serious amount of open space, and could create a tension between our new energy policy and the way in which we treat our landscape.

What was the result of the EEG? It took a few years but then there was a strong increase in installation of solar modules. We had a 1 GWpeak installation base by 2007, compared with under 50 MWpeak in 2000. There has also been a big increase in the production of photovoltaic elements and modules in Germany. In the late 1990s the volume of solar modules produced was pretty small. But in 2007 Germany had about a 20 per cent worldwide market share. This is a significant amount given that this is high technology and Germany does not occupy a very prominent position in worldwide semiconductor production. We expect to be able to maintain this. The German government recently relocated one of the so-called Spitzencluster ("High-Tech Cluster" funded with €40m over a period of five years) to a region in East Germany where most of is the country's solar modules are manufactured. The good thing about this



acatech
DEUTSCHE AKADEMIE DER TECHNIKWISSENSCHAFTEN

EEG Promotion of PV Technology (2)

Photovoltaic (new installations) (§ 11 EEG)				
Commission - ing in	Under 30 kW $_p$	Over 30 kW $_p$	Over 100 kW $_p$	Open space installations and other installation (without power limitations)
	ct/kWh			
2004	57,40	54,60	54,00	45,70
2005	54,53	51,87	51,30	43,42
2006	51,80	49,28	48,74	40,60
2007	49,21	46,82	46,30	37,96
NEW 2008	46,75	44,48	43,99	35,49
2009	42,48	40,36	39,90	32,00
Bonus for house front installations: + 5 ct/kWh				

Source: www.iwr.de
and BMU, February 2007

region is that the companies being established there have been able to recruit highly trained personnel from the former GDR semiconductor industry. This has been a considerable boost to employment. Companies involved in PV show the strongest growth in Eastern Germany, generating more jobs than companies in the "old" fields of technology like chemistry and energy. About one billion euros will be invested in that region in 2008. For the next five years approximately 20,000 new jobs a year – three-quarters of them in the East– are expected for Germany in PV.

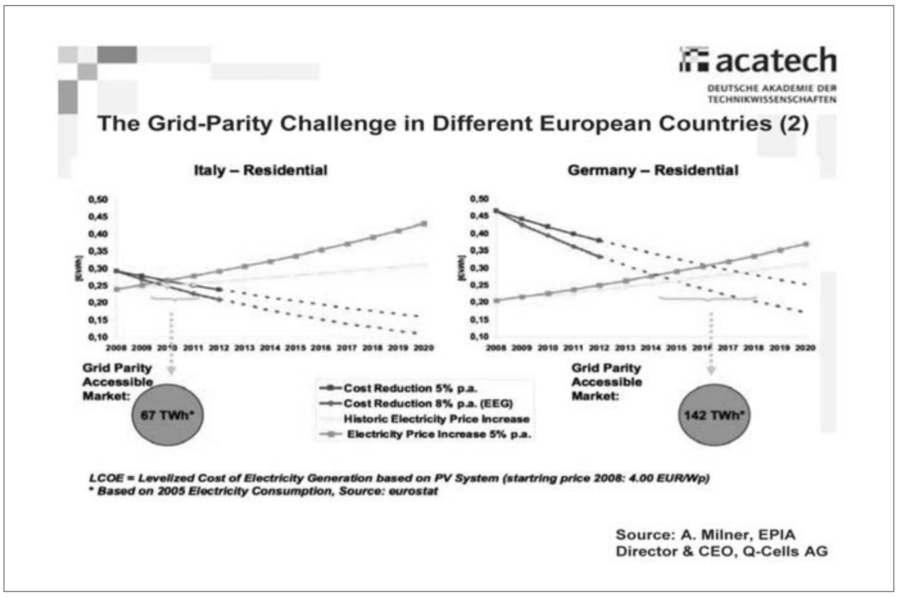
However, this law is only a part of the story behind PV growth in Germany. One needs to keep in mind that simply pouring money into this field does not work. You have to talk about the innovative capacity of the country. That means the universities, the research institutes, and also the R&D departments of the companies involved. In the end, the companies have to make the investments.

For semiconductor plants the investments are roughly of the same order of magnitude for a PV plant as for a plant for memory chips or computer chips. You definitely need skilled workers, and if you do not have them then you have to come up with a scheme to educate and train people, at all levels.

In the former East Germany the EEG brought the money in and the people were also there. The big challenge the companies are now facing is that all the skilled workers are essentially fully committed. If companies want to expand further they will need to overcome this. That means working with the universities and other educational institutions.

So, the law is important. It helps to bring products to the market, but if you want to do additional research, if you want to have additional production capability, you need innovation, R&D, and investment, and you need trained people. Otherwise the rest of the money is wasted.

The grid parity challenge in different European countries



At current prices PV is not really competitive. But that will change. Exactly when PV becomes competitive depends on the assumptions you make. For example, you may choose the average of past rates of electricity price increases, or the current rate of increase, which is slightly higher. In addition, one must assume some average rate for cost reductions in PV generation. The result also depends on location, as PV costs are higher in some countries than others. If you look at two countries, Italy and Germany, and plot the historic price increase, or the current price increase, for electricity sold to the end-user on one side and the gradual reduction in the price of PV power on the other, you can see where the lines cross.

On this graph, the trends indicate that so-called "grid parity" for solar PV and conventional generation will arrive in Italy by around 2010, and about 8-10 years later in Germany. Germany is definitely not a very good country for PV; it is a reasonable one but not a fantastic one.

What I tell my students is: 'A good place for PV installation, not research and production, is a location where you are also able to grow a reasonable red wine'. This is definitely the case in the Mediterranean, and it is possible in parts of Southern Germany and France and so on. Nevertheless the question is whether it is reasonable to put PV on each and every Germany rooftop, or more helpful to do the development and production there and to actually install it in those regions where the application is more fruitful and effective?

The answer depends on grid adaptation. If we achieve about 15 or 20% improvement in efficiency by 2020, PV costs will have come down and consumer prices will have gone up so that PV has parity with other sources in roughly two thirds of the European market by 2020. Such calculations indicate that by 2020 photovoltaics can reach grid parity. That means they can be used for the same cost as conventional electricity for about 90% of European electricity demand. We have to be careful about these numbers. If, for example, we bring photovoltaics up to about 12% of Europe's electricity supply there will be competition between photovoltaics and wind in certain regions.

The development of a reasonable European-wide electrical grid is absolutely essential to distribute the electricity from the places where it is generated – wind more on the coastlines and PV power more in the Mediterranean area – to the industrial centres of Europe. Those centres most definitely do not coincide with the renewable power production sites, so without a grid we are in deep trouble here. The kind of grid we are proposing has never been planned and never been installed. In Germany the average time between planning and installation of an electrical grid or part of a grid is about one decade, for various reasons. That means we have to start to come up with a reasonable grid pretty soon. We cannot make promises about electricity generation if we are not able to bring this electricity to the consumer, whether industrial or domestic.

Politics and industry need to interact here. For example, at least in Germany we have strong opposition to over-land lines for electricity, but underground lines are pretty expensive compared with over-land lines. If we want to develop renewables we will need one or the other. We have to be very open in our discussions and we have to have this discussion pretty soon. Will we build renewable energy sources on a large industrial scale – and that is what we are talking about here – and how can we then bring the electricity to the consumer?

Hydro, Tidal and Wave Energy

Hydro, Tidal and Wave Energy

The Severn Barrage : Europe's Largest Proposed Tidal Power Project

Professor Roger Falconer FREng
Halcrow Professor of Water Management
Cardiff University
UK

The proposed Cardiff to Weston Severn Barrage would have a range of environmental effects, reducing the inter-tidal habitats and tidal currents but increasing light penetration and water clarity. If built, the barrage would reduce flood risk, create 40,000 jobs, increase the potential for tourism and recreation and, most importantly, produce 9 tWh of electricity per year- meeting 5 per cent of the UK's electricity needs.

Tidal power is very attractive. It is predictable. A limited input of tidal power is expected to be built across Europe by 2020 but as I understand it, large projects will count toward the targets if they are in progress at the time.

In Britain, the Severn Estuary is very attractive from the point of view of providing renewable tidal power because it has the second-highest rise and fall of tide in the world. The UK government through the Department of Energy and Climate Change is currently analysing the range of options for this Estuary. If we put this into context: Wales has a plan to produce 14 tWh per year from marine renewables by 2025, and if the barrage were to be built it would provide nine of those. It is a massive project, one of the biggest engineering projects ever undertaken.

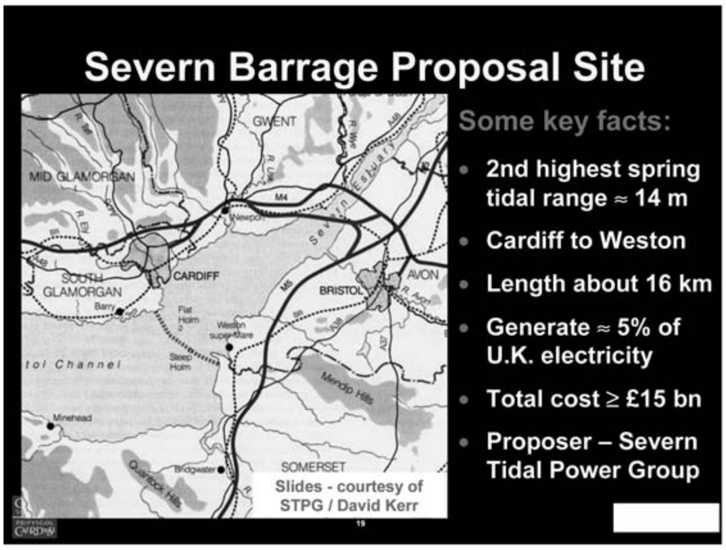
If you look at the planned renewable energy provision from the European Union at the moment, tides and waves constitute a very small component of what could be produced – and I do think there is a lot of opportunity to expand this.

In the UK there are two areas in particular where there are high spring tides which offer great opportunities to convert our tidal potential energy to kinetic energy and then through the system into electricity. On the Severn, the tidal range under spring tide conditions and near to the location of the proposed barrage will be around 14 metres.

The current proposals that are being considered by the Government through their contractors Parsons Brinckerhoff include a whole range of options in different parts of the estuary. The one I am focussing on is the one called the Cardiff to Weston barrage. This is what is called the outer barrage and has been discussed for at least the last 30 years.

There are three proposals for converting tidal energy from the Estuary. The first is tidal stream turbines. These are wind-type turbines underneath the water surface. The energy comes directly from tidal stream currents. The problem is that such turbines typically require 30 metres of water and a current of two metres a second before they become financially viable and there are very few sites where these could be placed outside navigation channels in the estuary. So the Severn Estuary is not very attractive for tidal stream turbines.

Then we have tidal impoundments (lagoons) either offshore or attached to the coastline. These are smaller scale than the barrage. A typical offshore lagoon proposal in Swansea Bay envisages a square kilometre lagoon, with 9 km of embankment, yielding 124 GWh per year. The estimated cost – which I believe to be far too low - would be around £200m (€245m) and you would need 135 such lagoons to match the energy potential from the Severn barrage. I do not want to give the impression that it should be either the barrage or 135 lagoons because I think we need all of the renewable energy that we can get over the next century, but we need to put things into context. The offshore lagoon does not offer any flood defence, for example – in fact, in many ways it may cause a range of hydro-environmental problems associated with redistributed currents, such as large tidal eddies.



The barrage was first proposed in 1849 by Thomas Fulljames. The original intention was to build a wall, a bridge basically, across from England to Wales, mainly at that time for rail communication.

The modern proposal spanning the stretch from Cardiff in Wales to near Bristol in England is costed at £15 billion. The barrage would consist of 216 turbines, each nine metres in diameter, generating 17 TWh per year. That is 5% of the UK's electricity. There would be sluice gates, fish passes and locks to get into the port of Bristol and so on.

It would be constructed in the form of large caissons, built in various deep water ports around the UK, transported to the Estuary and linked together.

There are a lot more complications but they would not be built on land in the normal way as was the case with smaller barrages that have been built recently in the UK, for example, the Cardiff Bay Barrage. A public road could then be located on top of this barrage.

The idea is that the water would come in on the incoming tide. It would then be held upstream, the tide would drop on the seaward side and then, when the head difference was large enough, the water would be released through the turbines generating electricity on ebb tide only. The main consequence of this is that the 14 metres spring tide near Avonmouth would be reduced by about half.

Estuarine environment

The existing estuarine environment with that 14 metre range under spring tide and 7 metres under neap tide conditions has high tidal currents. This means that small craft will find it pretty well impossible to use the estuary for recreation.

There are 30 million tonnes of suspended sediment in this estuary in spring tidal conditions. Under neap tide that drops to one seventh of this, four million tonnes. The neap tide range of seven metres is what we will have if the barrage is built, so the suspended sediment levels will be expected to drop accordingly.

There is very little light penetration through the water column at present. It just looks like fluid mud under spring tide conditions and there are relatively low dissolved oxygen levels in the water column. It is a very harsh environment, with limited aquatic life, and the bird numbers are small per square kilometre compared to other British estuaries.

What would be the main effects of the barrage? The reduction in tidal range would lead to a significant loss of inter-tidal habitats – mud flats – estimated at 14,000 hectares, but a barrage would reduce the tidal currents considerably. It will reduce the turbidity and suspended sediment levels dramatically and the water will become much clearer. There will be much more light penetration through the water column. This will increase primary productivity in the basin, and there will be a changed biodiversity. This means we could even operate the barrage in such a way that we could sequestrate carbon.

As already noted, the upstream tidal range will still be seven metres, bigger than the Humber, the Thames, or the Mersey.

The tidal elevations would be reduced both upstream and downstream of the barrage so the currents will be reduced considerably. The sediment would drop out dramatically. This also has a big impact on taking out faecal bacteria and other water quality indicators, which now come down the river from sewage outflow and are adsorbed onto the sediments. If more of the sediment drops out of the water column, then the adsorbed bacteria are taken to the bed and the bacteria in the water column decay more rapidly. The barrage also gives us the big benefit of flood defence.

So in summary, the Severn barrage would have a lasting impact and we need to look at it in a European context. If we hold back this project we then ask questions about a whole range of similar projects which we might want to consider across Europe. It will provide 5% of the UK's electricity from renewables. It would reduce the inter-tidal habitats by 14,000 hectares. It would reduce the tidal currents and the suspended sediment levels but it would increase the light penetration and the water clarity. It would change the ecology and the benthic flora and fauna in this estuary. It would reduce flood risk, both upstream and downstream. It would create up to 40,000 jobs across a wide range of sectors, and it would increase the potential for tourism and recreation.

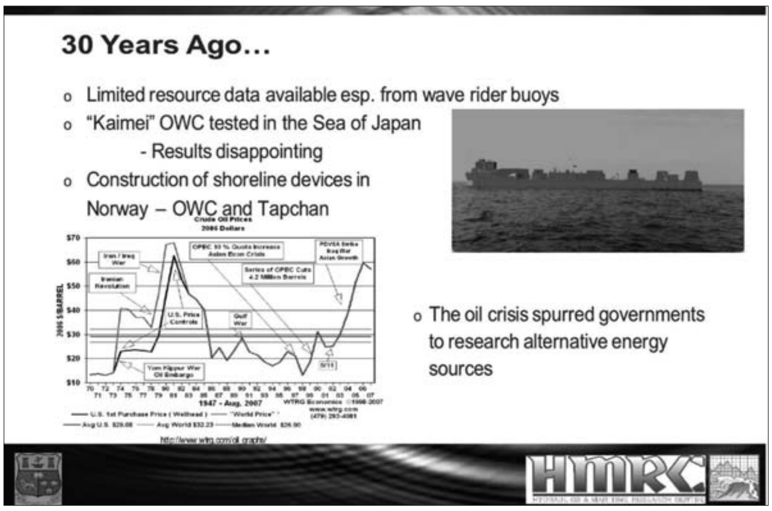
The Future of Wave Power in Europe

Pat McCullen, ESB International,
Dr Ray Alcorn, University College Cork,
Ireland

Wave power research and development are seeing renewed interest from public and private actors. Recent assessments indicate that wave power could meet 15-20 per cent of UK electricity demand. Key hurdles to further development include technical constraints, permitting, costs, grid connections and the lack of a clear committed national strategy.

Wave power has now been actively researched for thirty years with large swings in investment and support. However, recent developments mean the technology is becoming available and support systems are being put in place that will allow it to reach the commercial stage.

Early investigations



Thirty years ago, much work had been done to convert a database reflecting over one hundred years of visual observation by ship's officers into probability estimates of world-wide wave distribution. Models based on meteorological data and spaced on a grid of 50km resolution were available. These had to be referenced against measurements made on ocean weather ships located hundreds of kilometres from projected sites of interest. Relatively few sets of measurements using wave rider or other buoys were available.

Under the auspices of the International Energy Agency (IEA) this gave rise to international trials utilising the 'Kaimei' device in the Sea of Japan. The oscillating water column (OWC), coupled to either a rectifying or conventional air turbine, had evolved as a means of converting slow wave motions into the higher speed rotation necessary for electricity generation, primarily at shoreline locations. An alternative view favoured the use of hydraulic conversion systems.

Having digested the somewhat sobering result of the 'Kaimei' trials, the brightest hopes of the wave energy community were probably the Kvaerner Brug (500kW) and Tapchan (350kW) coastal installations in Norway. Unfortunately the Kvaerner Brug converter suffered severe storm damage some time later and was not recommissioned.

Soon after this, the UK and others wound down their research programmes. Cheap oil was back and except for limited work principally in the UK, Portugal, Japan and Denmark with some EU support, wave energy research found itself reduced to a 'care and maintenance' level for over a decade. There were other reasons for this, too. They included lack of confidence among policy-makers in a high risk technology that had not delivered large scale generation, rapid development of a world coal trade that helped moderate other fossil fuel prices, confusion as to which wave conversion system would become dominant and recognition that the price of weeding out unsuccessful technologies would be high. There was also promise shown by other renewable technologies such as wind.

In the lean years that followed, attempts to achieve a breakthrough via shoreline converters (which at least provided a fixed frame of reference) were bedevilled by difficulties, although two shoreline converters, known as Limpet and Pico, are still in use.

The revival

The low-key research of these years gave way to a revival around the turn of the century. This resulted from a reappraisal in the new context set for renewables generally by concerns over climate change and energy security.

Part of this was due to the increased interest in the seas around Britain as a location for wind farms. It became clear that there are many areas where offshore wind farms cannot readily be built but which will be suitable for wave farm installation. They include exposed deep-water locations along Europe's Atlantic coastline.

In the UK, the British Wind Energy Association has led the way in attempting to resolve issues that confront both offshore wind and ocean energy developments.

While still subject to caveats, such as transmission system implications, the prospect of complementary benefits when used in combination with wind power provides a 'pull' for wave power, provided that costs and reliability reach acceptable levels.

There is also more interest now on the part of utilities. Although utilities were involved in the early wave energy investigations, most reduced their involvement in the succeeding years. Interest has revived recently with rising fossil fuel prices, recognition of environmental benefits, and political support.

Also noteworthy is establishment of the European Marine Energy Centre (EMEC) in Orkney, partly funded by the Carbon Trust. This includes a full-scale test and demonstration site for grid-connected prototypes, a necessity in developing the credibility of wave energy resources, converters, systems and techniques.

New assessments.

As part of the groundwork for renewed interest in wave power, external reviews of the technology by consultants to the Electric Power Research Institute, the Carbon Trust and IEA have found the technology to be basically sound, urged the deployment of full-scale working prototypes and emphasised the need for adequate investment. The 2006 review by the IEA indicated that the UK had the largest number of wave projects – at 17 – followed by the USA with 10. Fifteen other countries had between one and four projects each.

The Carbon Trust concluded that the potential energy resource could meet 15-20% of current UK electricity demand. They estimated that the cost of energy from initial wave farms would range between 12-44p/kWh with estimates for offshore farms converging to 22-24p/kWh. The Trust foresaw considerable potential to reduce future costs. This is the main focus of current research.

It concluded that wave energy had the potential to become competitive with other generation but this would need hundreds of MW of capacity and that fast cost reduction was needed to make wave energy converters cost competitive for reasonable amounts of investment.

Obstacles to further development.

Longer-term, the vulnerable stages in development between prototype, demonstration and deployment of large-scale arrays have been identified and funding mechanisms for bridging these gaps discussed. Each member state must decide what mechanism is appropriate but it is notable that those countries which obtained the most rapid growth of wind power did so by means of a feed-in tariff.

There is increasing recognition of the need for standards in numerous aspects of ocean energy development and work is underway to provide these.

Key hurdles to development remain, including technical constraints, permitting, costs, resource/grid mismatch and the lack of a clear committed national strategy.

Continued interest from the utilities will depend on a range of factors including demonstrated converter performance. Utilities need to see commercialising of the technology, as well as ways of dealing with consenting and environmental issues, and be assured of deployment and survivability at sea. There are also grid issues. These companies are looking for clarity of costs, and cost reduction via economy of scale and technical refinement. They have their own role to play in creation of the right policy framework, and in providing technical support in key areas.

Licensing processes for offshore wind energy development projects are reasonably well established. However the introduction of the EU Strategic Environmental Assessment process (SEA) has added a new hurdle to ocean energy development.

The conflicting objectives of national and developer interests are also significant. While early technical development is most likely to be carried on in the home country, the developer's long term objective is participation in markets elsewhere. An optimal partnership must be found between state and the industry for mutual benefit. Again, different countries may have their own ideas about how this should be achieved.

Differing national approaches

In choosing a demonstration in a country other than their country of origin, developers cite three key factors: presence of a proactive Government there; availability of Government funding; ease of access to a permitted site and network connection. Firms will tend to go to locations where these conditions are met.

For example, the UK (Scotland) aspires to create the world's leading marine energy industry by 2020 with an installed capacity of 1300 MW, growing at 100 MW/yr and employing 7000 people. A series of reviews have identified shortcomings in support and remedial measures have been introduced in recent years. However the issue of licensing barriers has not yet been cracked – witness the delays experienced by the 'Wave Dragon' large scale demonstrator in South Wales in 'educating' the numerous bodies with involvement in the environmental and permitting processes. 'Wave Hub', another demonstrator, has had a rather similar experience.

Portugal on the other hand took the view that its objectives could best be met by the import of foreign developed technology and with maximum participation by Portuguese based expertise. It is targeting a possible 330MW capacity in a pilot zone designed to bridge the gap from demonstration to commercial projects.

Ireland falls somewhere between the two. It wants a home based technological capability if this can be done cost-effectively but recognises that meeting a target of 500 MW capacity by 2020 would most probably involve the use of imported technology.

In addition to these diverse national approaches, the way forward will be shaped by the need to cultivate wider, international markets. The downside of early involvement in international markets is cost, but a classic example is the effect of the Danish wind industries' involvement in California and the feedback of revenue and knowledge that was put to good use. (By way of encouragement, it is worth noting that the early wind turbines in California were only of 60-100kW capacity, achieved capacity factors below 0.2 and frequently failed, yet formed the basis of a subsequent thriving industry.)

New markets will be important, not only for revenue generation, but due to the rather limited opportunities and energy absorption capacity that exist on the coastal margins of any one country or indeed Europe as a whole. Diverse markets should produce a more stable development environment.

Conclusion – the conditions for future growth

Marine energy development is capital-intensive and depends largely on political actions. If a nation wants the benefits it must pay the club membership fee.

Looking forward to 2020, the table below reviews development objectives and key actions needed in different sectors.

Sector	Actions
Developers	• Maintain strong focus on cost • Accelerate engineering testing and prototype testing to produce track records of survivability, reliability, performance
Public Sector Funders	• Provide increased support, particularly for RD+D, to help deliver cost reductions • Support project development into medium term, for viable technologies showing evidence of cost reduction • Improve investment certainty by development of a clear long term policy framework of support
Academic Funders +Researchers	• Place greater emphasis on cost reduction topics
Regulators/Network Operators	• Consider future wave capacity when planning prioritised approach to cover coming environmental Uncertainties
Govt./Industry Env. Stakeholders	• Take a proportionate approach to local environmental impacts of small developments balanced against global; benefits of low carbon output from future larger projects.

Projected Key Actions for Ocean Energy Growth

Our own assessment of installed European capacity for 2020 is below some of those made in earlier reports. This is based on the rather slow early growth of the offshore wind industry, inertia in the SEA planning and permitting process, uncertainty in world financial markets and a slower rate of convergence toward an optimum converter design. It amounts to 750 MW, comprising a variety of different converters (which also militates against rapid cost reduction).

UK	Portugal	Ireland	France	Spain	Denmark	Total
250	150	100	100	100	50	750MW

However, the overall picture remains that, with the establishment of the UK Carbon Trust, its Marine Energy Challenge and the European Marine Energy Test Centre together with other test centres, and in depth reviews of available conversion systems, funding mechanisms, standards, permitting and fabrication of large-scale converters, the medium term prospects are much improved. Wave power technology is getting out of the lab and into the sea.

The Future of Hydro Power in Europe

Professor Einar Broch
Norwegian University of Science and Technology, Trondheim
Norway

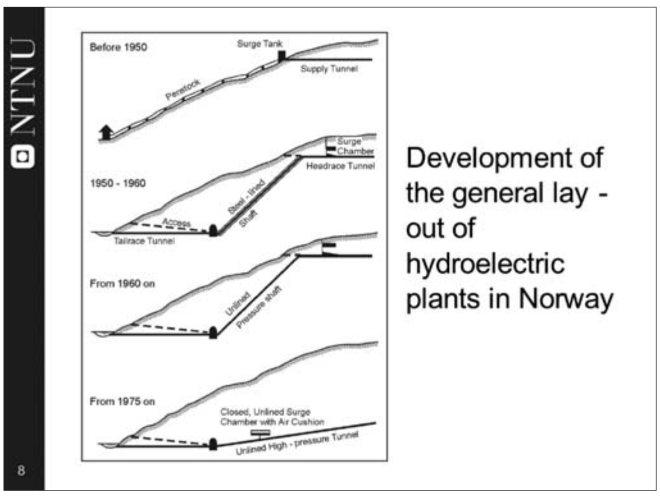
Hydro power produces more than 99% of Norway's electricity. Most of the nation's power stations are underground, which is safer, cheaper, and has big environmental advantages. Further measures can minimise the environmental impact of diverting river water, by using sills to create lakes, and excavated rock, by landscaping.

How can Europe's engineers help to moderate the environmental impact upstream and downstream from hydro projects, both in Europe and elsewhere? There is no simple answer to this question. There is a relatively large spectrum of hydro projects. There are gigantic projects like the Three Gorges project in China and the Itaipu hydro-electric project on the border between Brazil and Paraguay. Itaipu, for example, features a reservoir of 1,350 square km, more than 7,000m of dams, 20 generators of 700 MW, and annual electricity production of 92,000 GW hours. Then there are hundreds, even thousands, of mini and micro hydro installations in smaller rivers and streams

I will concentrate on medium-sized projects, up to 1,000 MW, mainly using experience and examples from Norway. In Norway we have more than 99% of our total annual electricity production of 125 TWh generated from hydro power, so Norway is pretty much a hydro power country. Two hundred of the world's 600-700 underground powerhouses are located in Norway. We have approximately 4,000 km of hydro power tunnels, so hydro power in Norway is an underground business to a large extent.

After the Second World War, underground location of powerhouses was preferred because it was safer. However, rapid advances in rock excavation methods soon showed that this was also the most economic solution. In addition, underground solutions gave freedom of layout independent of the surface topography. You can move around, change the alignment of terminals and so on. Underground location of powerhouses is thus chosen whenever sufficient rock cover is available.

To begin with, we evolved from an old system with a tunnel, a search tank, and a penstock (water feed) down to the powerhouse. Then in the 1950s the powerhouse was put underground, along with a steel penstock. Gradually we learned that we could make it even more simple. If we were deep enough inside rock the steel lining was unnecessary. We could just take the water through the rock. In some cases we also replaced the search tank with an air pressure search tank. Since the mid-1950s, through our period of rapid expansion of hydro-power which lasted up to the 1990s, essentially everything in Norway has gone underground.



Locating the powerhouse underground and replacing the above-ground penstock by an underground shaft gives considerable environmental advantages. Above ground projects currently under construction in the Andes, for example, entail huge excavations to furnish sites for power houses. Our approach would avoid these.

Another aspect of hydro power is of course that you need reservoirs and water goes up and down in these reservoirs. Depleted reservoirs are unattractive, so we will always try to avoid reducing levels too far, particularly in the summer when people are in the neighbourhood.

A related problem with this kind of hydro power development is dry rivers. We have to take the water through a tunnel to the powerhouse and that does lead to some dry rivers. Again, this is not a beautiful sight, but it is often possible to do something about it. A small sill can stop the water and create a new, long lake, and the cost of these small sills is relatively small compared to the benefits.

One problem when making tunnels is that there will be a lot of blasting. A lot of rock has to be brought out from the tunnel and placed somewhere. The visual effects of this can be minimised by careful landscaping, although covering the rock mass with vegetation can take 10 or 15 years.

We should also recall that the European hydro power industry experienced two very serious dam failures 40 or 50 years ago. The Malpasset dam in France in 1959 failed because it was located on poor rock conditions. When the water broke through, 420 people were killed downstream of the dam. In 1963 came the Vajont dam disaster in Italy. The dam had a long reservoir with steep slopes and 250 million cubic metres of rock started moving and suddenly slumped into the reservoir. A huge wave flooded over the dam and killed more than 2,000 people in Longarone.

In addition to killing people, these failures were also very serious from an environmental point of view, with major landslides and erosion due to the flooding. Slope failures are a constant threat to safety and the environment in reservoirs with steep slopes like Longarone when there is rapid and repeated lowering of the water level. So systematic control of dams and reservoirs is a constant challenge to the hydro power industry.

To conclude I would say that in the discussions about renewable energy we should not forget that hydro power is a 100-year-old technology but it is still very viable as a technology. And one of the great advantages as compared with all the other technologies discussed for generating electricity is that the energy can be stored. For that reason alone I believe that hydro power will be increasingly important and valuable in the years to come.

Biomass and Biofuels

Biomass and Biofuels

Second Generation Technology for Biofuels Production

Professor Bruno Jarry
NATF Fellow
Chairman of the National Biofuels Committee,
France

First generation biofuels are very unlikely to meet the 2020 targets. Second generation biofuels will be developed over the next 15 years. This will involve technologies which use the entire plant, as well as novel feedstocks. These technologies include biochemical and thermochemical routes for converting biomass to liquid fuel (BTL), which are already at the prototype stage in France and Germany. They may prove suitable for widespread use in Europe, but not before 2020.

The next fifteen years should see the development of a second generation of biofuels. There are two categories of biofuels – ethanol and ethanol derivatives, and biodiesel, which is produced from oil producing plants. First generation biofuels are produced at present in many countries, the biggest producers being the United States and Brazil – both of which produce mainly ethanol. Then there is Europe, which produces a little ethanol but mostly biodiesel.

First generation biofuel production is very unlikely to meet the requirements of the European Commission, for several reasons. Few countries in Europe made substantial industrial investment in biofuels and, as there will be a limitation on subsidies for imports, there will be a problem for countries which import them.

In any case, we lack sufficient rape or sunflower to produce enough biodiesel for Europe. France is an instructive case study here. France has a very strong programme for biofuels and biodiesel. The French state plan, approved by Parliament in 2004 and 2005, calls for a substitution of fossil fuels by biofuels, without import, of 5.75% in 2008, 6.25% in 2009, and 7% in 2010. A 10% indicative figure is given for 2015, which is the level proposed for 2020 by the European Commission.

To date, 53 biofuel plants have been authorised in France, and in 2010, 3.2 million tonnes of rape or sunflower biodiesel should be produced, together with 800,000 tonnes of ethanol. However, biodiesel production from locally grown raw materials is likely to be limited. Indeed, biofuels today are already using 70% of the land devoted to oilseeds. Although new land, now used for pasture, could in future be used for oilseeds, it is generally accepted that the 7.5% substitution rate is a maximum which will require more time to sustain. This is why the French proposal in the EU negotiation is now to limit biofuel substitution in 2020 to this figure. Realistic strategies for going further will depend on the development of second generation biofuels.

Expectations for second generation technologies

Europe wants to produce biofuels to avoid imports of fossil energy and to decrease CO_2 emissions. This makes biofuels a logical choice because the plants capture CO_2 and the energy consumed in producing biofuels is less than that released when they are used. The gain on emissions is evident, even for the first generation, with ethanol from wheat or sugar-beet, and biodiesel from rape or sunflower oil.

Ethanol from lignocellulose also involves reduced energy consumption and CO_2 emissions, as will biomass to liquid (BTL), which is second generation biodiesel. While on paper this appears to offer even greater carbon savings, we do not yet have real data on this technology.

An important feature of second generation technologies is that they make use of the entire plant – not just the seed oil. This should bring higher yields, more tonnes equivalent of petroleum per hectare. Second generation biofuels will also derive from a wider range of raw materials and avoid competition with food crops.

Second generation raw materials may include straw, spent grain, or beet pulp, by-products which have no use today except as animal feed. Biofuels processing will produce further by-products, some of which at least may still be used for feed.

There is also potential for growing dedicated annual plants as biomass rather than food, and this will be compatible with annual economic cycles. Then there is the option to stop production and if required, re-plant the fields with food plants.

In addition, perennial cultures, like miscanthus or switchgrass, can produce a huge amount of biomass per hectare. We need to find the best compromise between productivity and the local environment, by experimenting with the nitrogen used to grow those plants, and with pesticide levels. In principle, there is a potential use for forestry and forestry by-products because today these products are used by the paper construction industries.

How much raw material can we plan to use in Europe for biofuels? The prediction is for 10%, which is the target that the European Commission wants to reach. This would be around 40 million tonnes of petroleum equivalent (TEP) across the EU - 6 million TEP in France. This would require 27 million hectares of raw materials, 6 million in France, which is rather small in comparison to the total used in agriculture today.

Process developments for biofuels

The most interesting biofuel production process is the thermochemical route, which is a real breakthrough in the production of biodiesel. It was first developed in Germany during the war, for the production of carbon monoxide from coal, and is now being adapted for the production of the same gas from biomass. The idea is simple. Heat the biomass to a very high temperature with a gasification reactor and produce a gas which is then purified. This gives carbon monoxide plus hydrogen, which can then be recombined. The products are hydrocarbons and water and the hydrocarbons can then be fractionated.

This biomass to liquid (BTL) process still needs refining. The gasification stage produces by-products which include tar and ash. The later reactions also need to be optimised and improved catalysts are needed, as those used today are easily poisoned by the by-products from the reaction.

Current results in practice

Currently, if we have seven tonnes of wood or straw, we can get six tonnes of dry wood or dry straw by eliminating the water. This is then concentrated in a slurry that gives 4.7 tonnes and after all the steps in the production are completed, we get one tonne of biofuel as a final product. So you need seven tonnes of raw material that you collect in the field for one tonne of biofuel as a final product.

At the same time, and this is extremely important in the BTL process, much heat is also produced. As a matter of fact, 54% of the total energy yield dissipates as heat and only 46% remains as biofuel. Optimising this system therefore requires a good source of biomass and an industry close by that is a major consumer of heat, or a large-scale heating plant.

Another very important issue is the type of logistics associated with the BTL process. You need to have scale effects in order to optimise the system but that requires very large plants with continuous processes. These plants would have to treat at least one million, or even two to three million tonnes of oil per year. This would then raise new questions about the sort of logistics needed to bring so much biomass into the system.

Today, in Germany and France, this technology is at prototype level. The French Government recently approved the construction of two second generation pilot plants. One uses the biochemical route where alcohol is produced from all the sugars in the plant, including cellulose. The other will demonstrate this very promising thermochemical route. At this stage these two technologies are not expected to yield their full potential before 2020, most probably later for the thermochemical route. However, we hope that, in the next 15 years, we will have sufficient data to support much wider use of this thermochemical route throughout Europe, because it is certainly a breakthrough technology.

Biomass in the Czech Republic

Professor František Hrdlička
Czech Technical University, Prague,
Czech Republic

The Czech Republic depends heavily on coal and on imported oil and gas, but has good potential for producing renewable energy from biomass, with a reasonable reserve of arable land and meadowland. Along with continued exploitation of hydroelectric elecricity biomass is key contributors to the country's strategy for meeting the 2020 targets.

The contemporary fuel mixture in the Czech Republic is based on the production of electricity from brown coal and nuclear energy and a significant part of the centralized heat production is dependent on hard coal and brown coal.

Almost 100 % of fuel and a significant part of heat for business and domestic use is covered by imported oil and natural gas. They were imported first from Russia. However, after 1990 there were new routes built – transport of oil by pipeline from western Europe and of natural gas from Norway by the northern part of the gas pipeline TRANSGAS.

The current import dependence of the Czech Republic is relatively low by EU standards. It has never exceeded 36%, including imported fissionable fuel, in the past.

In earlier times the Czech Republic exploited a significant part of its water flow, and in the past 20 years expansion of hydro power has contributed most of the renewable energy expansion in the country. Our geographical position, in the closed ring of border mountains and above the 50th parallel, limits the possibilities for solar and wind energy.

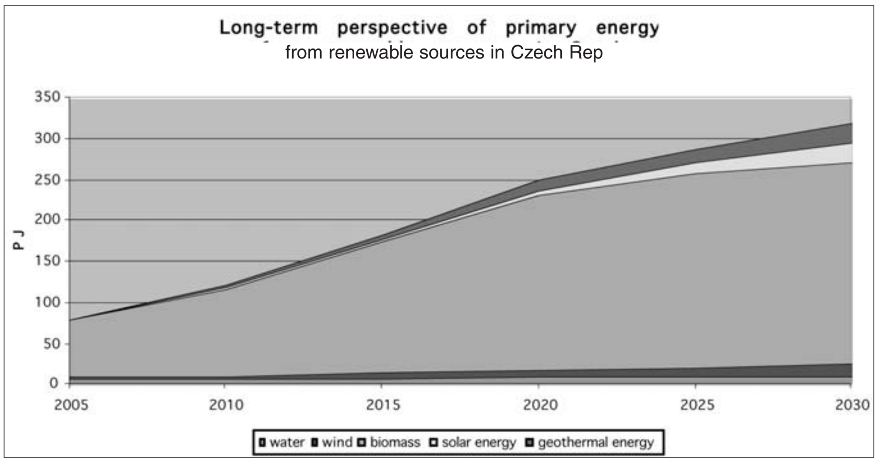
Our high dependence on coal means the country has high CO_2 production per unit of GDP. The policy of CO_2 emission permits and the limited possibility of exploitation of domestic coal sources in the near future, the energy policy of the EU and its obligatory guidelines, all point to the necessity of rapid development of renewable energy. Aside from hydro power (ca 2,6% of electricity production) the exploitation of biomass for heat production is our main opportunity.

The current share of renewables is around 6%, so it needs to increase very significantly. This is only realistic if the biomass potential is intensively exploited. Here, the prospects are good.

ARABLE LAND	ha	1 million
MEADOWS AND PASTURES	ha	1 million
DENDROMASS	t	5 million

The Czech Republic has reasonable reserves of so far little exploited arable land and almost 1 million hectares of meadows and pastures. Of course it is necessary to take into account the arable land required for food security, or for reasonable food independence. However, even if we consider food security, there is still available:

The maximum exploitation of this potential for biomass is obvious from the renewable energy scenario until 2030, where the importance of biomass is irreplaceable:



Responsible exploitation of our land and forest potential is the basis for the achieving an adequate share of the energy demand supplied by renewables in the next decades and for decreasing imports demand of fossil fuel. It is also a way to minimize dependence on unstable countries, which possess these reserves.

What role can GM technology play in bringing forward a new generation of non-agricultural biofuels?

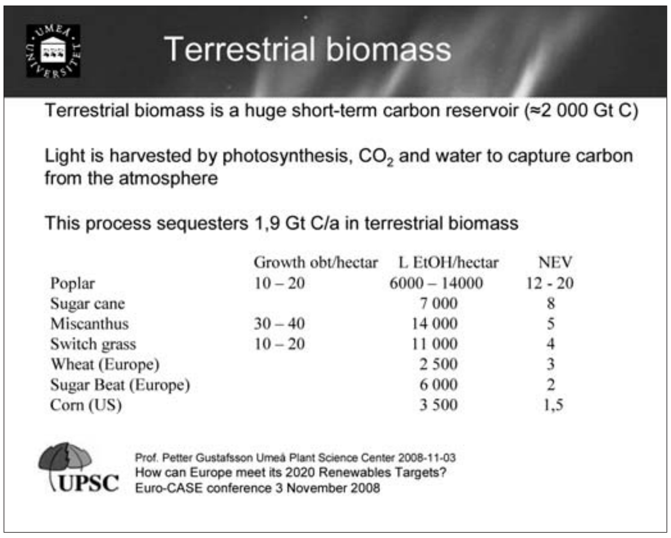
Professor Petter Gustafsson
Department of Plant Physiology, Umeå Plant Science Center,
Umeå University,
Sweden

Trees are an important resource for future production of energy from biomass. Improved genetic breeding, selection, and genetic engineering can improve tree production and develop tailor-made trees for future industrial needs. Poplar (aspen) has particular potential, as it grows well in much of Europe, has been extensively studied, and can easily be transformed into GM-improved trees, with vastly superior biomass production and shorter rotation types.

Terrestrial biomass is a huge short-term carbon reservoir (≈2 000 Gt C) that uses light harvested by photosynthesis, CO_2 and water to capture carbon from the atmosphere. This process sequesters 1,9 Gt C/a in terrestrial biomass, an amount that is almost counterbalanced by emission of 1,7 Gt C/a from deforestation. The earth receives approximately 4 000 times as much energy from the sun each year as the total projected human energy use in 2050. Because plants can be deployed on a large scale to capture and store solar energy and carbon, we need to use this resource to the best of our ability and exploit plant biomass for sustainable production of carbon-neutral energy, such as biofuels, and green chemicals. In other words, it is of utmost importance to increase biomass production to meet the needs of industries involved in biofuel, bioenergy and green chemical production.

Biomass needs can be met with dedicated biomass crops like grasses and trees as well as using residues from agriculture. Few plants sequester carbon dioxide better than trees and fast-growing, short rotation forest crops like eucalyptus, willow and poplar are the forestry sector´s answer to annual energy crops, like switchgrasses. In these plants, carbon is stored in the complex, polymeric chemical structure, lignocellulose, the major constituent of trees but also, for example, of corn stover, grain straw and energy grasses. Trees have been used for a long time in pulp and paper making, as construction material and as heating and fuel – globally the latter still being the two largest uses of trees by far.

The long-standing traditional pulp and paper industries can be regarded as the starting point for future biorefineries. Thus, the industrial knowledge gained from these industries can be quickly mobilized in order to move forest industries into the green-chemical society. However, because of rising demand for these products, trees are being cut down faster than they are replaced. The demand for trees will increase even further in the future as the demand for lignocellulose increases due to the rising shortage of petroleum. Improved breeding, selection, genetic engineering and intensive management are key to meeting the goals of increased biomass production. For these reasons, it is of vital importance that we use all our genetic and biological knowledge in order to improve tree production and to develop tailor-made trees for future industrial needs.



Poplars are of interest for us because of their capacity to grow well in a number of locations in Europe, their ease of transformation in order to produce GM-improved trees, their high productivity (up to 22 metric tonnes/hectare and year), the minimal fertilizer applications they require, and their high net energy value of 10–12, as compared to corn, below 1.6.

Forest biotech took a giant step forward in 2006 when scientists from Umeå Plant Science Center in collaboration with the Royal Institute of Technology, Stockholm and the US Department of Energy´s Joint Genome Institute deciphered the first tree genome (at that time only the second plant genome to be sequenced), that of the black poplar (aspen) or cottonwood, Populus trichocarpa. The sequencing of a model tree genome will simplify the development towards highly productive biomass tree crops but also towards tailor-made trees specialized for e.g. newsprint production by making the fibres easier to separate in refiners. Trees with longer and more flexible fibres would mean stronger liner and board qualities, while trees with shorter fibres would make matters easier for the fine-paper producers of tomorrow. A modification of the wood's chemical composition could result in a more favourable energy balance for both mechanical and chemical pulp production.

GM trees have been used in research for over twenty years. Umeå Plant Science Center has the largest collection of transgenic trees in the world, several hundred different transgenic variants. Transgenic trees have also been tested in field trials at a number of locations around the world, both for scientific and commercial purposes. Of the over 30 field trials with forest trees in Europe, 5 trials were run by industrial companies. All of these early trials between 1993 and 1997 used eucalyptus and poplar. Two were carried out by Shell Forestry and one by CEASA in collaboration with Advanced Technologies Cambridge. A trial in 1996 performed by Syngenta in collaboration with INRA lasted for four years and used poplar with altered lignin content. The poplars yielded a more high-quality pulp without impairing growth or fitness. Unfortunately, these trials were destroyed by activists in 1999, making it impossible to study long-term effects.

In a field trial performed by researchers at North Carolina State University in Raleigh, transgenic poplars were used, in which one of the genes in the lignin biosynthetic pathway was depressed. The result was a decrease in lignin production and an increase in cellulose production. In a study performed by Thomas Moritz and colleagues at Umeå Plant Science Center, where researchers over-produced a key growth regulator in a transgenic poplar, they also found boosted biomass production and increased fibre length. These findings show that there is a great genetic potential in improving biomass production in trees using GM technologies.

At Umeå Plant Science Center, the largest forest biotech research centre in the world, research is performed on wood, leaf and flower development. Major research is based on modification of specific genes taking part in wood synthesis, and studies into how these modifications influence wood quality. Research groups are also studying new ideas for tree fertilization and forest management.

Five years ago a gene-mining programme was started, using hybrid poplars as the model organism. Initially, an EST-program was established, enabling the production of microarrays. The wood-forming tissue of the poplar was cut into thin slices separating the four major developmental zones: the cambium (responsible for wood growth), the elongation zone (responsible for fibre length), the maturation zone (responsible for cellulose and hemi-cellulose production) and last the cell death zone (responsible for lignin synthesis and deposition). Using these slices in microarray experiment, a number of individual genes of particular interest for these processes could be identified. Analytical methods such as NMR, FTIR spectroscopy, mass spectrometry and electron microscopy make it possible to determine chemical and structural modifications controlled by specific genes. These descriptions of the modification expressed by specific genes will be of great importance in the development of tailor-made wood in forest trees. These findings are brought to the forest marketplace by the R&D company SweTree Technologies, in collaboration with major Scandinavian forest companies.

The project has resulted in tens of thousands of GM poplars with speculative properties, as well as a database with the function of influential genes when determining the qualities of the wood fibre. This new knowledge may be utilized in the enhancement of trees to give them physiological specifications desirable for use in different kinds of industry.

In the future we will see better trees developed using traditional breeding as well as GM trees. These trees will have vastly improved biomass production and shorter rotation times. We will also see trees with modified lignin, better fuel qualities or higher suitability for production of cellulose, hemi-cellulose and lignin-based polymers and other materials. Other future GM trees will display lignocelluloses modified for better functionality in production of pulp or ethanol. GM tailor-made trees with a modified chemical composition in wood and bark also provide a new basis for chemical products, providing a stronger economic base for the pulp and paper industry. Thus, GM trees will be used in the future to meet the demands of biofuel production, to increase industrial efficiency and to produce a broad array of chemical feed stocks for the chemical industry at biorefineries.

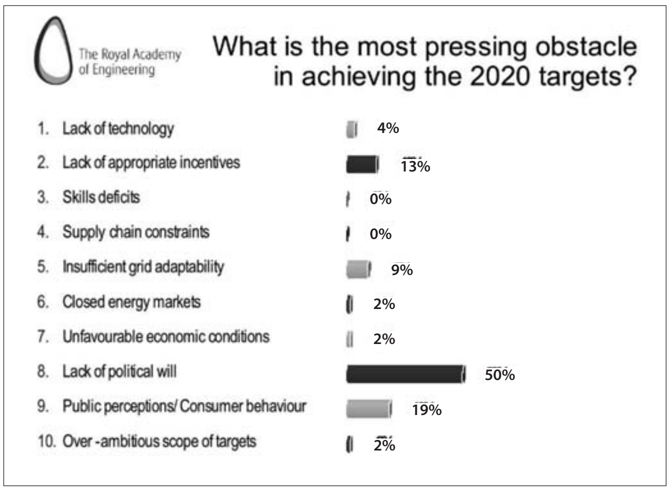
The long-term goal is to give the forest-based industry the potential to enhance the effects of naturally occurring variations in wood. Transgenic technologies may offer improvements in the precision and speed with which this is done. To be able to provide for the world population, while at the same time taking care of environmental and climate issues, we simply have to increase the use of sustainable raw materials. By making use of all new knowledge in forest biotechnology, and well-administered clone forestry, we may be able to get at least close to the level of plant breeding used in farming. The result will be high-yield, short-rotation tree crops, often with tailor-made properties, grown and managed in plantation strategies. These highly productive forests will ease pressure on land-use, and allow more space for recreation and environmental protection. The convergence of breeding selection, GM trees and forest management practices, together with engineering skills, will create the foundation for new value creation for forestry. Umeå Plant Science Center is active in all areas of the first set of GM technologies that can be applied today in Europe in order to allow Europe to meet its 2020 renewable target. However, we must always remember that it takes years to develop and certify new tree crops and that it takes years to deploy them in large numbers.

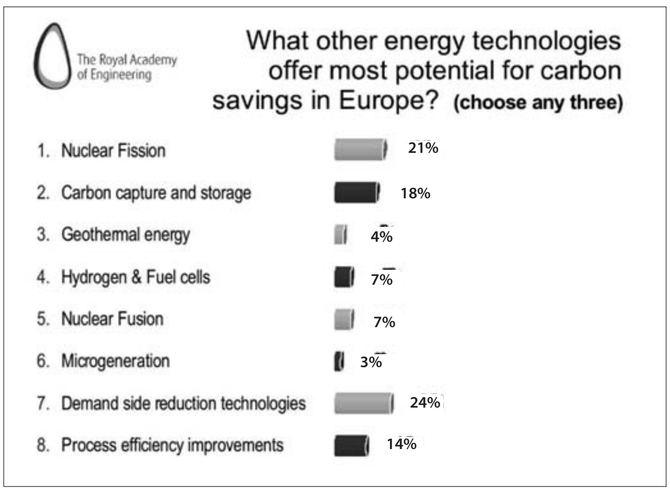
European Targets, Global Goals: The Broader Context of the 2020 Renewables Targets

The final session took the form of a panel discussion on the broader context of the 2020 targets. Panel members included Dr Jan van der Eijk, Group Chief Technology Officer at Royal Dutch Shell Plc, Mr Paul Caseau, Fellow of the National Academie des Technologies Francais and former Director of EDF, Mr Željko Jurić, Senior Expert at the Energy Institute Hrvoje Požar in Zagreb and Dr Irene Aegerter, Vice President of the Swiss Academy of Engineering Sciences. The session was chaired by Professor Ian Fells CBE FREng. Following the discussion, voting technology was used to obtain a snapshot of the views of conference participants on each of the chosen topics.

The first question addressed was straightforward: what is the most pressing obstacle in achieving the 2020 targets? The most strongly supported opinion was that it was not technology which was lacking, but political will. There was still a diversity of views at policy level about energy security and the threat of climate change, which diluted the potential for concerted global action. While there was a high level of public concern about the risk of climate change, public opinion had not been fully prepared for the financial cost of climate change mitigation.

Perhaps the key problem after that was the absence of appropriate incentives, especially outside the field of electricity generation; for instance, there was little support available to promote heating and cooling powered by renewable energy sources. This highlighted one of the dangers of the 2020 targets— that Europe was setting out highly specific targets without a clear vision of the mechanisms needed to make them a reality. All agreed that while the technology to meet the 2020 targets was already in development, investment in renewables technology and innovation was urgently needed if Europe was to meet the more exacting targets of 50% carbon savings by 2050.





The preceding sessions concentrated on the renewable electricity generation and transport technologies expected to make the greatest contribution to the 2020 targets: solar, wind, wave/tidal and biomass. The second question posed for discussion in this session was: are there any other technologies with the potential to achieve significant carbon savings in the medium to long term?

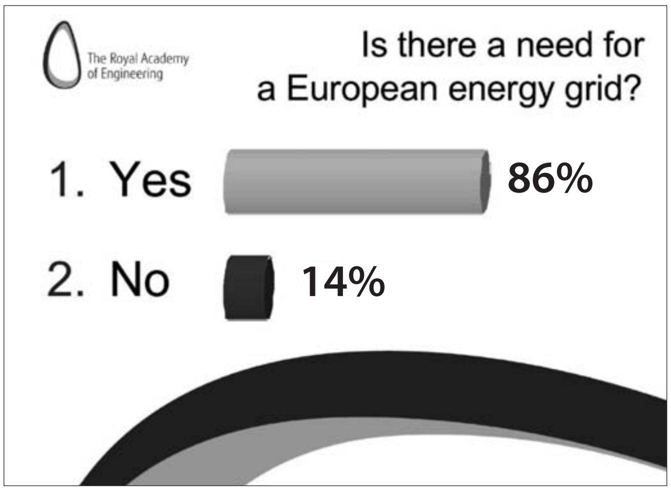
The key issue, it was suggested, was reducing CO_2 emissions, not increasing use of renewables for their own sake. In that light, it was only realistic to assume that fossil fuels would be in use for a long time to come. Studies looking as far out as 2050 showed fossil fuels still accounting for two-thirds of the energy supply. This meant that investment in carbon capture and storage must be a priority. Demand side management was also important – both in reducing demand for energy for heat, power and transport, and improving efficiency in construction and industrial processes. Changes on the demand side involved changes in consumer behaviour as well as technical improvements. But the technological and social changes ought to be attractive because they would not be expensive and would have long-term benefits. Increasing fossil fuel prices, when such increases resumed, would also make such frugality more attractive.

It was emphasised that the longer-term requirements for reduction in carbon emissions suggest that all options are likely to be needed to realise savings which may have to exceed 50% by 2050. That would include nuclear fission, though few believed fusion was a realistic contributor on this timescale. Hydrogen and fuel cells for transport would also be part of the picture.

It was also suggested that any technology which helped boost networks and made energy storage easier should be supported. Renewable sources are generally poor at coping with fluctuating energy demand, so storage would be at a premium in the new energy economy.

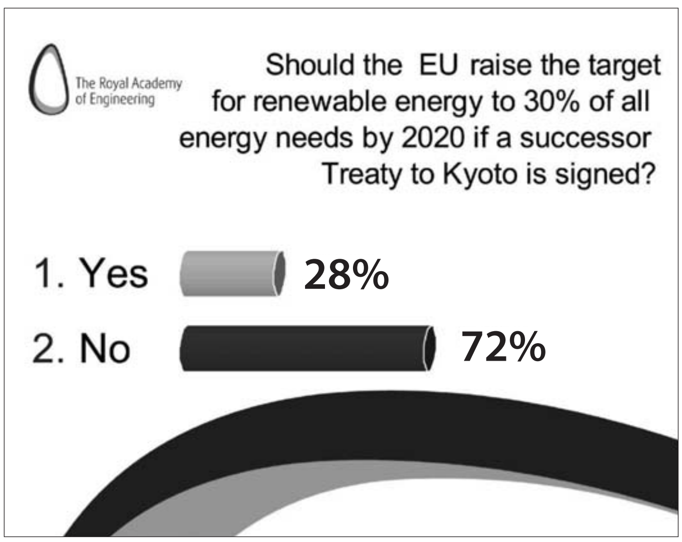
Next, the call for a European energy grid was examined. Delegates had heard several speakers argue that the benefits of renewable energy could be maximised with a new DC grid bringing wind energy from the north and solar energy from the south to the industrial heartland of Europe. Other arguments in favour included the fact that grids in various countries are now under-developed, and have difficulty raising capital. Separating grid companies from electricity companies makes this worse. This view commanded broad assent.

In addition, a limiting factor in maximising use of intermittent sources can be the difficulty of integrating them into the grid, and a new technology European backbone would facilitate energy transfers between countries. That would improve security of supply and help ensure competition.

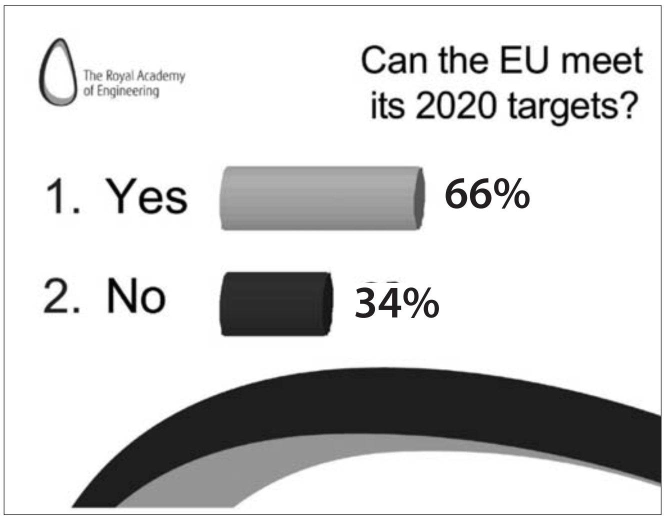


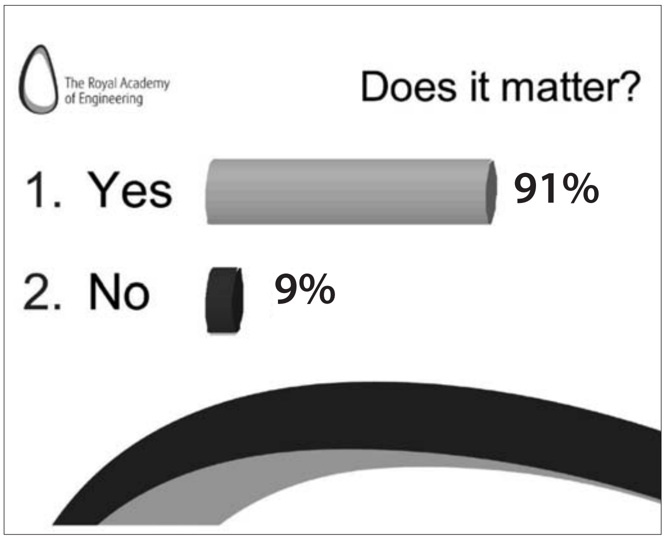
However, there were some reservations. The whole system, with a new mix of sources and modes of energy conversion, is set to become more diverse – and more complex. Cars may need electricity or hydrogen, for example, which imply different infrastructure. There may be biogas systems in place. So while the system needs to be strengthened and diversified, a grand plan for a European energy grid might not be the best way to do it. Nation-specific targets which can be achieved in stages could be preferable in terms of policy and implementation. The European wide development required would very likely extend beyond 2020.

Assuming the 2020 target is feasible, should the EU increase its ambition? One suggestion is to increase the target for renewable energy to 30% of all energy needs (not just electricity generation) by 2020 if a successor treaty to Kyoto is signed. On the other hand, cutting carbon dioxide emissions can be seen as more important than any particular target for renewables, which takes one back to the point that all energy sources should be part of the future portfolio. It might be better now to establish a single target, like 30% reduction in carbon dioxide emissions by 2020, and let member states find their own ways of meeting it, each with their own mix of energy saving and energy production with low greenhouse emissions.



Again the point was made that enhancing energy efficiency was an important part of any overall policy for greenhouse gas reduction. In addition, if it is accepted that the main obstacle to realising the present target for renewable contribution is political will, then increasing the target might be considered a rather pointless gesture. The majority opinion was against the suggestion of increasing the targets. It would be better to focus on achieving the existing target. Other effort should be focussed on devising international regimes that promote the use of renewable sources outside Europe as well as inside – including providing financial support where needed - and, as some argued, developing the nuclear option in some countries.





Returning to the targets already formulated, the panel debated whether the 2020 targets, however desirable, could actually be met. The predominant view was that the targets could be met, though some argued that it was unlikely that they would be. There were reservations about the state of the market and the international cooperation needed within Europe. In any case, meeting them would depend on some of the conditions already highlighted. This meant that political will has to be converted into implementation of new measures. It is no use having a European directive on energy-efficient buildings, for example, without implementation through building codes and standards. At the same time, it is realistic to recognise that meeting the energy targets will increase costs, and that other countries, including fast-developing countries, need to reduce their greenhouse gas emissions, too, for there to be a real global impact.

The financial crisis may make it harder to finance new investment. New concerns about job creation might dovetail with investment in green energy. But paying more for energy would be less feasible. On the other hand, the measures taken to stabilise the banking system suggest that the scale of the finance needed for upgrading energy supply does not put it out of reach. The UK government's financial rescue package, for example – valued at the time of the meeting at £500 billion – would pay for the entire power system of the UK to be replaced seven times over, on one estimate. Similarly, the current combined defence budgets of the United States and Europe exceed $600 billion a year, and other threats to security could potentially mobilise similar spending. In any case, affordability is a choice, and it is best to take the view that the targets must be met. Then, even if the result is a miss, it should be a near miss. If efforts to meet such targets are not made now, they will simply lead to more costly measures being needed in future.

Finally, does it matter if the targets are met? The answer here from the vote was a resounding yes. The panel emphasised that, while the precise figure was not the issue, it was vital to try to meet the targets because of the larger objectives they embody – energy security, and a reduced environmental burden. In addition, success in Europe would only matter if it were part of a worldwide achievement. As one panel member summed up the situation, we have only one planet and we want our children and grandchildren to be able to live on it.

Closing Presentation

Professor Brian Collins
Chief Scientific Adviser at the Department for Business, Enterprise and Regulatory Reform and the Department for Transport

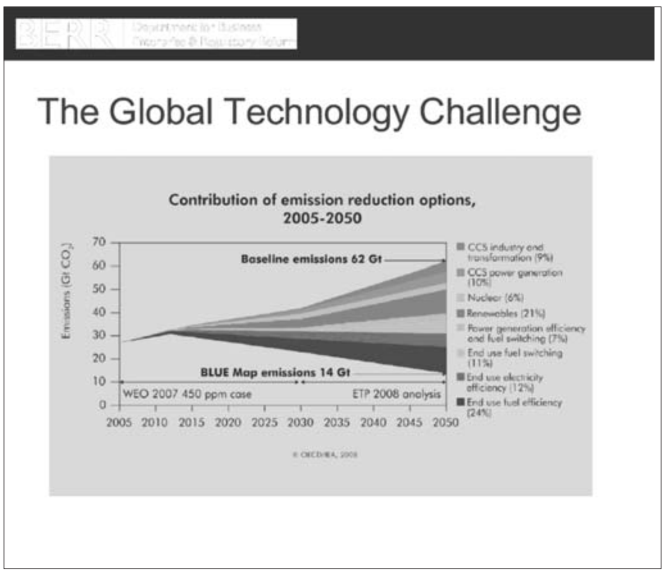
Good afternoon, everybody. I am the Chief Scientific Adviser to the Department for Business, Enterprise and Regulatory Reform, which was formerly known as the Department for Trade and Industry. I also look after the Department for Transport, which gives me a pretty broad canvas to offer advice to two Secretaries of State and a number of ministers and other officials. There is a Chief Scientific Adviser in most government departments in the UK and we operate as a network. We don't necessarily agree on everything but we argue to conclusions fairly rigorously. The topic under discussion today is a subset of my portfolio of advisory functions.

The global challenge

I want to go back to the top and talk about the global challenge that we are facing in addressing the issue of climate change and greenhouse gas emissions. As was very wisely said earlier today, renewable energies sit in the context of reducing greenhouse gas emissions but they have to be situated in the context of two other rather vital things for human kind – water and food. One of the things we try to do is to keep in balance the issues of investment in water and food, as well as energy – although they are of course linked and very tightly coupled. So that means a focus on energy efficiency, clean energy generation- which includes renewables of course- and security of supply, without which the lights go out and the wheels stop turning. Because an important factor is the need to keep the money coming in. This means that in the short term we may do some things, or advise on doing things, which appear in the long term to be the wrong things to do, but we have to keep the lights on. One has to keep the big picture in mind.

One of the issues that we have particularly been dealing with, and which has been debated today, is the competition between food and biofuels. We use land for growing crops, but what do you grow the crops for, energy or food? There has been a very heated debate as you are well aware, in this and other countries, about that competition. We are now in the process of re-consulting on what our position should be in the UK. I will not dwell on that particular topic but it is just one example of where we have to manage the tension between competing uses of prime assets such as land.

The global technology challenge



The global technology challenge for reducing emissions – and this is an extract from the IEA report – shows interestingly the balance between end use and energy generation going out to 2050. It unashamedly talks about 2050 as well as 2020. The longer term perspective takes account both of what we can do by 2020 and the way that technologies mature – you can see the dramatic kinks in these curves at around 2025/30. The bottom three bars on this slide represent end-use and the rest cover energy generation and supply. Overall, nearly 47% of potential reductions by 2050 occur in end-use.

The debate today has been overwhelmingly focused on energy supply, yet we must not forget that a considerable gain in reducing greenhouse gas emissions can be achieved by concentrating on end-use efficiency. Thus, where we put our money is something that we need to be concerned about.

Policy drivers

We have already announced the composition of the Climate Change Committee. An interim report that came out in late October 2008 is recommending that we aim to reduce our greenhouse gas emissions by at least 80% by 2050. The EU target currently is to increase the proportion of energy use from renewables to 20 % by 2020, and we have spent all day discussing that. We have been consulting on our renewables policy for the last nine months and that closed at the end of October and, as you can imagine, there is now a large number of officials poring over many inputs to that consultation. In the early part of next year we will produce what we consider to be the UK position on renewables.

Role of UK Government

The role of the UK Government is, as we have heard right at the beginning of the day, to provide a clear and stable regulatory environment for investors. That is one of the most crucial things, to get private money into this whole area of renewable energy.

However, on top of that we are facilitating technology demonstration and reducing the risk to investment in both technology and the supply chain. The supply chain is particularly important. At the moment, the economic crisis is not necessarily impacting hugely upon major suppliers, although they are inevitably becoming more fragile, but it is hitting one or two key smaller companies who are critical to the supply chain. They may make some special metals for bearings in turbines, for example, so any problems they experience would affect the pipeline of wind farms, and so on. We are therefore busy spotting where there are vulnerabilities in our supply chain and I would be interested to know whether any other country in Europe is doing the same sort of work in that situation. Of course, we are not just doing it for renewables but we are doing it for all supply chains and it is quite a large undertaking.

We are looking to academia and government science to lead and influence the development of new technologies. Government does not pick winners but it brokers debates at which promising technologies emerge. We also promote innovation and knowledge transfer and accelerate the commercialisation of those technologies. Acceleration is an important word: it is bringing money to exactly the right place, to make things happen much more quickly.

We are also looking to remove supply chain barriers and regulatory barriers to the take up of renewables. A bête noire of almost everybody in the room is the reform of the planning system. Actually, to be pedantic, it is not so much the planning system as the approvals system where the problem lies. We are quite good at planning; most engineers and scientists plan things pretty well, and they get their plans well established and well substantiated, but it is then the approvals of those plans which takes time. We are also looking at how to improve access to the electricity grid. I take the point from earlier that we have many grids for moving energy around, including tankers full of petroleum – and, with my transport hat on, that is a grid as well, albeit a differently constructed one. We are looking at how we change the role of UK Government to accelerate the way in which national infrastructure that depends on energy can be taken forward.

One of the things I have noticed is that 60 years ago governments owned the national infrastructures in most of the countries you lived in. In some of them, you still own more than we do in the UK. But in the UK and many other European countries much of the infrastructure has been privatised, which means that governments do not influence the operation or even the investment in national infrastructure in a systems way. They influence it through regulation and legislation in a rather disconnected way.

At the moment, I am trying to put in place an initiative to apply the principles of systems thinking to national infrastructures – and I am deliberately using the plural because energy is coupled to water, is coupled to telecoms, is coupled to sewage and to other utilities that we all depend upon. They are all interlinked – in fact, they are very closely interlinked, as we all know, when things go wrong. I would be delighted to hear whether other countries are taking similar sorts of initiatives. And of course, alongside our national infrastructure inter-dependencies, we also need to understand our pan-European dependencies, especially when we take up the debate over a European grid.

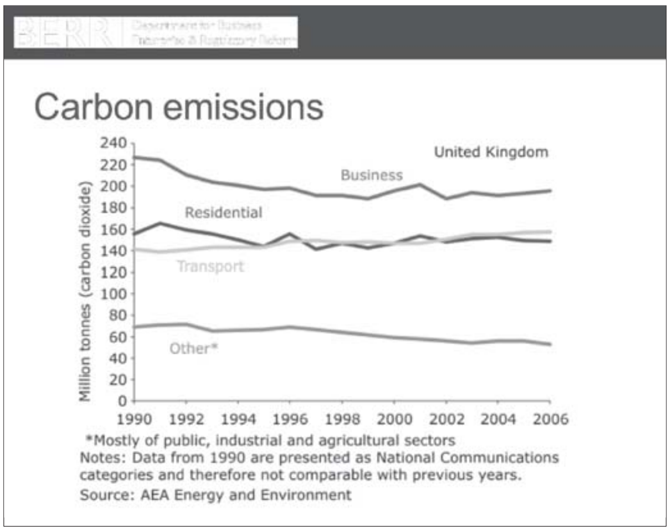
The national energy innovation landscape

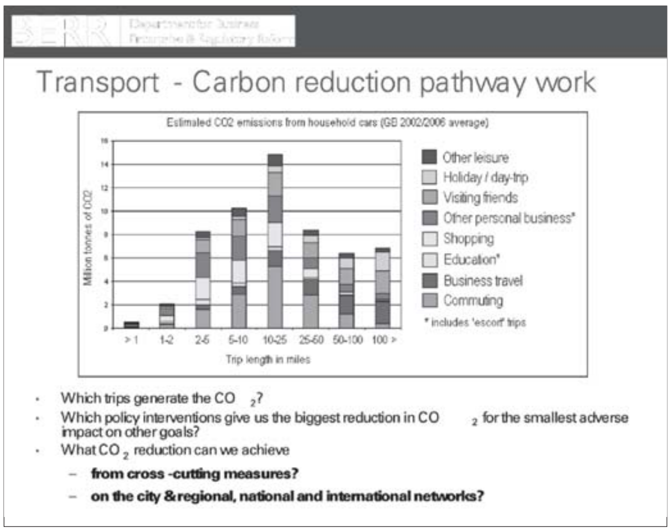
There is a clear innovation landscape in national energy development in the UK, and I shall briefly mention some of the main actors.

The Research Council, which funds the basic research work that is done in universities, has a major programme underway on energy, at £200 million over five years I believe. Moving closer to the market, we then have the Technology Strategy Board, and also the Energy Technologies Institute (ETI). You have heard David Clarke talk about some of their work earlier today.

Even closer to the market we have the Carbon Trust, which facilitates technology demonstration and looks at how to reduce the risk of investment. The Environmental Transformation Fund (ETF) is a new fund that has been set up this year to encourage the development of technologies with high potential of a positive impact. Then, very close to market, there is the Energy Saving Trust. In December we will launch the Office for Renewable Energy Deployment, which will provide advice to people on how to develop a whole range of energy sources, and not just renewables.

Carbon emissions





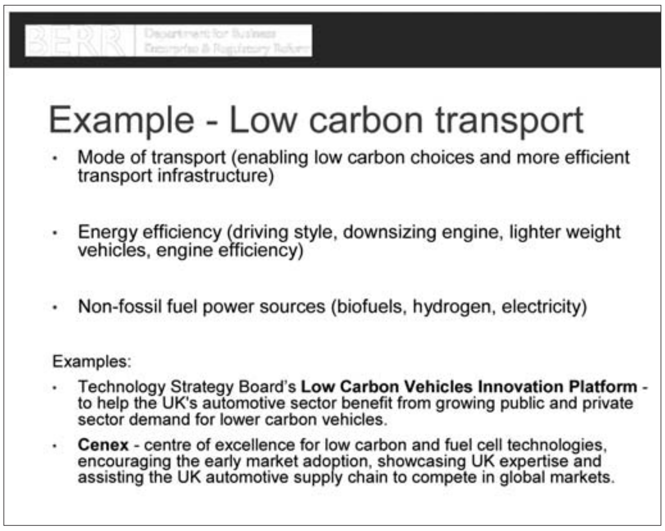
It is always worth thinking about where emissions come from so that, again, we can put renewables in context and see where they are likely to have the greatest impact. These are UK curves and I guess that they are not too different from those of other European countries. As you can see, transport is the bad guy, the one that is going up. Everything else has been going down and we know now how to bring residential and business emissions down quite quickly. The 'other' curve refers to public, industrial and agricultural emissions– and, again, we know reasonably well how to deal with these, but transport is the difficult one.

Transport – carbon reduction pathway work

I thought I would spend a moment talking about some work in progress on the nature of journeys that produce carbon emissions. Along the bottom of this slide you can see trip length in miles, since this is for the United Kingdom, and emissions are measured along the vertical axis in millions of tonnes of carbon dioxide. This is averaged over four years of private cars travelling on our roads in the UK. You can see that most of the emissions, shown in the blue bars at the bottom, come from journeys of less than 50 miles and they are commuting – it is people travelling in their cars to and from work, because there is no public transport.

Most of you who know London say that you would not dream of using a car in London but, anywhere else in the UK you do not have many options and that is part of our problem. Most of the debate about what is happening in transport tends to become London-centric because most of the debate takes place in London, while most of the experience of commuting is actually outside of London and has nothing to do with public transport. I know that that is a generalisation but it has a particular impact on how we think about electric vehicles in the near-term because that type of journey is ideal for electric vehicles. Yes, you have to worry about the interface to the grid and yes, you have to worry about fuel cells or batteries, but that looks to us to be quite a quick win, and the Government has put a great deal of money into investment in electric vehicle technologies.

Low carbon transport



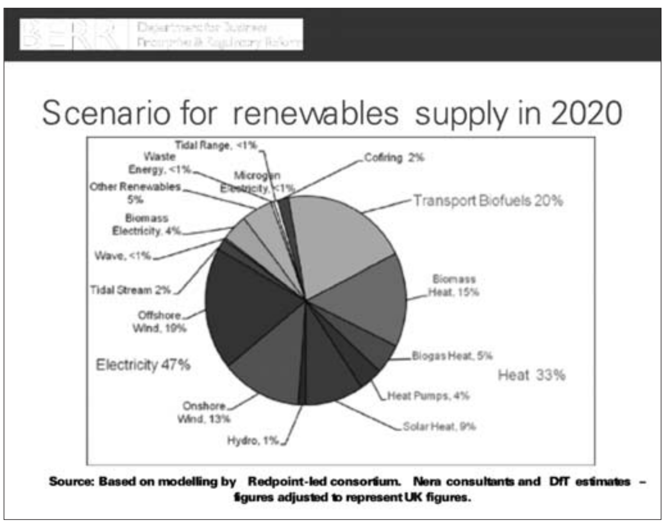
With low carbon transport, just to dwell on this a little longer, how do people switch modes of transport and what causes behavioural change? How do you make engines more efficient and can you use non-fossil fuel power sources? This is the Low Carbon Vehicles Innovation Platform that I just referred to, and Cenex, which is a major centre of excellence for low carbon and fuel cell technologies, about 40 miles north of here near Bedford, is a showcase of what we are doing in this space and it is open for people to go and visit.

Scenario for renewables supply in 2020

Going back to the big renewables picture – and this is a UK picture – what is interesting is the vast array of renewables available to us. This slide shows us where the major technologies will be by 2020. As we heard this morning, there is wind, offshore and onshore; solar, which is still significant in the UK and I agree with Professor Abascal in that we should be looking at this much more than we currently are; biomass and transport – which is euphemistically known as biofuels but I would suggest that we should actually put electric in there and make our biofuels problems and our food issue a little easier to resolve. However, you will see many other technologies which, in the short term, look as though they will not produce very much, which is why I have included that growth target for 2050 because a number of those will come into play later as the technologies mature.

One of my jobs, of course, is to advise on where we should put our money. The short-term money has to go to deal with the 2020 target, while the long-term money has to be used for de-risking some of the technology in the longer term. I also have to protect it from being diverted to other needs in an uncertain financial climate. Part of the issue for us, therefore, is how to balance our short-, medium- and long-term investment portfolios. And how does the picture for future renewables change as a result of our investment?

Long-term market potential



The greatest long-term market potential, at least for the UK, lies in a massive expansion of offshore wind, and that is where we are likely to go. As David Clarke mentioned earlier, there will be many private sector partnerships through the ETI for offshore wind projects, and then there is the Carbon Trust for projects that are nearer to the market. So you can see that the scale of investment that we are putting in is quite considerable.

Challenges and opportunities for renewables

Overall, the bottom line is that we need a step change in renewables deployment. It is a very challenging target. The Government certainly has a role to play in removing barriers – regulatory barriers, planning controls – and in reducing cost, as we heard earlier. I believe we also need to do something about a national or an international infrastructure. When people were talking about having a European-wide grid, I was thinking about whether there is a European-wide grid now – and yes there is, and it is called air traffic control. We have almost reached the stage where we have pan-European air traffic control as an integrated entity: we move aircraft around as packets full of people, or freight, in a European-wide manner. If we can do that, why can we not do it for other entities such as packets of electricity? We actually do it on the internet, of course, without even thinking about it. So there is something to do with willpower, to behave on a European basis, at the appropriate level of principles, leaving some elements at a level of subsidiarity.

In the UK, of course, I am concerned that we have enough skills and expertise to take forward our ambitious plans, but we must do this in concert and in partnership with everyone else.

I hope I have been able to give you an overview of the UK position on the themes of today's conference. It has been extremely interesting for me to hear where different views and opinions come from. We are all living in this joined-up world, this joined-up continent. We all have slight differences of opinion on what we need to do, because we all come from different places, but we need to continue to have forums such as this where we share views and opinions and hear about our differences, and harmonise our approach – to use a very European term— in order to take forward a common agenda. Thank you very much.

Biographies

Keynote Speakers and Chairs

Professor Lena Treschow Torell

Professor Treschow Torell is Professor of Physics at Chalmers University and President of the Royal Swedish Academy of Engineering Sciences (IVA). She is also Chair of Euro-CASE, the European Council of Applied Sciences and Engineering. Between 1998 and 2001, she held the position of Research Director at the European Commission Joint Research Centre (JRC) in Brussels. Professor Treschow Torell is heavily engaged in industrial research and technology development and has served on the board of several industry-linked research institutes and companies. She is a member of the Globalisation Council of the Swedish Government and has received the Seraphim Medal from H.M. the King Carl XVI Gustaf. Professor Treschow Torell received her B.Sc. and Ph.D from the University of Göteborg, Sweden.

Lord Browne of Madingley FREng FRS

Lord Browne is the President of The Royal Academy of Engineering. He also holds the post of Managing Director of Riverstone Holdings LLC. He began his career in BP as a university apprentice in 1966 and between 1969 and 1983 held a variety of exploration and production posts in BP. In 1989 he became Managing Director and Chief Executive Officer of BP Exploration and in 1991 was appointed to the Board of The British Petroleum Company plc as a Managing Director. He was appointed Group Chief Executive in 1995. Following the merger of BP and Amoco, he became Group Chief Executive of the combined group from 1998 until 2007; in this role he was voted most admired CEO for four consecutive years by Management Today. He was knighted in 1998 and made a life peer in 2001.

Andris Piebalgs

Andris Piebalgs took up the post of Energy Commissioner in November 2004. Before joining the European Commission, Mr Piebalgs worked for almost a decade in diplomacy, first becoming the ambassador of Latvia in Estonia, and later the Ambassador of Latvia to the European Union and Undersecretary of State for EU affairs at the Ministry of Foreign Affairs of Latvia. Mr Piebalgs was born in Valmiera (Latvia) and obtained his degree in Physics from the University of Latvia.

Dr John Roberts CBE FREng

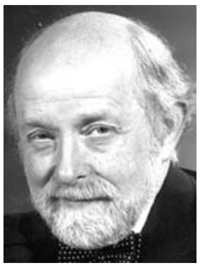
Dr John Roberts is Chairman of Viking Consortium holdings and of Remote Energy Monitoring Holdings Ltd. From 1999 to 2006 he was Chief Executive of United Utilities plc. Dr Roberts has a degree in Electrical Engineering from Liverpool University and is a Fellow of The Royal Academy of Engineering.

Peter Saraga OBE FREng

Peter Saraga is Vice President and Honorary International Secretary of The Royal Academy of Engineering and the immediate past President of the Institute of Physics. From 1992 to 2002, he was Director of Philips Research Laboratories UK responsible for major research programmes in displays, wireless communications, and interactive digital television.

Professor Julia King CBE FREng

Professor King is Vice-Chancellor at Aston University, Birmingham and a board member of the European Institute of Innovation and Technology (EIT). She has previously served as Principal of the Engineering Faculty of Imperial College London, as Chief Executive of the Institute of Physics and as Head of Materials at Rolls Royce Aerospace Group. She is a leading expert on the fatigue and fracture of structural materials. She is a member of the UK Government's Technology Strategy Board and a non-executive Director of the Department of Innovation, Universities and Skills. She is also responsible for the King Review on low carbon transport, commissioned as a key element of the 2007 UK budget.



Professor Ian Fells CBE FREng

Professor Fells was educated at Trinity College Cambridge where he gained a PhD in reaction kinetics. He has been Professor of Energy Conversion at The University of Newcastle since 1975 and has published some 250 papers on topics as varied as the chemical physics of combustion, fuel cells, rocket combustion, energy economics, environmental protection, energy conversion systems, and energy policy. He has been Energy Adviser to the EC and European Parliament and has advised a number of governments on energy policy.

Professor Nigel Brandon FREng

Professor Brandon is currently Executive Director of the Imperial College Energy Futures Lab and is Shell Chair in Sustainable Development in Energy, Department of Earth Science & Engineering, Imperial College London. In 2006 he was appointed Senior Research Fellow to the UK Research Councils Energy programme and the UK Government Office of Science Focal Point in Energy with China. He leads the EPSRC funded Supergen fuel cell consortium. Prof Brandon holds an engineering degree and PhD from Imperial College London. Prof Brandon was elected a Fellow of The Royal Academy of Engineering in 2008.

Professor Brian Collins

Professor Brian Collins is the Chief Scientific Adviser (CSA) at the Department for Business Enterprise and Regulatory Reform (BERR) and the Department for Transport (DfT). He is also Professor of Information Systems at the Defence College of Management and Technology (DCMT), Cranfield University. Previously, he has held senior positions at Clifford Chance, the Wellcome Trust, and was Chief Scientist and Technical Director at GCHQ and Deputy Director at Royal Signals and Radar Establishment (RSRE). Professor Collins is a graduate of Oxford University, where he read physics and also obtained his doctorate in astrophysics. He is a Fellow of the Institute of Engineering and Technology (IET), the British Computer Society (BCS), the Institute of Physics (IOP) and the Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA).

Dr David Lindley OBE FREng

Dr Lindley is an executive director of Pelamis Wave Power Ltd and was its Chairman from 2002 to 2005. He is also a member of the advisory Council of SAM Private Equity Sustainability Fund II of Switzerland. He was founder and managing director of National Wind Power Ltd, the UK's leading developer and operator of both onshore and offshore windfarms, and Wind Energy Group Ltd, a company which designed and manufactured wind turbines and rotor blades. He received an OBE in 1998 for services to renewable energy and wind turbine industries. Dr Lindley is a Fellow of The Royal Academy of Engineering.

Erik Kjaer Sorensen

Erik Sorensen is Director and Senior Power Sector Expert in the Group Government Relations Department of Vestas Wind Systems A/S. Between 2006-2008 Mr Sorensen was international senior technical adviser to the 3-year Sino-Danish wind energy development programme in Beijing, aimed at building wind energy capacity at key institutions in China. Prior to this, he worked as General Manager of Business Development at the production utility ENERGI E2, where he was responsible for the successful implementation of E2's renewables strategy outside Denmark, including the development and evaluation of numerous onshore and offshore wind projects throughout Europe.

Dr David Clarke

Dr David Clarke is the Chief Executive of the Energy Technologies Institute (ETI) a public private partnership set up in the UK to support demonstration projects which will enable accelerated deployment of low carbon energy solutions. He joined the ETI from his previous role as Head of Technology Strategy at Rolls Royce Plc, where he was responsible for development and management of global research strategy and leadership of a range of research groups. He is also a member of the Energy Research Partnership, the North West Science Council, and advisory boards at several UK Universities.

Professor José Domínguez Abascal

Professor Abascal took up his current position as Chief Technology Officer of Abengoa in May 2008. Prior to this, he served as the General Secretary for Universities, Research and Technology in the regional government of Andalusia (2004-2008) and as Vice-Rector (1990-1992) and Dean of Engineering (1993-1998) at the University of Seville. He served as a consultant in the structural design of the Palenque for Expo 92, the Real Betis football stadium and the Chapina Bridge, all in Seville, and was responsible for structural integrity in the restoration of the 16th century bronze scuplture "El Giraldillo" on the spire of Seville Cathedral, for which he was awarded the National Culture Heritage Restoration Award in 2006. Prof Abascal obtained his Mechanical Engineering degree in 1975 and his Ph.D. in 1977, both at the University of Seville, and was a Postdoctoral Fulbright Scholar at MIT from 1977 to 1978.

Dr Arnulf Jaeger-Waldau

Dr Jager Waldau is Senior Scientist at the European Commission Joint Research Centre Institute for Energy, at Ipsra, Italy, and recently led work on a technical reference system for renewable energy and energy end-use efficiency. Prior to this he was a scientist at the Hahn-Meiter Institut in Berlin, where he led research on thin film solar cells, at the University of Konstanz and at Shinshu University, Nagano, Japan, where he was a Humbold scholar. Dr Jager-Waldau has written over 100 papers and produced several patents in solar cell technology.

Professor Frank Behrendt

Professor Behrendt is Professor for Energy Process Engineering and Conversion Technologies for Renewable Energies at the Berlin Institute of Technology (TU Berlin). In 2007 he was appointed Speaker of the Innovation Centre Energy, with responsibility for the coordination of all energy-related research at TU Berlin. He received his PhD from Heidelberg University in 1989, and since then has carried out research on catalytic ignition and combustion at Gothenborg University, Sandia National Laboratories in California, and Stuttgart University. In 2007 Professor Behrendt was elected as member of the German Academy of Science and Engineering (acatech).

Professor Einar Broch

Einar Broch is Professor of Geological Engineering at the Norwegian University of Science and Technology, Trondheim. He has worked as a private consultant on a wide variety of projects, mainly related to tunneling and underground work, including over 25 hydropower projects in Norway, and hydro and tunneling projects in China, Nepal and 13 other countries worldwide. He is senior editor of 'Tunneling and Underground Space Technology' quarterly journal and has authored or co-authored over 150 papers. Professor Broch is a member of the Norwegian Academy of Technical Sciences.

Dr Ray Alcorn

Dr Raymond Alcorn is currently the Research Manager at the Hydraulics and Maritime Research Centre, at University College Cork an executive management and business development role. With the 30 strong multi-disciplinary team, he is involved in providing research andcommercial services to the ocean energy and coastal engineering sector. Raymond joined HMRC from an Australian commercial wave energy company where he spent 4 years as Head of Electrical Engineering, working on design, development, deployment and commissioning of full scale wave energy plant. Originally an electrical engineer he has been involved in wave energy for the past 15 years after having obtaining his PhD in the field from Queens University, Belfast.

Pat McCullen

Pat McCullen is special consultant to ESB International. He has over 44 years experience of engineering design, project management and construction of energy related projects. In the past decade he has concentrated on renewable energy resource analysis and has led groups responsible for the Republic of Ireland and Northern Ireland Wind Atlas in 2003 and 2004, the 1997 Total Renewable Energy in Ireland report and its 2004 update, and the Accessible Wave Energy Atlas– Ireland.

Professor Roger Falconer FREng

Professor Falconer is currently the Halcrow Professor of Water Management at Cardiff University, UK. He is also Director of the Hydro-environmental Research Centre and Head of the Insitute of Sustainability, Energy and Environmental Management. Roger Falconer graduated with a BSc from King's College, London, an MS from the University of Washington, Seattle and a PhD from Imperial College, London. He was elected Fellow of the Royal Academy of Engineering in 1997.

Dr Bruno Jarry

Dr Jarry is a Fellow of the French Academy of Technologies, and is presently serving as a Senior Adviser on biofuels to the Prime Minister of France. Dr Jarry first worked as a researcher in CNRS in Marseille and Strasbourg where he held tenure as Professor of Genetics and Biotechnology. He then moved to industry to become Vice-President R&D of ORSAN, a global subsidiary of the Lafarge Group in the field of industrial biotechnology. Later he joined the Belgian Amylum Group, a European starch producing company, as R&D Director, and when Amylum merged with Tate & Lyle he became Scientific Director of the amalgamated company. Dr Jarry has founded several start-up companies in the field of biotechnology.

Professor Petter Gustafsson

Professor Petter Gustafsson is Professor in Plant Molecular Biology at the Department of Plant Physiology, Umeå University, Sweden. Prof. Gustafsson is presently chairman of Umeå Institute of Technology and has been the dean of the faculty of science and engineering at the university and a board member of the Swedish Research Council for Engineering Sciences.

Professor František Hrdlička

Professor Hrdlička is dean of the Faculty of Mechanical Engineering, Czech Technical University (CTU) in Prague and a Court Authority in the Field of Power Engineering. He is a Member of the Supervision Council of Czech Chamber of Civil Engineers and a Member of the American Society of Mechanical Engineers (ASME), U.S.A.

Dr Jan van der Eijk

Dr van der Eijk took up his position as Group Chief Technology Officer at Royal Dutch Shell in May 2006. Within this role he is responsible for establishing and implementing the technology direction that will help shape Shell's future. Starting as a research scientist in the Amsterdam laboratories in 1980, Dr van der Eijk went on to hold various research and management positions in the technology organisation of Shell, and in manufacturing and strategy/planning. Dr van der Eijk's educational achievements include a doctorate in physical organic chemistry from the State University of Utrecht (NL).

Paul Caseau

Paul Caseau was responsible for scientific and technical applications at Electricité de France from 1971-1981 and later became Head of R&D at that organisation, a position he held from 1987-1994. He has been a member of the Académie des Technologies (National Academy of Technologies of France, NATF) since its foundation in 2000 and is a member of the Academy's Energy and Climate Change commission.

Dr Irene Aegerter

Dr Aegerter is Vice President of the Swiss Academy of Engineering Sciences. Dr Aegerter obtained her Ph.D at the University of Berne, and undertook post-doctoral studies at the University of California, Los Angeles, under Nobel Prize winner Professor Willard F. Libby. After taking time out to raise her family, she returned to the world of energy as founder and first President of the Swiss association of Women for Energy, and in 1993 became the first President of the international organisation "Women in Nuclear" (WIN). She has served as Vice President and Director of Communication of the Association of Swiss Power Producers and Distributors, and from 2000 to 2007 she was a Member of the Swiss Federal Commission on Nuclear Safety.

Željko Jurić

Željko Jurić is a senior researcher in the Department for Renewable Energy Sources and Energy Efficiency at the Energy Institute Hrvoje Pozar in Zagreb, Croatia. He obtained his M.Sc. from the Faculty of Electrical Engineering and Computing in Zagreb.

Euro-CASE Conference Delegate List

Mr Yaver Abidi	*Halcrow Group*
Mr Tim Abraham	*BERR*
Dr Irene Aegerter	*Swiss Academy of Engineering Sciences - SATW*
Mr Georgios Ageradis	*Technical Chamber of Greece*
Dr Shafiq Ahmed	*The Royal Academy of Engineering*
Dr Ray Alcorn	*University College Cork*
Prof Salvator R. Amendolia	*Embassy of Italy*
Prof Dinos Arcoumanis FREng	*The City University*
Mr John Armitt CBE FREng	*EPSRC*
Mr Peter Bance	*Ceres Power*
Mr Keith Batchelor FREng	*Foster Wheeler*
Prof Frank Behrendt	*German Academy of Science and Engineering - acatech*
Mr Murray Birt	*Confederation of British Industry*
Prof Nigel Brandon FREng	*Imperial College London*
Prof Einar Broch	*Norwegian Academy of Technological Sciences - NTVA*
Lord Browne of Madingley FREng FRS	*The Royal Academy of Engineering*
Dr Pere Brunet	*Real Academia de Ingenieria - RAI*
Prof Gerry Byrne FREng	*The Irish Academy of Engineering*
Mr Ben Caldecott	*Policy Exchange*
Dr Finbar Callanan	*The Irish Academy of Engineering*
Mr Paul Caseau	*National Academy of Technologies of France - NATF*
Prof Enrique Cerda	*Real Academia de Ingenieria - RAI*
Dr Peter Chester FREng	
Ms Anna Christiansson	*European Commission Representation London*
Dr David Clarke	*Energy Technologies Institute*
Prof Roland Clift CBE FREng	*University of Surrey*
Mr Ben Coates	*Conservative Party*
Prof Brian Collins	*BERR and Department for Transport*
Dr John Constable	*The Renewable Energy Foundation*
Mr Rob Cope	*Business and Enterprise Select Committee*
Prof David Cope	*Parliamentary Office of Science and Technology*
Mr Cuong Dang	*The Royal Academy of Engineering*
Prof Richard Darton FREng	*The Institution Chemical Engineers*
Ms Rosie Davies	*The Institute of Physics*
Mr Keith Davis	*The Royal Academy of Engineering*
Dr Duncan De Lugt	*High Commission of Canada*
Prof Ian Diamond	*Research Councils UK*

Prof Jose Domingues Abascal	*Abengoa*
Prof Dame Ann Dowling FREng FRS	*University of Cambridge*
Mr Nick Dusic	*Campaign for Science and Engineering*
Ms Kate Elliot	*TLG*
Mr Gil Erez	*Embassy of Israel*
Mr Michael Everard	*Institute of Marine Engineering, Science and Technology*
Prof Antonio Falçao	*Portugese Academy of Engineering*
Prof Roger Falconer FREng	*Cardiff University*
Prof Ian Fells CBE FREng	*Fells Associates*
Ms Luisa Frumenzi	*European Commission Representation London*
Prof Janoz Ginsztler	*Hungarian Academy of Engineering*
Prof Peter Glavic	*Engineering Academy of Slovenia*
Mr Malcolm Gooderham	*TLG*
Mr Andy Gooding	*Institution of Civil Engineers*
Prof Derrick Gosselin	*Royal Belgian Academy - Royal Belgium BACAS*
Mr Iain Gray FREng	*The Technology Strategy Board*
Dr Jason Green	*Engineering and Physical Sciences Research Council*
Mr Philip Greenish CBE	*The Royal Academy of Engineering*
Prof Ferdinand Gubina	*Engineering Academy of Slovenia*
Prof Petter Gustafsson	*Umea University*
Dr Hans Hanni	*Swiss Academy of Engineering Sciences - SATW*
Dr Jeff Hardy	*UK Energy Research Centre*
Ms Ritva Haukijarvi	*Embassy of Finland*
Mr Mickael Haustant	*Embassy of France*
Mr Michael Hayden	*The Irish Academy of Engineering*
Dr Milos Hayer	*Engineering Academy of the Czech Republic*
Mr Roy Hill	*CH2M Hill*
Prof Andrew Hopper CBE FREng	*University of Cambridge*
Mr Martin Horwood MP	*Liberal Democrats*
Dr Ulrike Hotopp	*Department for Energy and Climate Change*
Prof Frantisek Hrdlicka	*Czech Technical University*
Dr Rolf Hugli	*Swiss Academy of Engineering Sciences - SATW*
Mr Vernon Hunte	*Institution of Civil Engineers*
Dr Arnulf Jager Waldau	*Institute for Energy, European Commission Joint Research Centre*
Mr Bruno Jarry	*National Academy of Technologies of France - NATF*
Prof Nick Jenkins FREng	*University of Cardiff*
Mr Alok Jha	*The Guardian*
Mr Hein Johnson	*Norwegian Academy of Technological Sciences - NTVA*
Mr Zeljko Juric	*Energy Institute Hrvoje Pozar, Croatia*

Mrs Olga Kalantzopolou	*Technical Chamber of Greece*
Dr Malcolm Kennedy FREng	
Prof Julia King CBE FREng	*Aston University*
Mr Erik Kjaer Sorensen	*Vestas Wind Systems A/S*
Prof Zlatko Kniewald	*Croatian Academy of Engineering - HATZ*
Prof Reiner Kopp	*German Academy of Science and Engineering - acatech*
Mr Kostas Kremalis	*Technical Chamber of Greece*
Mr Hendrik Kuiken	*Netherlands Academy of Technology and Innovation - AcTI-nl*
Dr David Lindley OBE FREng	*Pelamis Wave Power Ltd*
Mr John Loughhead FREng	*UK Energy Research Centre*
Prof Dennis Loveday	*Loughborough University*
Mr Simon Maine	*House of Lords*
Prof Geoffrey Maitland FREng	*Imperial College London*
Dr Balin Manuel Marquez	*Real Academia de Ingenieria - RAI*
Prof Emanuel Maranha das Neves	*Portugese Academy of Engineering*
Prof Jacqueline McGlade	*European Environment Agency*
Mr Shane McHugh	*The Royal Academy of Engineering*
Ms Iffat Memon	*The Royal Academy of Engineering*
Mr Bjorn O. Nilsson	*Royal Swedish Academy of Engineering - IVA*
Prof Per Odling	*Royal Swedish Academy of Engineering - IVA*
Sir John Parker FREng	*National Grid*
Ms Beverley Parkin	*The Royal Academy of Engineering*
Dr Douglas Parr	*Greenpeace*
Mr Andris Piebalgs	*EU Energy Commissioner*
Mr Richard Ploszek	*The Royal Academy of Engineering*
Dr Guenther Rabensteiner	*Austrian Academy of Sciences*
Mr Jonathan Radcliffe	*Energy Research Partnership*
Dr Kurt Richter	*Austrian Academy of Sciences*
Dr John E. Roberts CBE FREng	
Prof Asbjorn Rolstadas	*Norwegian Academy of Technological Sciences - NTVA*
Mr Jens Rostrup Nielsen	*Danish Academy of Technical Sciences - ATV*
Mr Gilbert Ruelle	*National Academy of Technologies of France - NATF*
Mr Peter Saraga OBE FREng	*The Royal Academy of Engineering*
Dr Carsten Schröder	*German Academy of Science and Engineering - acatech*
Ms Deborah Seddon	*Engineering Council UK*
Dr Hayaatun Sillem	*The Royal Academy of Engineering*
Prof Jim Skea	*UK Energy Research Centre*
Mr Lasse Skovby Rasmusson	*Danish Academy of Technical Sciences - ATV*
Dr Scott Steedman FREng	*Institution of Civil Engineers*

Ms Jane Sutton	*The Royal Academy of Engineering*
Mr Bernard Tardieu	*National Academy of Technologies of France - NATF*
Prof Lena Treschow Torell	*Chair of Euro-CASE*
Mr Jon Turney	
Dr Jan Van Der Eijk	*Royal Dutch Shell PLC*
Mr Gerard van Oortmerssen	*Netherlands Academy of Technology and Innovation - AcTI-nl*
Prof Ben Veltman	
Mr Simon Virley	*BERR*
Mr Peter Vis	*Cabinet of Commissioner Piebalgs*
Dr Alfredo Viscovic	*Croatian Academy of Engineering - HATZ*
Dr Alan Walker	*The Royal Academy of Engineering*
Ms Robin Webster	*Friends of the Earth*
Prof Bernard Weiss FREng	*University of Surrey*
Mr Chris White	*EU Reporter*
Mr Philip Wolfe	*Renewable Energy Association*
Dr Henrik Wolff	*Technology Academy of Finland*
Mr Paul Yiannouzis	*London Climate Change Agency*
Mr Lionel Zetter	*Institution of Civil Engineers*
Prof Petr Zuna	*Engineering Academy of the Czech Republic*

Acknowledgements

The Royal Academy of Engineering and Euro-CASE are grateful to Professor Lena Treschow Torell, President of Euro-CASE, who opened the conference, Professor Nigel Brandon FREng, who acted as rapporteur, and the session chairs: Mr Peter Saraga OBE FREng, Dr John Roberts CBE FREng, Professor Julia King CBE FREng and Professor Ian Fells CBE FREng. The Academy thanks its Fellows and staff, the staff of Euro-CASE and all the conference speakers and panellists for their input into the conference and this publication. The event would not have been possible without the generous support of the Energy Technologies Institute and the Research Council UK's Energy Programme.

The Royal Academy of Engineering

As Britain's national academy for engineering, we bring together the country's most eminent engineers from all disciplines to promote excellence in the science, art and practice of engineering. Our strategic priorities are to enhance the UK's engineering capabilities, to celebrate excellence and inspire the next generation, and to lead debate by guiding informed thinking and influencing public policy.

The Academy's work programmes are driven by three strategic priorities, each of which provides a key contribution to a strong and vibrant engineering sector and to the health and wealth of society.

Enhancing national capabilities

As a priority, we encourage, support and facilitate links between academia and industry. Through targeted national and international programmes, we enhance – and reflect abroad – the UK's performance in the application of science, technology transfer, and the promotion and exploitation of innovation. We support high quality engineering research, encourage an interdisciplinary ethos, facilitate international exchange and provide a means of determining and disseminating best practice. In particular, our activities focus on complex and multidisciplinary areas of rapid development.

Recognising excellence and inspiring the next generation

Excellence breeds excellence. We celebrate engineering excellence and use it to inspire, support and challenge tomorrow's engineering leaders. We focus our initiatives to develop excellence and, through creative and collaborative activity, we demonstrate to the young, and those who influence them, the relevance of engineering to society.

Leading debate

Using the leadership and expertise of our Fellowship, we guide informed thinking, influence public policy making, provide a forum for the mutual exchange of ideas, and pursue effective engagement with society on matters within our competence. The Academy advocates progressive, forward-looking solutions based on impartial advice and quality foundations, and works to enhance appreciation of the positive role of engineering and its contribution to the economic strength of the nation.

Please recycle this brochure (the cover is treated with a recyclable laminate)

The Royal Academy of Engineering promotes excellence in the science, art and practice of engineering.

Registered charity number 293074

The Royal Academy of Engineering
3 Carlton House Terrace, London SW1Y 5DG

Tel: 020 7766 0600

Fax: 020 7930 1549

www.raeng.org.uk