HOUSE OF LORDS

MINUTES OF EVIDENCE

TAKEN BEFORE

THE SELECT COMMITTEE ON ECONOMIC AFFAIRS

THE ECONOMICS OF RENEWABLE ENERGY

TUESDAY 17 JUNE 2008

DR KEITH MACLEAN, MR SARWJIT SAMBHI and MR BOB TAYLOR

PROFESSOR GORDON MACKERRON

Evidence heard in Public Questions 212 - 265

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TUESDAY 17 JUNE 2008

Present

Best, L
Griffths of Fforestfach, L
Lawson of Blaby, L
Layard, L
MacGregor of Pulham Market, L
Moonie, L
Paul, L
Vallance of Tummel, L (Chairman)

Memoranda submitted by Scottish and Southern Energy plc, E.ON UK and Centrica

Examination of Witnesses

Witnesses: **Dr Keith MacLean,** Head of Policy and Public Affairs, Scottish and Southern Energy plc, **Mr Sarwjit Sambhi,** Director, Power Business Unit, Centrica and **Mr Bob Taylor,** Managing Director, Generation, E.ON UK, examined.

Q212 Chairman: Good afternoon and welcome to Mr Taylor, Mr Sambhi and Dr MacLean. Thank you very much for giving up some of your time to be with us this afternoon. Thank you very much for the written submissions that each of you has given us in advance. Whether we will have been able to read all of them I am not sure; I think two of them were late runners, if I can put it that way. Before we move into questions I do not know whether you would like to make any preparatory or introductory remarks. No. In which case let us go straight into questions. I will start by asking you how do the costs of generating electricity from renewables compare to fossil fuel and nuclear generation? What are the current estimates for the costs of greener fossil fuel generation with carbon capture and storage and how do those costs compare to renewable generation?

Mr Taylor: Firstly we have shared some costs in the evidence in this regard. Before I go into the detail of answering the question, energy investments of course are long term investments

and the basis of the analysis to come forward with these costs takes long term judgments about the relative commodity prices for fuels, in addition to some other costs. In our evidence you will see that we are showing costs for offshore wind – these are long run marginal costs – of around £107 per megawatt hour; the costs for onshore wind of around £75 per megawatt hour. That compares to coal, assuming 40 euros a tonne for carbon price, of around £70 per megawatt hour. Broadly you can see that if you make some assumptions around the cost of carbon you can see the cost of coal with the cost of carbon approaching the cost of onshore wind. As soon as you move away from the carbon price and just take the basic underlying costs you get different figures with fossil fuels being much cheaper than the cost of renewable generation. When it comes to carbon capture and storage our view is that the cost of coal with carbon capture and storage, once carbon capture and storage is commercially proven, it will break even at the order of 40 to 50 euros per tonne, so you get a cost for coal plus carbon capture and storage of around about £70 a megawatt hour. That is really sharing with you the information that is given in the written evidence.

Q213 Chairman: Just coming back to wind for a moment, you were talking about long run marginal costs, does that include the impact on standby facilities, given that there is intermittency in the wind, and does it include the impact on the grid?

Mr Taylor: No, this is purely the long run marginal costs of the renewable investment, the wind investment itself. It will assume a certain cost of connection charge in the economics and the capital cost of that investment, but it does not include any costs associated with supporting the intermittency of wind on the system.

Q214 Chairman: In order to make decisions presumably one would have to look at the total systems. This is perhaps not for you.

Mr Taylor: Exactly. We are looking at these as individual choices and investments that we make, but it is important when you are looking at the overall generation mix, the holistic economics of operating the system going forward, as we move from two gigawatts of wind on the system to 20 or 30 gigawatts of wind on the system then there are other issues to take into account and maybe in other questions we can address that and other colleagues can comment also.

Q215 Chairman: Are there any further comments or do you both agree with your colleague?

Mr Sambhi: On the comment on the long run costs of generation I would add the word of caution that it really does depend on what you assume the long range prices are for the input fuels. If I took, for example, today where we have very high gas prices and very high coal prices, building a coal fired station or a gas fired station looks very expensive; if you use today's commodity prices, the cost of gas would be over £90 per megawatt hour and coal above £70. They are pushing to either at least or above the cost of offshore wind which does not have any fuel exposure. However, if you assume that prices are half of what they are in the long run the picture does look different. On your question around the cost of intermittency, I think that that point could be overplayed because we have to remember that in the future if we do have a lot of offshore wind in the power system in the UK, the role of our existing plant changes - the existing plant being the existing fossil fuel plant – and they change to become backup plants; they have longer lives because you are using them for less hours and therefore the new investment cost may not be prohibitive.

Dr MacLean: A further point on that, I think it is important to underline the fact that once the investment has been made in the renewable forms that we are talking about, they are then independent of the fuel price going forward, whereas one of the big issues that we are facing at the moment is not only the high price but the volatility and uncertainty of the price, but also the difficulties with availability that will increasingly have in the prices. It is slightly difficult

to do a comparison. In our written evidence – which I think was amongst the later papers – you will see that that we have tried to show a graph which compares the price dependency of gas generation versus renewables and it can be seen from that that the curve for gas goes up very, very steeply depending on the oil price, whereas for renewables it is a much flatter curve. With regard to the back up issue, I think it is wrong to think that it is only renewables that have to have backup. We currently have a system that is made up of generation that is best suited for doing different things. Peak lopping, for instance, is not something that nuclear does and we already have to have things on the system which will do that. As you rightly said, the capital costs of many of the backup measures - which need not be generation, they could be storage, they could be demand side measures as well – if those are, as with coal or gas, relatively low capital cost then the overall cost to the system is still relatively small because the main cost will then be incurred only when they are having to run to provide that backup capacity. That is an economy reality that we already face with the mixed portfolio of generation that we have and we are just changing the balance of that situation by moving to a higher renewables penetration.

Q216 Chairman: Previous witnesses have suggested to us that the degree of intermittency associated with wind is of a different order than for any other form of generation; is that correct?

Dr MacLean: It is a different type. If you look at the situation we had a couple of weeks ago when Sizewell B and Longannet both dropped off the system at the same time, that was a massive intermittency of gigawatts. That is something we would never have with that single point of failure with renewables. The system has been built to be able to cope with that sort of change. It must also be remembered the biggest intermittency on the system at the moment is not on the supply side but actually on the demand side. The change from the summer trough to the winter peak is absolutely enormous and the system has been designed to be able

to cope with those ups and downs, minute by minute, hour by hour, month by month. We are altering the balance but we are not fundamentally introducing a situation that we have not been dealing with for many years already.

Q217 Chairman: Is there not a different between intermittency which is a failure of plant and intermittency which is a failure of the source of power?

Dr MacLean: The durations are certainly different and I am not saying that we will not have to modify the system to cope. All I am saying is that we already manage these issues within the current system; the technical means are there and we believe the economic model that we currently have will probably cope with that change as well.

Q218 Chairman: Is there a point at which there is so much wind generated into the system that the costs then flip into being significant? You are suggesting at the moment that it is done on the margin. Perhaps your colleague would like to answer that.

Mr Taylor: I do think there is a difference once we start going to the extreme levels that we aspire to in order to meet the renewables target. At the moment we are able to cope with that on the system and, as my colleague mentioned, National Grid operate enough spinning reserve to cope under most circumstances with a major plant coming off the system. If we look at the load factors, and in particular here we are talking about wind as the main part of renewables investments, we are looking at onshore load factors of around 30 per cent, a little higher towards 40 per cent for offshore. If we look at the inherent variability compared to the running variability of a conventional plant, of course the running capability available of a conventional plant it suffers up to five per cent forced outages at any one time, but on average it is running with technical running capability outside of planned outages is 95 per cent. When we analyse the data from our real wind farms that exist now - we have 21 geographically dispersed wind farms across the UK – and we look at that data, that data

clearly demonstrates that in particular during the winter peak periods (which are some of the most essential periods for capacity on the system) the firm capacity of our wind portfolio is somewhat under ten per cent, around eight per cent. The implications for that are that in fact in the longer term we will aspire to solve some of that through energy storage, through demand side management and indeed through very significant interconnection between the system. If we look at northern Germany – of course our company is present there – there are some 20 gigawatts of wind and there are lessons to be learned from how the system operates and the impact there. Some of the submissions we have made elsewhere have demonstrated that we could require the capacity to be increased from around 76 gigawatts (which is the current total capacity on the UK system) to beyond 100 gigawatts, possibly up to 120 gigawatts, in order to support up to 40 gigawatts of wind and towards 50 gigawatts if we go even further. So I think there are some differences and it needs to be addressed and thought through. There are differences technically and differences commercially.

Q219 Lord Layard: Could you tell us how much capacity is held in reserve to cope with fluctuations in the wind and how much more reserve capacity will be needed as the proportion of wind within the system increases? Does the backup have to come from fossil fuel?

Dr MacLean: The answer to that is partly what we were saying before, that there is already currently somewhere between ten and 15 gigawatts of capacity that is kept in reserve over and above what is technically needed to meet the absolute peak in the system. It is over 20 per cent at the moment but that number is coming down rapidly as plant closes and is not replaced. Our companies have all worked together on a report from the UK Business Council for Sustainable Energy and I am happy to give the Committee a copy of the paper or a link to that. We have calculated that we will need an extra 17 gigawatts of capacity in order to balance the increase of renewables from about five gigawatts to 55 gigawatts, so 17 gigawatt increase in the backup. That can be in the form of generation or storage or demand side

measures which will allow either the peaks to be met or the other situation that we have that if, for instance, in the middle of the night a gale is blowing, it is raining very hard, the tides are all doing what they are doing very well, we are quite likely in a high renewable penetration world to be generating far more energy than we have actually got demand for at the time and that will make storage as an element of that 17 gigawatts much more important in order to be able to harvest all of that energy. That is 17 gigawatts over and above what would be held at the moment.

Q220 Lord Lawson of Blaby: Have you got any figures on the cost of storage?

Dr MacLean: The cost of storage at the moment is relatively high. I am not a great expert in that area but there is a lot of work being done at the moment, for instance in Scotland, looking at what more we can do with storage and what we can do with the existing hydro plants that are there in order to be able to better use them for those sorts of purposes. We are talking about an order of magnitude of change but one which we think, by 2020, could play a significant role in that overall one, but it will not replace the need for a big proportion of that 17 gigawatts to come from some form of despatchable generation.

Q221 Chairman: I think Lord Lawson was asking whether you had anything on paper that you could give us.

Dr MacLean: No, I do not have at the moment. We are currently commissioning some work on that and we will have to share that at a later date.

Q222 Lord Moonie: Have you done any modelling work on, for example, charging batteries as a means of looking to the future or production of hydrogen?

Dr MacLean: One of the very interesting measures that is being considered at the moment is to use peak capacity for the charging of batteries for electric hybrid vehicles. In carbon terms,

even using current grid electricity and the carbon intensity of that, it is actually preferable to charge the battery of a hybrid vehicle from the mains than by doing it through the inefficient internal combustion engine of the car itself. As we move to a situation of 30 or 40 per cent renewables it then becomes much more attractive to use electricity for batteries for vehicles and for heat storage as well through immersion heating. You are then actually looking at the much wider picture of heat and transport as well as electricity in order to make the best use of the resource that you have.

Q223 Lord Layard: I do not quite understand the return to the individual company that is supplying the wind energy. Is there some linkage between the wind capacity and the backup capacity?

Mr Sambhi: Today the requirement for backup for wind is relatively small because wind as a percentage of the generation mix is tiny. To answer the question of whether today we hold backup generation the answer is no because the grid has enough reserve capacity in the system to cope with fluctuations in supply from wind farms in the UK. Fast forwarding to the future where the share of wind is much bigger, then there will be a requirement almost to create a new market which is a backup market and so your last question about the incentive for companies, today in the current market design there is limited incentive and that is one of the things that the industry is discussing at the moment: how should this backup plant be rewarded? Is there a regulated mechanism? Is there a market for backup that is created amongst the generators? So we have not solved the problem; we know what the problem is but there are different solutions.

Mr Taylor: If you think about it at the moment, we have some 76 gigawatts of capacity on the system. Over the next 12 years a third of that will close out anyway, that is the old coal plant and the old nuclear plant. We have the challenge of potentially supporting some 40 gigawatts of variable renewables capacity which can vary between being 40 gigawatts and being four

gigawatts and that will require us not only to use the existing capacity that we have because that will be closing and there will be a need to invest in capacity to support the renewables capacity that will be coming on the system. That is a very significant challenge and one that needs to be thought about holistically in the costs of running a system with that mix.

Q224 Lord Macdonald of Tradeston: When you come to the need for backup sources for your wind farms if it is not required yet, what do you think the net effect will be on carbon emissions? As the amount of wind capacity rises can you help with the equation of how the carbon emissions will decline?

Dr MacLean: All of the calculations are based on energy rather than capacity and I think it is important that we split out the two issues. Let us take, for example, one of the scenarios we are working on that we reach a penetration of renewables of 40 per cent, it means that 40 per cent of the electricity will be generated by fuel free means and the remaining 60 per cent will require us to burn fossil fuels or to use nuclear plants in order to provide that. The carbon equation is based purely on that energy; it is only in a tiny, tiny way impacted upon by the amount of capacity that we have sitting there in the system. In a world where we expand the system that we have at the moment of 70-something to 120-something then that increase in capacity does not have a significant impact on carbon. It is only when you actually start running the plant that the big benefit of renewables is that it displaces the need to burn fuel in order to create that energy. That displacement is what is giving us the carbon saving and it is unaffected almost completely by the capacity that we have sitting there.

Q225 Lord Macdonald of Tradeston: It is quite a simple reduction.

Dr MacLean: Yes, absolutely simple, based on that penetration level.

Mr Sambhi: Let us say we went to 40 per cent renewables and let us say we had 20 per cent nuclear and the balance of electricity being provided by fossil fuels – so the balance is 40 per

cent – that is nearly half of what we have today. In simple terms you are halving the amount of carbon emitted.

Q226 Lord Lawson of Blaby: Lord Macdonald has a point because if, to take an extreme case, you went to 100 per cent renewables there would still not be 100 per cent reduction in carbon emissions because you still require the backup.

Mr Sambhi: You could not go to 100 per cent renewable energy because there will be days where the wind does not blow.

Q227 Lord Lawson of Blaby: Exactly, that is the point.

Dr MacLean: Even if you did get to a very high penetration the only carbon there is in the system comes from the embodied carbon that you have because you have built the thing and for any fuel that you burn as you run it. That is the simple equation and the embodied carbon is so much lower than the carbon from the combustion process that it can be pretty much ignored for the purposes of that calculation.

Q228 Lord Paul: What have been the main obstacles to building more renewable power stations? Is it the money? Is it the planning permission? Or is it the connection to the network? Does it make any difference who owns the network? Have you done any studies that if you built a brand new fossil fuel plant and then at the same time if you are asked to supply 20 per cent of renewable energy, what will be the difference in cost to the consumer?

Dr MacLean: There are a lot of points there; I will take the first part. The two main blockers that there are to progress are planning and grid. It is not the availability of money; it is not the support mechanism. The Renewables Obligation has created a lot of interest; it has created a lot of backing from investors. Our problem is that there is a queue of projects waiting to get on to the system and either they cannot get planning permission or, when they do get planning

permission, they cannot connect to the network. All of us are very supportive of the Planning Reform Bill and the ideas in there to speed up decision making. We do not expect every decision will be a yes; we want quick "yeses" and quick "nos". The decisions are not better but if they can be made in months that is better than years as we have at the moment. Grid access must be reformed to allow renewable generators to connect to the system when it is technically possible for them to do so. At the moment that is not happening. We must also, on the planning side, ensure that we are building what new network needs to be built in order to accommodate the renewables in those areas where they are going to be developed. That is going to be particularly true of the offshore wind where we are going to have to ensure that there is a lot of investment not only in the wires to bring the power in but also onshore to make sure it gets to the right places once it is there. Those are the two things and I hope one of my colleagues will come up with an answer to the second part.

Mr Sambhi: Lord Paul, could you please clarify your second question because I am not sure I fully understood it?

Q229 Lord Paul: If you have to build a new plant for fossil fuel generation and if you have to supply along with that 25 per cent of renewable energy, what will be the cost to the consumer?

Mr Taylor: Assuming that the figures I quoted a little earlier on which were of the order of £100 a megawatt hour for offshore wind versus the base costs of coal without the cost of carbon which is around £50 a megawatt hour, if you were doing 20 per cent by offshore wind and displacing the coal you would incur a 20 per cent increase I think of the overall cost. That is just a quick calculation that can be done from the figures that we quoted in the evidence. I would just like to add to the comments from colleagues. I full agree with the issues of the grid, planning and supply chain. I think, given the scale of investment that we are now talking about here (if we go to 30 gigawatts of offshore wind we are talking about

£60 billion plus investment just in the actual plant itself together with other investments in new support capacity and transmission) one of the things that of course is an issue is the attractiveness of the market to invest in for investors that have a choice across a whole range of countries to invest in. We have seen some examples of that most recently with people taking decisions in that regard.

Q230 Lord Paul: I was not asking the question about your costs; I am talking about delivery to the consumer which includes connection and storage backup.

Mr Taylor: I am sorry I am not able to answer that. My answer was really just an implied increase in the wholesale cost.

Q231 Lord Moonie: Shell has recently pulled out of the London Array offshore wind farm project in which E.ON is an investor, citing unfavourable economic factors. Could you expand a bit on the economic problems facing offshore wind compared to onshore projects and other forms of renewable generation? Do you think this is going to change over time?

Mr Taylor: In a sense I have to leave Shell to make their own comments, but the comments they have made are around them reviewing their investment options including opportunities to invest in onshore wind in the US and they have concluded that they wish to dispose of their share as was announced. Everything is relative and they were looking at other options for their investment. The investments in offshore wind are significant. London Array is £2 billion-plus for one gigawatt of offshore wind and therefore these are big investments. We are now looking at that in the light of what has happened with Shell and of course reviewing that project to understand the economics and to work with the supply chain to try to make sure that the economics work for that project. I cannot really go into too much more detail really on that, suffice to say that there is bound to be a delay as a result of Shell - who had a

third of that project – deciding to sell their share. We hope to resolve this as quickly as possible so that we can determine whether that project goes ahead or not.

Q232 Lord Moonie: Is one gigawatt the headline figure or the 30 per cent figure?

Mr Taylor: That is the headline figure, so its contribution will be of the order of 38 per cent of that on average.

Q233 Lord Moonie: Is the winter profile any better than for onshore?

Mr Taylor: I do not have the exact figures but on average over a portfolio of wind farms we actually have an average contribution during the winter peak periods of around eight per cent. I cannot quote what we expect during that period specifically for the London Array project.

Dr MacLean: Perhaps in contrast we have just made an announcement in recent weeks of a big offshore project which will be the biggest in the world - assuming we are there before the London Array – of half a gigawatt and that is an even higher cost per gigawatt than Bob was talking about there. It is 500 megawatts for £1.3 billion. We are putting our money where our mouth is; we believe that we can make the economics of that project work. We would be delighted if the capital costs were lower but we still believe in the environment we are investing in at the moment that that makes economic sense for us to move ahead with what is a very, very significant investment. I just want to reinforce the point, it is very difficult to compare capacity and energy. We are building the project because we get money for providing energy not providing the capacity. The capacity is almost an irrelevance. As with a car the capacity of the engine is actually far less of interest than the acceleration, the fuel consumption and the top speed, depending on which particular one you are interested in. You can get a lot of power out of a low capacity. It is really a misleading comparison. The renewable world is a different one. We have looked at hydros with capacity factors of less than 20 per cent quite happily and they do a good job for what they are designed to do, which

is to provide energy at particular times. Wind and tide and wave will do exactly the same. Let us see the energy rather than the capacity.

Q234 Lord Griffths of Fforestfach: I would like to ask you questions about carbon capture and storage. One is what are the challenges to making it commercially viable? Secondly, in terms of your own company, what is the potential of CCS for cutting your own carbon emissions? Thirdly, how advanced, if at all, are the plans of your own companies to install these facilities in plants? Fourthly, is there anything the Government should be doing to enable this technology to be developed more rapidly? Fifthly, in the chart we have from E.ON the marginal cost of coal compared to coal plus carbon capture seems at first sight to be almost negligible; I just wondered if you could comment on that.

Mr Taylor: On the last point, the reason why it looks comparable with coal is because if you have carbon costs at 40 euros a tonne then when you add the cost of carbon on to an unabated coal plant you see it approaching a similar kind of cost.

Q235 Lord Lawson of Blaby: Where do you get that figure from?

Mr Taylor: It is based on some of our own analysis plus other publicly quoted figures for a view of commercially proven costs of carbon capture and storage.

Q236 Lord Lawson of Blaby: The cost of carbon?

Mr Taylor: In our information you can see we have quoted it at 20 euros a tonne, we have quoted it at 40 euros a tonne, and this is basically looking at future scenarios of carbon costs dependent on the European Emissions Trading Scheme and the decrease in caps.

Q237 Lord Lawson of Blaby: So it is pretty contextual.

Mr Taylor: It does make some assumptions about the price of carbon as a result of the European Emissions Trading Scheme. That is why you see the figures aligning when you

assume a certain cost of carbon. I have just a few comments on carbon capture and storage and then I will offer it across to colleagues. The importance of carbon capture and storage probably cannot be understated. Coal, whether we like it or not, is a very important part of the energy resource both in the UK but particularly elsewhere in the world, in China and India. As you know, in China in 2006 they built 90 gigawatts of coal plant – a modern coal fired plant – but of course unabated coal plant in terms of carbon emissions. I think if we are serious about solving and reducing carbon emissions from generation plant then carbon capture and storage is a fundamental issue to be addressed. In terms of the technology, in essence the components of the technology exist today and are used at a smaller scale and in their various parts across aspects of the energy industry today. You can see examples of carbon being sequestered and stored underground, whether that is for enhanced oil recovery or into depleted gas fields elsewhere. There are three or four fairly sizeable examples of that.

Q238 Lord Griffths of Fforestfach: In the UK?

Mr Taylor: Not in the UK, in Norway, Algeria and Canada. If you look at transmitting CO_2 over long distances through pipelines there are a lot of examples of that particularly in the US where they do pipe CO_2 over quite long distances – 1000 kilometres plus – as part of enhanced oil recovery processes as well. When it comes to the capture part, how you capture CO_2 from either post-combustion, combusting coal and then treating the flue gases and separating out the CO_2 from the flue gases, there again some of that technology exists but it is smaller scale at the moment. For pre-combustion there are examples of other aspects of how you capture carbon. One of the issues is that there needs to be a major initiative to establish a large scale demonstration project. There are number of initiatives of the pre-combustion phase and the US are trying to get some of that off the ground and other colleagues can talk about examples in that regard. The UK Government has come forward with its competition for a demonstration project for post-combustion carbon capture and, as you will see in our

evidence, we submitted an application to compete for funds to be able to demonstrate large scale carbon capture and storage in the UK. The main issues to be sorted are scaling issues – scaling up this technology – integration issues, so operating it as an integrated chain, as part of a power station as well, and also research and development to make the process more efficient because at the moment there is a sizeable amount of power and energy that is needed in order to operate the process itself. There are issues to be solved and the next decade should really be about the demonstration and commercialisation of that technology.

Q239 Lord Griffths of Fforestfach: How far away are we from realising this?

Mr Sambhi: If I look at what we are doing we set a target to reduce the carbon intensity of our generation fleet, so that is the grams of CO_2 emitted per unit of electricity produced. How do we get there? The main driver is by investing in more offshore wind which clearly has zero CO_2 emission. There are other initiatives aimed at reducing carbon that we emit in the normal course of business, but for utilities the biggest impact that they can make is by reducing the carbon intensity of their fleet.

Q240 Lord Best: How effective is the UK's system of support for renewables compared to other countries that your companies are working in? For example, would a feed-in tariff be a more cost-effective way to boost renewable generation than the Renewables Obligation?

Dr MacLean: I think I mentioned in an earlier question that we believe that the Renewables Obligation has been very effective. In contrast to other countries the problem has been that they have introduced support mechanisms; they have also supported running applications and they have made sure that good access has been possible so that projects can be built and do not get stuck at one or other of the stages. Our problem with the Renewables Obligation has not been that it has not generated the projects; we have had gigawatts and gigawatts in the queue. That has then made the Renewables Obligation do what it was designed to do which

was to further increase the financial benefit to those who are able to produce in the short term. This is why we have had a lot of criticism of the system because it appears to be over-rewarding those who are coming through and to an extent that is true, but the way to sort it is to remove the blockage in the system so that we get the planned number of projects being built and generating the electricity that they need to. That will then reduce the price down to where it was designed to go in the first place. We certainly do not believe that feed-in tariffs will be more effective. We have lived for a number of years under the Non-Fossil Fuel Obligation and other approaches which were very similar to feed-in tariffs and they were totally ineffective in bringing forward projects. The first thing that has really ramped up the market's interest and investors' interests in renewable energy in the UK has been the Renewables Obligation and it is far better matched to the liberalised electricity market that we actually have in the UK. One final point, if you look at the example that is often quoted of the success of feed-in tariffs in Germany for solar photovoltaics, I would just remind you that the level of support in Germany under the feed-in tariff was 40 pence and in the UK under the RO it has been four pence. I think we would probably come to the same conclusion, that 40 pence is probably the reason that it has happened rather than the delivery mechanism that was chosen for giving that to the generator.

Mr Sambhi: If I look at other markets in terms of renewable support a lesson that I take away from countries like Germany where they have introduced feed-in tariffs is that they selected a mechanism and they stuck with it. That is very important for the UK because the RO is a relatively young mechanism and I think we are now seeing utility and investor confidence to put in more capital to meet the Government's targets.

Q241 Lord Lawson of Blaby: So far as carbon capture and storage is concerned this is obviously completely speculative because it does not exist on a commercial scale at the present time and it is certainly not going to be introduced on a commercial scale for a very

long time and might never happen. I am all in favour of research and development but this is completely speculative. It is probably going to be very expensive indeed not least because the idea of getting some return using the carbon dioxide and enhanced oil recovery not only is it not possible to be done on a large scale but also the plan is to phase out oil, coal and gas altogether. Clearly there is no market there so this is pretty dicey altogether. I will not ask any further questions about that because we are running out of time and because it is so expensive. I would rather focus on wind power because wind power is the here and now whereas carbon capture and storage is just a twinkle in the eye. I entirely accept that your companies are seeking very hard to produce wind power in the most economic way you possibly can; I accept that unreservedly. However, the fact is that all your projections are mere wishful thinking. As Dieter Helm has pointed out, "There is little doubt that wind has turned out to be so far much more expensive than forecast by the politicians and the wind power lobby". It is very striking, is it not, that when the Government put out its original Energy White Paper in 2003 it expected wind power to be economic as against conventional power in the near future. The price of oil then was 25 dollars a barrel; the price of oil now has increased by more than five times and yet you still need government support, you still need taxpayers' support. This is without taking into account that the costs, as you pointed out, of technology, of the spinning return and the connection costs. Is it really not the case that in fact what you are doing is something which is totally uneconomic by a huge margin, is likely to continue to be uneconomic which you are doing, as I said, in the most efficient, low cost way that you possibly can and working very hard at that, but basically the business case is that the Government has made its particular targets, the European Union has its particular targets, you have this great confidence in politicians – bless you! – and therefore you feel that whatever it costs there is the commitment to give you whatever support is required?

Mr Taylor: You are right in that to a certain extent this is predicated on wanting to de-carbonise our generation infrastructure but to do so in a secure and affordable way. That must be the objective. Renewables is part of the answer – a very important part of the answer – if you are seeking to de-carbonise our energy infrastructure. I do believe, for all the reasons of uncertainty which you have pointed out over the various other fuels and other parts of the mix, that a diverse energy mix is important, including a strong and material role for renewables as part of that process.

Mr Sambhi: There are two points I would like to make, Lord Lawson. The first point is that the costs have gone up in terms of offshore wind. That is not because there is a misunderstanding of the technology and it is a more complex product to deliver; it is because the input cost and the supply chain components have become more expensive. Oil has gone up but so have steel and copper which are a big component of the costs of building an offshore wind farm. Will the costs come down? I think they well. I am not betting on steel or copper prices coming down but I am looking at the supply chain for delivering these large infrastructure projects coming down. An example would be moving manufacture closer to the source of demand. We know that wind turbine manufacturers are already considering this given the future demand in EU and the US. The second point is what is the alternative? You have already said that carbon capture and storage is a long way further ahead. In terms of other options on the supply curve for reducing carbon emissions, offshore wind is the next best alternative; it is expensive but it is proven.

Q242 Lord Lawson of Blaby: If I may I would like to get at this question a different way. What you are talking about is what is the cost of cutting carbon emissions? I think that is something we would like to know. Clearly there is no case for doing any of this unless you want to cut carbon emissions because the conventional stations are clearly very much cheaper.

The question which we need to find out is in these various different fields what is the actual cost of cutting carbon emissions?

Dr MacLean: I think there has been quite a lot of work done on that. There are the carbon abatement curves which show the whole range of different measures. What is interesting from that is that a lot of the very low cost measures are actually on the demand side rather than the supply side, things that could be done in terms of energy efficiency in reducing the amount that we actually consume.

Q243 Lord Lawson of Blaby: You are quite right, but this inquiry is about renewables.

Dr MacLean: The point I was wanting to make from that is that despite the fact that some of these things, when you actually have a very positive business case, they do not happen automatically and they require intervention, they require subsidy or some sort of money to make them happen. That is no different to what we have seen with mobile phones or the internet; they did not happen naturally, they required a lot of marketing and input. We will get to a stage at some point if the oil price continues to rise where wind is actually comparable with the fossil fuel plants, but that does not mean that all the investment that needs to be made will happen and will happen fast enough. That is why, at the moment, there needs to be an intervention and a subsidy to make sure that these things are happening and are happening quickly enough. It is not simply the difference between one or the other and whether that makes it worthwhile doing, whether that is the measure of the price of carbon. You have to add into that the cost of actually making it happen and of accelerating the process to make it happen quickly enough. At the moment that is the big challenge for the 2020 targets to make the investment decisions on nearly all of these things in the next two or three years otherwise they will not be there for 2020.

Q244 Lord Lawson of Blaby: That is a completely arbitrary date.

Dr MacLean: The 2020 date is, yes, but it is an arbitrary date which the Government will be bound by and will face sanctions if it misses the target. That is the reality of the situation we are moving into.

Q245 Lord Lawson of Blaby: That is what gives you the confidence to invest in something which may be totally uneconomic.

Dr MacLean: We believe that there are good reasons for the investment beyond simply the carbon. We believe, as I said previously, decoupling ourselves from the need for imports and the uncertainties of that, decoupling ourselves from what seems to be the inexorable rise in the price of fossil fuels and of the volatility and the uncertainty that that creates has a value which we do not actually have a way of calculating into the system at the moment. It makes it very difficult to compare one thing with another and the difference that is required to make these things happen is not just the price of carbon and waiting for that or establishing the value of that and then using that will not be enough to make these things happen on their own.

Q246 Lord Macdonald of Tradeston: Could you give us a reckoning on what the total annual cost of public subsidy might be once the system is fully developed under the Renewables Obligation?

Dr MacLean: I do not have that figure. I believe it will be published next week in the Renewable Energy Strategy as part of the analysis that the Government has done. It is not a number that we have access to at this stage.

Mr Taylor: I think it is essential that as we respond to the consultation on the green package that there is absolute transparency about how much investment and how much this is going to cost customers so that they can understand the trade-off – there is a genuine trade-off here – being made between carbon security and cost. There is considerable investment and although there are obligations on companies and we seek to use those obligations and make

investments, it is important at the end of the day for customers to understand the full underlying costs of these choices.

Chairman: Thank you. We have traded upon your time rather longer than either you or we were expecting, but thank you very much indeed for spending your time here and answering our questions.

Witness: **Professor Gordon MacKerron,** Sussex University, examined.

Q247 Chairman: Welcome, Professor MacKerron. Thank you for coming to give evidence to us. I do not know if you want to say anything by way of introductory remarks.

Professor MacKerron: I am happy to go straight into questions.

Q248 Chairman: What do you consider to be the key considerations for UK energy policy (that is energy and not just electricity)? How do you see renewables fitting into that policy?

Professor MacKerron: That is a big question; I will endeavour to be fairly brief on it at least to start with. I would have thought the most important single difficulty facing energy policy is the potential trade-off between different objectives. Clearly the two major objectives now are energy security on the one hand (which seems particularly powerful as an objective at the moment) and the long term climate change objectives (which, as you know, the Government has espoused since at least 2003). I think the difficulty is that policies designed to counteract climate change are nearly always good for security, but policies that are designed to be good for security are not always good for climate change. Specifically a policy for security that emphasises the use of coal is going to counteract objectives for climate change in the absence, as we have already heard, of any realistic prospect for carbon capture and storage in my opinion probably for 15 or 20 years and that is if things go reasonably well. Perhaps in a slightly more political context, the real difficulty Government faces is the urgency which it and the European Union perceive in proceeding towards rapid carbon emission cuts and acquiring enough political legitimacy to do so. It may require some difficult choices which voters and consumers may find quite awkward and making policies stick while having the urgency which Government now believes is necessary I think is a big and difficult issue which Government will have to keep grappling with for some time. On the subject of renewables, renewables have a number of advantages in relation to policy objectives. In

terms of the security objective they add diversity to the system and a subject to which I might return later if we have time is the portfolio effect of adding renewables to a system that is predominantly fossil fuel. They clearly substitute at some level for fossil fuels; they reduce pressure on world fossil fuel markets to the extent that security is an issue of dependence on oil and oil prices. There is help in that area too. There is of course a direct effect on climate change. You have already explored with the previous witnesses who have more expertise than I do some of the issues about intermittency of renewables which, in another dimension of security, may be thought to reduce security. My own view is that we will probably find ways of managing that relatively cheaply partly because other countries such as Denmark are already facing and, as far as I can judge, making reasonably good technical progress in solving the problems. In economic terms there are two major market failures involved in renewable energy. First of all it helps the problem of unpriced carbon which, of course, despite the European Emissions Trading Scheme, is not a good investment incentive at all, and the fact that R&D will tend to be underprovided in any private system because of its widespread availability to other parties. Whether renewables currently are well managed in relation to these objectives is a different question. I would differ slightly from the previous witnesses in thinking that there are real difficulties in terms of risk around the Renewables Obligation. In terms of value for money feed-in tariffs appear to have strong advantages. That is a subject you may wish to return to later, but those would be my opening remarks on the subject.

Q249 Lord Layard: Looking at electricity, how do the costs of generating electricity from renewables compare in your view with fossil fuel and nuclear generation?

Professor MacKerron: It is very easy being an academic to say that that is a very hard question to answer, but that is how I will start. The first issue is that although the stand alone costs of individual technologies do matter and of course to private companies who are going

to invest their return will very much depend upon the balance of the costs and the return they will get on their investment but, to come back to the point I made earlier, it is important to look at the system impacts on investments; whether that is a nuclear investment or a renewable or a fossil fuel investment that matters a great deal. A particular advantage of renewables is that because their risk profile is not correlated with the risks of fossil fuel generation - so when fossil fuels become more expensive that does not affect the generating costs of renewables or, for that matter, nuclear - the value to an energy system (an electricity system) of adding renewables which are currently a small proportion of the system and where the risks are not correlated without the fossil fuels, the value to the system is greater than reflected in the probable much higher stand alone costs. The difficulty in a privatised, liberalised system is that that advantage cannot be captured by the individual investor because it is a system property which affects consumers. That must be set against some of the drawbacks of renewables which you have heard about before which include a need for backup, which again is a cost that will not be met by the renewables investor as and when it becomes an important issue. That is important to say. What are the costs of renewables? They are very various. You have heard estimates for onshore and offshore. For other technologies for which we have hopes but which are not yet commercial such as tidal and wave, frankly it is really not very helpful to put numbers unless you put a very wide range around them in which case their value is of restricted use. When it comes to fossil fuels it is clear that under current conditions they are the cheapest and most commercial option, historically gas and probably coal now if that was not subject to regulatory provision. However, as we have also heard, oil and gas prices do vary very substantially. To quote a single number for what is the cost of, say, a gas fired power station built today with a lifetime perhaps of 30 years depends entirely upon unknowable figures for the future of gas prices, so it is very difficult to say. In terms of nuclear there are real difficulties in prediction there as

well. We have not tried building a nuclear power station in this country for over 20 years; we do not yet know which design we might build; we do not know what regulatory provisions will adhere to that design with implications of cost. Perhaps, most importantly of all, we do not know whether or not we will build a series or a single unit. If we were to build a series we would probably have construction costs something like 30 per cent lower than if we build only one. Our history, as you probably know, is that we tend to build one at a time in the UK; that could change, but that is our history. There are finally issues about the back-end of the nuclear fuel cycle, about radioactive waste and de-commissioning which probably are not very large costs, especially if you allow a discounting over a long period into the future, but which nevertheless worry investors a great deal. I am quoted in the *Financial Times* saying that Government has offered now a fixed price to take waste off nuclear operators' hands which may be a necessary condition for nuclear investment but is, in my view, a subsidy of some indeterminate kind. I do not necessarily object to it but I think it is important to recognise that it is a subsidy rather than something that the market has provided. That is my somewhat qualified answer, but I just do not think it is worth pretending that we know things about the future that we do not; that is a major difficulty for Government and for private investors.

Q250 Lord Macdonald of Tradeston: Just picking up on your quote in the *Financial Times* on the hidden subsidies, as you saw it, for new nuclear plants in the form of fixed price for waste disposal. Do you think that the Government should support nuclear power in a similar way to renewables? If so, the waste disposal that you talk about, is that where subsidy might best be focussed? How would subsidising nuclear affect the economics of renewable generation overall?

Professor MacKerron: There is clearly a case for subsidy of nuclear on the grounds that it is a low carbon option and because carbon is not adequately priced there is a case for helping

nuclear power on those grounds similarly to renewables. On the other hand I would have thought the subsidy that nuclear, as it were, deserves in this kind of analysis is somewhat less because nuclear has a long history of research and development support. There is a very large and increasingly now flourishing international industry in nuclear power and in those circumstances I think the subsidy probably should not be so great because renewables I think have greater and longer term prospects because their research and development has historically been so limited. In terms of how a subsidy might be given, it does seem to me that waste is a very likely area because that is what investors seem to worry about most, even if the discounted costs of waste so far ahead are relatively low. It does seem to me that the back-end of the nuclear fuel cycle – that is the decommissioning of waste – is a responsibility which always in the end devolves to governments partly because of the extreme hazard that might be represented by the worst possible outcome but also because of the very long time horizons. On current estimates we would not start to dispose underground of waste from new build for about a 100 years. That is because of the time it will take us to build a repository and the fact that our legacy waste is inevitably ahead of new build waste in the queue to be disposed; one would not want to re-package it at very high cost. We are talking about timescales of 100 to 150 years which we do not really have any mechanisms for private firms to handle. In the end I think it has to be a government responsibility and that may be seen as a drawback of nuclear power but I think it is an inevitable consequence of support for it. Finally on the subsidy issue, clearly what investors in nuclear power also desperately want is some guarantee of the selling price they will get for their product which will be something like ten to 30 years ahead. Of course present market conditions do not provide that and although the carbon price may be positive and large in ten to 30 years' time no private investor will bet on it right now. I think these are questions that are still somewhat open and Government's reluctance to admit to subsidy I think is because if they did they would be sent

off to Brussels under state aids and we do not know quite how long it would take before they would come back out of Brussels on that score.

Q251 Lord Paul: How significant, in your view, is the potential for reducing carbon emissions by placing greater emphasis on the development of carbon capture and storage? How cost-effective, compared with the alternatives, is carbon capture and storage? Should the government be more pro-active in supporting its development?

Professor MacKerron: I will try to be brief; my answers are not terribly different from those you have already heard this afternoon. It is clearly going to take a long time. I have recently been speaking to people who represent the Government of India at a bureaucratic level who tell me that for India there is no serious policy interest of any kind at all. It is a matter of probably 20 years before it gets fully onto the policy agenda. Of course that could be sooner, but that is their current estimate. From a domestic perspective, carbon capture and storage is probably more helpful in relation to gas than to coal because it will be cheaper and gas still emits carbon dioxide. Because of the international perspective, especially in relation to India and China, coal is inevitably the main focus. The major difficulty about predicting the cost is that the cost will vary enormously depending upon the storage location and the distance from the point at which the carbon is captured and the point where it will finally be stored. If it is in a relatively nearby offshore oil well and there is the possibility of enhanced oil recovery, that part of the cost equation will be very low. If, on the hand, one has to find a deep saline aquifer and characterise it and it is perhaps a couple of hundred miles from where the capture takes place, the costs are frankly yet unknown but probably very high. It will be an expensive technology, there is no question about that. On present technologies you pay a significant penalty in reducing the power output because of the power you need to run the capture plant. That is a major objection that, for example, the Indian Government currently has, that it will lose a great deal of the power that it badly wants for its development effort and capturing the

carbon is of rather less interest to the Indian Government for quite legitimate reasons at present.

Q252 Lord Griffths of Fforestfach: How long do you think it is going to take before we see this practically implemented in the UK?

Professor MacKerron: I would have thought 2020 would be very optimistic. We have yet to demonstrate it fully on a commercial scale and there are questions about whether pre-combustion or post-combustion is the right route to go down. The Government is going for post-combustion probably because it thinks the long term export prospects to India and China might be better served that way. It is not clear to me that that would necessarily prove to be economically the most viable or best way forward. I heard on the radio the other day the Energy Minister saying that in the current comprehensive spending review there is no money for government support for the carbon capture and storage project to move onto the competitive process. I have heard industry people saying perhaps 2025 as a more or less hoped-for estimate of when commercial application at scale might be possible. These things are of course speculative.

Q253 Chairman: Let me put the question in a slightly different way and that is that if Government decided to put its shoulder to that wheel and put the resource in, how soon could it be done?

Professor MacKerron: I think you could then talk about 2020 as being a more realistic timeframe but there are still significant technical uncertainties. It could go very slightly better than that, but even with shoulder to the wheel it might go worse than that as well. One might say 2020 would be a reasonably optimistic timeframe.

Q254 Lord Moonie: Do the UK's electricity trading and transmission arrangements provide a suitable framework for an industry with a high proportion of renewable electricity generation?

Professor MacKerron: I think the answer broadly speaking is no but that does not mean that there is no hope. On the subject of transmission and particularly the distribution of local systems they were of course designed for large centralised remote power stations, simply stepping the power down from very high voltage down to factories, households and so on. There is already a big and technically quite complex effort to try to change the transportation system for electricity to allow for a much more interactive system which can accept much smaller and more local generation which I think most of us think is going to be one important ingredient of any future which is more low carbon. There are real transmission difficulties which you have heard about already today in renewables because of course renewables have to be sited where they have to be sited not necessarily near centres of demand and that is an issue that takes some time to resolve. I think it is possible that we can change our transmission and distribution arrangements in time for the expansion that we expect in renewable energy, but the one area which I think is badly neglected and does need more attention is in the area of very small scale renewable generation. There is real prospect in the long term for micro-generation at household block of flats level which is, among other barriers, seriously inhibited by the fact that we do not have any arrangements for trading or physical distribution – reversing the flow – to give an incentive to owners of small commercial premises, householders or blocks of flats to engage in renewable and other forms of micro-generation. That is an area I think that is seriously neglected and in which Government has been extremely slow to take action despite a number of reviews.

Q255 Lord Best: You said blocks of flats and commercial buildings and one is perhaps looking at quite big blocks of flats – tower blocks – and big commercial buildings. Would

you agree that efforts to micro-generate at the level of the individual household are likely to be waste of everybody's time, unless you live in the Scottish Highlands?

Professor MacKerron: Micro wind at household level in urban areas is, I think, a dead duck; there is no obvious future in it without any major technological change. Some types of micro-generation do not work at that scale. The kind of micro-generation more likely to work at that scale would probably involve the use of fossil fuels but probably at very high levels of efficiency, so very small scale combined heat and power is potentially quite an attractive prospect and that will save a lot of carbon emissions compared to using mains gas or central heating. I know it is not the subject of your inquiry but in the area of micro-generation that is much more promising than micro-wind which frankly has not got much future at all for the great majority of householders in a country like the UK.

Q256 Lord Griffths of Fforestfach: Do you think it is important that we have in the UK a broad range of technologies providing electricity and do you think the benefits can be quantified?

Professor MacKerron: I think it is important to have a reasonable range. It is difficult to say how many; one cannot come to very deterministic answers. I think to return to a point I made earlier, there are some techniques, mostly borrowed from orthodox finance theory - mean-variance portfolio analysis – which do suggest that where a technology has a small share and its risks are uncorrelated with those of the dominant technology, the value to the system as in standard portfolio analysis is actually somewhat greater than the standalone cost. My late colleague Shimon Awerbuch from the University of Sussex did very good work on precisely trying to quantify the different standalone costs, what the system advantage might be of introducing renewables and there are other techniques being developed around valuation, diversity, trading it off against performance in the form of standalone costs which I would be happy to share literature with you on if that is of interest. There are ways of doing the

quantification. The more difficult issue is how to reward the existing rather fragmented market system for system benefits which at the moment cannot be captured by individual investors. That is one of the reasons why I personally think that the Government needs to intervene somewhat more than it currently does in order to try to find ways of rewarding genuine benefits for systems - which could apply to nuclear technology as well as renewables - where those effects take place.

Q257 Lord Best: In terms of that Government intervention, you are saying more of it is necessary. You would not say that the Government has been very effective so far in its policies in terms of more renewable energy. What have been the most cost-effective forms of support in your view in the UK and in other countries? What should be the balance between subsidies, guaranteed prices, quotas, carbon taxes and other forms of support?

Professor MacKerron: I think one has to confine one's attention to those instruments that seem politically plausible. Within Europe I think carbon taxes on any significant scale are not currently plausible and emissions trading is the fashionable way. I do not say "fashionable" to decry it but nevertheless, politically speaking, it is the way we are going. In terms of specific renewables instruments the research with which I am familiar does quite strongly suggest that well-designed feed-in tariffs, where you differentiate the guaranteed price you will give for individual technologies, not only elicit renewables more rapidly but they do elicit them at a lower cost to the consumer. There is good, reputable published research comparing, for example, Germany and the UK, which will show that value for money is substantially greater in the German system. Having said that, I think that the Government has a real dilemma. Having gone for a renewables obligation it is very sensitive to the criticism that comes from investors, but investors want some kind of certainty in the public policy system; they do not want Government to keep changing horses every five years. I think there are ways around that. You can ring-fence those people who have already invested in the

renewables obligation system; it is a little bit messy but it could be done, and I would not like us to be trapped forever in the renewables obligations systems when I think increasingly the evidence is that a feed-in tariff would be more effective. However, I recognise that the transitional problems are quite substantial and Government has some difficulty with that.

Q258 Lord Lawson of Blaby: This is all really totally unreal, is it not? You very correctly pointed out that the Indians have no interest at the present time and for the foreseeable future in making their energy more expensive by carbon capture and storage. That is really part of a general pattern. It is certainly the case of China and India and a number of less important countries; their priorities are the cheapest possible energy. That does not mean to say that they will reduce their energy intensity through improvements in efficiency, but they are going to keep on using carbon and producing energy and therefore the whole thing is pie in the sky. All the money we are spending is only to reduce global emissions, and global emissions are not going to be reduced by this massive amount we are told is necessary. Whether it is or not is another matter, we will not go into that. All we can try and do is do this charade at the least cost and that is really my question to you. If we are going to say that we want to have a renewables policy, have a significant part of our energy produced by renewables, the Government has gone very heavily into wind power and, although it is not a renewable thing, they are going in a slightly less enthusiastic way into nuclear. How that is going to work out we shall see. With your great knowledge of these various different forms of electricity generation what is in your opinion the best buy of the various renewables and by how much is it the best value? Or are they all much of a muchness? You may include nuclear in your answer.

Professor MacKerron: Let me start by saying something that is a repetition of what you heard before but I still hold that it is genuine. Renewables do bring other benefits than simply reduced carbon emissions. In a world that is increasingly worried about energy security

renewables can be quite helpful as both a more diverse source and a source that reduces our dependence on fossil fuels. There are countries – but we are not among them – that have acquired industrial policy benefits from renewables but I am afraid the way Government has organised its policy in that area in our country that is not the case. Coming now to the substance of your question, what is the sort of *Which?* report best buy on this subject, I think there is no doubt that because of the way the Renewables Obligation has worked it has sought out and concentrated on that technology which currently has been the best buy and that is onshore wind. Offshore wind, I believe, can become not quite as cost effective as onshore but will become, I think, substantially cheaper. I think we need, in cooperation with other countries – I stress that very much – to have much more intensive research and development efforts into other credible renewable energy technologies, among which the marine technologies (in which, as you know, Scotland has a particularly strong interest) do have major long term prospects, not least because some of them do not have some of the intermittency characteristics that wind does (in particular tidal is a possibility). Biofuels are of course a major issue at the moment. I think there is a certain hysteria about biofuels which suggest that they are in almost all circumstances terrible. I do not think we have the research base to say that, but clearly people are right to point to some of the conflicts between food and fuel for land use and they are unavoidable. If you want to come to nuclear, I think we are still in a position of enormous uncertainty about nuclear. If we repeat our past policy on nuclear which is to build the odd reactor here and there to a different design, frankly I think they will turn out to be very expensive. On the other hand, if we were to go for a very large programme with Government support we would seriously run the risk of undermining the market that we so painstakingly built up over the last few years. There are some difficult trade-offs there and frankly I do not think we know in the case of nuclear where we are. The short answer is that what we have been doing is the best option to date.

Q259 Lord Lawson of Blaby: Let me put the question another way, but maybe the answer is the same. Supposing the Government were to come in and say "We are prepared to provide a subsidy of whatever it is per gigawatt of electricity generating and we are committed to maintaining that for a reasonable period of time" and leave it to the market – the industry – to decide which of these various sources of energy or electricity they would be most likely to find investors to support, would they all go for wind power do you think, or not, looking across the world and not just from our own experience?

Professor MacKerron: The UK would certainly go for wind for now because there is a reasonably well-established cost base for wind. You heard the previous remark that the costs of the raw materials for wind such as copper and steel have inflated in recent years which has made wind, at least temporarily, as nuclear and substantially more expensive than we expected. Nevertheless, there is a kind of certainty about wind which would give investors some comfort. I am sure they would then wish to explore whether or not nuclear would give them the same degree of comfort and it is possible that over time – it would not be immediately – they might decide that nuclear was a good bet. If you look at other countries you get a different picture. If you went to France you would almost certainly discover that nuclear seemed the best bet, not especially because of the market but because the French state has built up a huge protective subsidy implicit and explicit around its nuclear enterprise which has been run quite efficiently for a long time. There would be large national differences and of course we have one of the more liberalised markets in the world; we would not have quite that kind of open market competition, the sort that is imaginable in the UK but probably would not happen to the same extent elsewhere. I suspect my answer has not been terribly different from the other way round when you first asked me it.

Q260 Lord Lawson of Blaby: It would be wind and nuclear but you think it would most unlikely to be wave, tidal or solar.

Professor MacKerron: It would not be wave or tidal and it absolutely would not be solar photovoltaics because, although they are technically very exciting and getting cheaper, they are still very expensive.

Q261 Chairman: Can I just move to heating for a little and perhaps ask you the same question about the best buy in terms of renewables. What is the best buy against fossil fuels or gas central heating?

Professor MacKerron: Heat has been a sector which, whether you are dealing with renewables or anything else, has been much neglected. Energy policy has been all about electricity for a very long time in a way that I think has over-emphasised the importance of electricity. For heat there are a number of established small scale technologies that are, by some definitions, renewable but work very well. There are various forms of waste combustion which raise political difficulties but are actually normally cheap and in my view a rather effective way of managing a good deal of waste. Although not much widely used in the UK, biogas from agricultural waste is actually a very effective form of generating potentially heat and other by-products, but probably not a major source for a country like the UK. Then one comes onto the difficult question of biofuels and the obligations for renewable transport fuel obligation and wider European Union obligations which I think realistically are too taxing for us to meet whether it is 2010 or 2020. Nevertheless I think there are real prospects and again in the area of second and even so-called third generation biofuels there is a very great need for substantially greater efforts in research and development because in these newer generations of biofuels the plant matter will almost certainly not compete in the same way with food uses of land because using cellulosic and other materials may allow us to use marginal land in quite productive ways. I think for heat biofuels as a longer term bet have some real prospects. Beyond that it is very difficult to know.

Q262 Chairman: As you suggested governments have not spent as much time or attention as they have done on power generation. How would they tackle promoting heat in a way that was comparable to the Renewables Obligation in power generation? How would one approach this if you really wanted to get at heat? What would they do?

Professor MacKerron: There have been suggestions about imposing various kinds of heat obligations not unlike renewable energy obligations. That is not impossible but I do not think it has been thought through in any way as to make it potentially at the moment a coherent issue. There is clearly significant scope for combining heat with power or combined heat and power at various scales ranging from the household to the industrial to the municipal and so on. To be commercially viable you need a reasonably good spread between the various different prices, in particular the probably gas input price and the electricity output price. When gas prices rise too high it becomes commercially unattractive, but in the long term I suspect that we could get a lot further than we currently have by judicious expansion and incentivising on combined heat and power at various scales. However, that has not been a matter of enough policy interest nor has there been enough governmental work or, for that matter, academic research to enable us to say with confidence that we can get very far with technologies like combined heat and power, but I would say that is probably because well established technically a very fruitful way forward.

Q263 Lord Lawson of Blaby: In another context you pointed out various kinds of collateral advantages you saw in various different renewables. There are also sometimes disadvantages. In the case of biofuels is it not the case that biofuel production requires the use of inordinate quantities of water and is that not something of a problem and indeed a cost in the real sense?

Professor MacKerron: You are absolutely right and it is very important to say that biofuels are far from the same thing in different agricultural and other regimes. Brazil, the pioneer, happens to have a form of biofuels based on sugar cane which does offer very large carbon

emission reductions compared to the equivalent volume of fossil fuels. The use of maize in the American Mid-West does not at all and on some calculations is a net carbon emitter compared to fossil fuels, so one has to be extremely careful to specify what kind of biofuels in what environments. Your point about water use is a very serious one in water short areas. Biofuels is a very diverse set of technologies and we should be very careful not to talk about it as if it were a single thing, but in many circumstances it has real problems, I agree.

Q264 Lord Macdonald of Tradeston: I would like to ask a quick question on nuclear cost. We are told in some of the more recent developments the costs have been escalating in an unexpectedly aggressive fashion. Why is this happening when it is an old and apparently stable technology in places like France? Are people striving for some particular gain that is producing all this uncertainty and undermining the economic model?

Professor MacKerron: Some of the recent escalations are, as it were, the backwash effect of world commodity prices which affect nuclear construction as they do others, but the other thing to say is that virtually all the nuclear technologies that are now under commercial construction in the world – that includes both Finland and France, the two prominent EU recent examples – although they are based on historic technology and the nuclear core is really very similar to technologies that are now 40 or 50 years old, nevertheless they have been substantially improved with more passive safety systems and improvements of one kind or another. However, unfortunately, none of them has ever been built at full scale until the first commercial order. As most engineers will tell you, even if it looks like it is familiar, if it is new and you have never built it before you are very likely to run into first of a hand – sometimes second and third of a kind – problems. That has certainly occurred in Finland where there has been difficult interaction between the local safety regulator and the French leading constructor. Even in France some difficulties are emerging. Although officially the design of reactor in France, the so called EPR (European Pressurised Water Reactor) is in the

same family as the one in Finland. The French design is not the same as the Finnish design, maybe because the safety regulatory systems in the two countries differ. It is very difficult when you play around with technologies like that to control the cost, especially when you have not built them in very large scales anywhere before.

Q265 Lord Layard: Do you think it is going to be possible for us to meet the target by 2020 of 15 per cent from renewables?

Professor MacKerron: It is possible but I would say low probability. I think if we do meet it it will be potentially at quite high costs, taking costs in their stand alone sense. We have every possibility that as we build more renewables and we learn and we get economies of scale we will come down some cost curves but we are also likely to move to less and less favourable locations given that renewables, especially in the form of wind, are very location dependent for their economics. It is imaginable but I think it is fair to say that within Government and perhaps behind closed doors most of the officials are exceptionally worried about the feasibility of the target. I do not think we are currently in a position of planning for it. When Government, for example announced the possibility of the 33 gigawatts of offshore wind it does not seem to have done any serious work on the huge industrial and logistical implications of such a vast programme, whereas it does seem to be a bit more interested in the logistical implications, for example, of a nuclear programme. I think we would only realistically be getting towards that 15 per cent if we pay a lot more attention to some of what we used to call indicative planning back in the 1960s because markets are jolly good things but they do not actually solve all the problems. When one has a huge industrial project of this kind we do need a bit more of what we used to call planning if we are to get somewhere near meeting the target.

Chairman: Thank you very much indeed, Professor MacKerron. You have been very helpful.