The Scottish Parliament
Pàrlamaid na h-Alba

Official Report

# ECONOMY, ENERGY AND TOURISM COMMITTEE

Wednesday 20 May 2015

Session 4

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## CONTENTS



## ECONOMY, ENERGY AND TOURISM COMMITTEE
**13th Meeting 2015, Session 4**

**CONVENER**

*Murdo Fraser (Mid Scotland and Fife) (Con)

**DEPUTY CONVENER**

*Dennis Robertson (Aberdeenshire West) (SNP)

**COMMITTEE MEMBERS**

*Chic Brodie (South Scotland) (SNP)
*Patrick Harvie (Glasgow) (Green)
*Johann Lamont (Glasgow Pollok) (Lab)
*Richard Lyle (Central Scotland) (SNP)
*Gordon MacDonald (Edinburgh Pentlands) (SNP)
*Lewis Macdonald (North East Scotland) (Lab)
*Joan McAlpine (South Scotland) (SNP)

*attended

**THE FOLLOWING ALSO PARTICIPATED:**

Professor Ian Arbon (Institution of Mechanical Engineers)
Professor Keith Bell (University of Strathclyde)
Brian Galloway (Scottish Power)
Professor Gareth Harrison (University of Edinburgh and the Young Academy of Scotland)
Professor Colin McInnes (University of Glasgow)
Dr Edward Owens (Heriot-Watt University)
Michael Rieley (Scottish Renewables)
Lawrence Slade (Energy UK)
Dr Alan Walker (Royal Academy of Engineering)

**LOCATION**

The James Clerk Maxwell Room (CR4)

# Scottish Parliament

## Economy, Energy and Tourism Committee

*Wednesday 20 May 2015*

*[The Convener opened the meeting at 10:00]*

## Decisions on Taking Business in Private

**The Convener (Murdo Fraser):** Good morning, ladies and gentlemen. Welcome to the 13th meeting in 2015 of the Economy, Energy and Tourism Committee.

I welcome all our witnesses, who I will introduce in a moment. I also welcome to the public gallery the delegation from Poland who are visiting Scotland to find out more about our energy successes and challenges. Welcome to you all. I hope that you enjoy the proceedings and find them to be of interest.

I remind everyone to turn off or at least turn to silent all mobile phones and other electronic devices, so that they do not interfere with the broadcasting equipment.

Agenda item 1 is consideration of whether to take item 5 in private. Do members agree to do so?

**Members** *indicated agreement.*

**The Convener:** I also ask whether members agree to take in private future reviews of evidence heard in connection with the security of supply inquiry. Is that agreed?

**Members** *indicated agreement.*

**The Convener:** Item 2 is a decision on whether to take in private next week's consideration of our draft annual report. Do members agree to take that item in private?

**Members** *indicated agreement.*

## Witness Expenses

10:01

**The Convener:** Item 3 relates to our inquiry on security of supply. Are members content to delegate to me, as the convener, the responsibility for arranging for the Scottish Parliamentary Corporate Body to pay, under rule 12.4.3, any expenses of witnesses in the inquiry?

**Members** *indicated agreement.*

# Security of Supply

10:01

**The Convener:** Under item 4, we will take evidence on our security of supply inquiry in round-table format. Given the number of people who are here, the easiest thing to do is go around the table and introduce ourselves. I will start. I am a member of the Scottish Parliament for Mid Scotland and Fife, and I am the committee's convener.

**Professor Gareth Harrison (University of Edinburgh and the Young Academy of Scotland):** I am the professor of power engineering at the University of Edinburgh.

**Dennis Robertson (Aberdeenshire West) (SNP):** Good morning. I am the MSP for Aberdeenshire West and the deputy convener.

**Professor Colin McInnes (University of Glasgow):** I am the James Watt chair and the professor of engineering science at the University of Glasgow.

**Chic Brodie (South Scotland) (SNP):** I am one of the SNP MSPs for South Scotland.

**Professor Keith Bell (University of Strathclyde):** Good morning, everyone. I am from the University of Strathclyde, where I hold the chair in smart grid technologies, which is supported by Scottish Power. I am also a co-director of the United Kingdom Energy Research Centre.

**Gordon MacDonald (Edinburgh Pentlands) (SNP):** I am the SNP MSP for Edinburgh Pentlands.

**Dr Alan Walker (Royal Academy of Engineering):** I am the head of policy at the Royal Academy of Engineering.

**Richard Lyle (Central Scotland) (SNP):** I am an SNP MSP for Central Scotland.

**Professor Ian Arbon (Institution of Mechanical Engineers):** I am representing the Institution of Mechanical Engineers. I am the author of several recent reports, which I know many of you have seen.

**Lewis Macdonald (North East Scotland) (Lab):** I am a Labour MSP for North East Scotland.

**Michael Rieley (Scottish Renewables):** I am a senior policy manager for grid and markets at Scottish Renewables.

**Johann Lamont (Glasgow Pollok) (Lab):** I am the Labour MSP for Glasgow Pollok.

**Dr Edward Owens (Heriot-Watt University):** I am from Heriot-Watt University. I run several large European research projects on demand-side management and microgrids.

**Patrick Harvie (Glasgow) (Green):** I am the Green MSP for Glasgow.

**Brian Galloway (Scottish Power):** I am the energy policy director at Scottish Power.

**Joan McAlpine (South Scotland) (SNP):** I am an SNP MSP for South Scotland.

**Lawrence Slade (Energy UK):** I am the interim chief executive of Energy UK.

**The Convener:** The official reporters are here to note everything that you say. That should not be seen in any sinister way—we simply keep a record of what is being said. We are also joined by Alasdair Reid, the lead researcher on energy in the Scottish Parliament information centre, and Rodger Evans, a senior assistant clerk. I thank you all for coming.

We have scheduled 90 minutes for the evidence session. Given the number of witnesses that we have, and if the witnesses can accommodate us, we will run the session until around 12 o'clock, if that is convenient. However, we must finish at 12 sharp, because of the other business that the committee needs to address, so we have a maximum of around two hours.

There are a lot of people here and we have a lot of ground to cover. If you all try to address every single question, it will take us a long time to get anywhere. I ask members to address their questions to a particular individual initially. If a witness agrees strongly or, perhaps more important, disagrees strongly with a view that they have heard, I ask them to catch my eye and I will try to bring them in.

We are keen to hear a range of different views. We do not necessarily want to hear you all agreeing with each other, although maybe you will.

**Dennis Robertson:** That is unlikely.

**The Convener:** The deputy convener says that that is unlikely to happen.

I will give all our witnesses a minute or two each to answer, in just a few sentences, the key question that our inquiry has to address. As we know, we are going to lose Longannet power station—perhaps within the next year—which accounts for 20 per cent of Scotland's electricity generating capacity. As matters currently stand, by 2023, we are due to lose Hunterston and Torness, which represent another 35 per cent of Scotland's generating capacity. Within eight years we could lose 55 per cent of our electricity generating capacity. Should we be concerned by that? If not,

why not? If we should be concerned, what do we need to do about it now?

**Professor Harrison:** The main issue is that, per se, you do not need to have a thermal generator located in Scotland if you have sufficient transmission capacity to import electricity. If your network operates properly and everything else works fine, you do not need it. The problem that might arise, as the written evidence from Scottish Power and National Grid has shown, is that you have other things going on. There are a range of different technical requirements in addition to the question whether there is enough capacity to ensure that you can operate the grid effectively.

If you are comfortable with lots of generation closing, you can probably cope, assuming that there is sufficient thermal generation in the rest of the UK to cope with the inevitable swings in wind. However, in my view, you should retain something, because that provides you with a degree of flexibility that you would not otherwise have.

**The Convener:** Thank you for being so succinct.

**Professor McInnes:** I agree whole-heartedly with those comments. If we are seeing a potential drop off in capacity of 55 per cent in eight years and we do nothing to put measures in place to get some kind of thermal plant into the Scottish grid, we are looking at being entirely dependent on importing the output of thermal plant from south of the border. All that assumes that the network south of the border is secure and has the spare capacity to deliver into Scotland at times when the wind speed falls to zero, as it does sometimes for many days at a time in the winter during periods of high demand.

My concern is that, because there is no clarity around the responsibility for security of supply in the UK system overall, it would be much more difficult for Scotland to ensure its own security of supply if we were to depend entirely on the rest of the UK for thermal generation. That would be a pretty grave mistake.

**Professor Bell:** There are definitely technical and cost challenges in delivering a decarbonised energy system—it is not just about electricity. On whether the regulatory and market environment is the correct way to make sure that the right responses are made to those challenges—my view is that, broadly speaking, they are—I do not quite agree with Colin McInnes's point about there being a lack of responsibility. The generation capacity margin was a bit of a grey area for quite a long time, but the capacity market does a lot to counteract that. It has had the first round of auctions for that—successfully, it seems—and we hope that it will all be delivered for 2018, although there will be a bit of a hiatus in the meantime.

It is important to note that there is also a statutory responsibility on the three transmission companies—the network companies—to comply with a security and quality of supply standard. That means that the capacity market is designed to ensure that there is enough generation capacity for Great Britain as a whole. The network standard is designed to ensure that any area of GB has access to it, both in terms of facilitation of competition for energy supply across the year and in terms of reliability of supply—security of supply, if you like. Those broad bits of the framework are in place; it is just a question of how they are interpreted, whether they could be clarified further—I feel that they could—and whether we feel that the transmission licensees who are responsible for delivering on that are taking it forward in a timely manner.

**Dr Walker:** I pretty much agree with what my colleagues have said so far. We see it as very much a GB electricity system in relation to the security of the electricity supply. It requires sufficient transmission services, which is an area that my colleagues will know a great deal more about than I do, but the capacity mechanism will, I hope, ensure that sufficient capacity comes along in a timely manner. We have had only one round, and it will be interesting to see how the situation develops and evolves from here. It is unlikely that the demand profile will change significantly in the timeframe that you are looking at—we will not get too much transport or heat demand transferred to the electricity system—so you have a bit more of a chance to plan and understand the capacity that you need.

The other thing that the academy thinks is important is the need to bring investment through. There is a need for certainty in the market and in political conditions so that there can be confidence to bring through the pretty massive investment that is required to evolve our system. That is the one thing that is really important.

**Professor Arbon:** I am not going to disagree as far as electricity is concerned, but I probably will in general, because it is not about electricity, as we have stressed in several of our reports. In Scotland, electricity amounts to 19 per cent of our total energy demand. The truly tragic thing about Longannet is not that we will lose 2,400MW of electrical power but that we have been wasting twice that much heat energy by heating up the Firth of Forth over the past 40 years. That is serious.

Looking at electricity in isolation is what got us into this mess; for sure, it will not get us out of it. We need to look at the security of supply of the 80 per cent of our energy that comes from fossil fuels

and will continue to come from fossil fuels in the heat and transport sectors. The electricity sector in Scotland has never been entirely dependent on fossil fuels, but the other two sectors are pretty much entirely dependent on fossil fuels. Unless we broaden the question and start looking at combined heat and power plants in particular, we are storing up enormous problems for ourselves. I agree with my colleagues about the electrical issues, but I think that we need to look at security of supply on a much broader basis.

**Michael Rieley:** The context is incredibly important. Security of supply in Scotland needs to be considered in a GB context, and the GB system is increasingly part of a wider European one. Across these markets, we are trying to resolve the energy trilemma of ensuring security of supply, reducing carbon emissions and ensuring that unnecessary costs are not passed on to consumers. National Grid, as the party with responsibility for ensuring that supply meets demand, in conjunction with the transmission owners, has assessed the system and has taken any actions required to ensure that security of supply can be maintained now and into the future.

10:15

However, there are some areas where Scotland could perhaps strengthen its position, including continuing investment in delivery of transmission assets, particularly the west coast interconnector; evaluating where storage and demand-side response can add value to the system and identifying any regulatory or commercial barriers to the uptake of those technologies; and, finally, ensuring that the recent reforms to the electricity market in relation to the capacity market and the contract for difference do what they set out to do.

**Dr Owens:** It is hard to disagree with anything that has been said so far. If we are going to lose 55 per cent of our dispatchable generation—generation that we can switch on and off when it suits us—we will be left with a big problem because of intermittency unless we can mitigate that and have back-up thermogeneration in one form or another. If we choose not to have that back-up generation in Scotland, that will have a positive effect on our headline emission levels but we will really just be displacing those emissions to England. The question is whether we take the view that it is a Scottish issue rather than a UK issue.

Things will change over the next seven or eight years. For example, I expect that the market for electric vehicles will start to expand over that period, which will provide a demand-side management opportunity. Just last week, Tesla Motors launched a new product that is, in essence, a home energy storage system in the form of a compact battery. Such things will introduce new opportunities to make more of our intermittent sources. However, in the end, when we have a high-pressure system in the middle of the winter, our grid will be stressed. We will need to find energy from somewhere and the English renewables will be stressed at the same time. That is a big problem for our being able to supply ourselves with reliable energy when we need it most.

**Brian Galloway:** There are a lot of moving parts, as several folk have said, and we are increasingly operating within a wider European Union market regarding electricity production and capacity, as Michael Rieley says. Transmission investment will be key in keeping our foot down on that.

Interconnection will increasingly play a role in the GB market context. There are probably between 4,000MW and 5,000MW of new interconnection that can play a role in security of supply. Energy efficiency also has a big part to play. We have seen reductions in peak demand in Scotland—and, indeed, in the UK—of around 20 per cent over the past seven or eight years, which is clearly relevant. We also have to consider heat and transport, as Ian Arbon and others have said.

Ultimately, security of electricity supply is National Grid's main responsibility, and our assessment is that it has all the tools that it needs to ensure that the lights stay on. I would highlight four things that we can do to ensure security of supply. First, we must make sure that we have timely and sufficient investment in transmission assets. Secondly, we must maximise the generation that we have in Scotland, which probably means continuing to develop low-cost onshore wind production. Thirdly, we must start a serious debate about energy storage and technologies such as pump storage and how those technologies can help to balance the system and provide much-needed flexibility. Fourthly, we must make sure that the GB mechanisms that we have, such as the capacity mechanism, are working as well as they can, that the procurement is right and that we are buying enough capacity to meet the challenges ahead.

**Lawrence Slade:** I agree pretty much with everyone who has spoken, but I will raise some further points. Geographically speaking, it is important that we look at the issue in the context of a whole-GB market. We should look at security of supply in terms of the level of interconnectedness across the whole of GB. In addition—this builds on the point made by Michael Rieley and others—we need to consider the level of interconnectedness with near Europe, Norway and so on over time, as that will obviously feed in. We also need to consider how that will impact on

the commerciality of current investment in GB. That is a positive that needs further investigation.

We have said that capacity margins are tightening—we have seen that coming—but it is worth noting that we have one of the most secure systems in Europe. As far as National Grid's responsibility is concerned, we are confident that it has the tools and the resources that it needs to deliver security of supply in the coming years.

That said, it is extremely important that, following the work that has gone into delivering electricity market reform, it is given a certain amount of time to bed in. Rushing change at this point would send out the wrong message to the investor communities. The system may require tweaking—I do not think that anyone would disagree with that—but let us monitor it and ensure that it is delivering before we make any rash changes. We must make sure that, when it comes to what it ultimately delivers, it is working from a whole-market perspective.

Demand-side response and energy efficiency have been touched on. There is no doubt in my mind that demand-side management reduction and energy efficiency have tremendous roles to play over the coming years. The improvement of housing stock is important, but let us not forget about improving the energy efficiency of businesses. There has been a lot of concentration on the domestic market, but we also need to consider how businesses can improve their energy efficiency.

I agree with Brian Galloway that, although storage—for which there are a multitude of technologies—is something that we know a lot about in some respects, there are many unknowns as we go into the future.

**The Convener:** Those responses are very helpful. It seems to me that, unless I am mischaracterising them, there is an astonishing degree of consensus on some of the big issues. To summarise, the view seems to be that we are not facing a crisis, but that in the longer term Scotland will be reliant on imports from elsewhere if we do not replace some of our existing thermal capacity. That seems to be the message that we are getting.

Among the other issues that have been brought up are heat, transport, transmission, storage and energy efficiency, but I do not think that anyone mentioned affordability and the impact on bills. Maybe we will get on to that issue in due course.

I will bring in the deputy convener, Dennis Robertson, shortly, but before I do that there is an issue that I want to follow up on. We have a submission from WWF, which produced the report "Pathways to Power: Scotland's route to clean, renewable, secure electricity by 2030". It argues that, by 2030, we could get to a position where we would not need any thermal plant in Scotland but could rely purely on renewables and interconnection. Does anyone have a view on that? Is that a realistic or, indeed, a desirable scenario?

**Professor Bell:** I would want to study the system behaviour first to reassure myself that it could be worked dynamically. An electricity system is complex, non-linear and dynamic—it changes all the time. There are particular challenges around stored energy. People talk a lot about the loss of inertia. Stored energy is very useful for managing short-term changes. That is one issue that would need to be examined very carefully. It is part of the transmission companies' responsibility to do that, and we must trust them to get on and do it. It is not a trivial matter, but there is some time to get there and to check that it would work.

I do not think that it is quite as easy as saying, "Of course it's going to be okay." Engineers are used to solving problems, so they should solve the problem. Things should be okay, but resources will need to be applied to make sure that that really is the case and, if necessary, creative solutions will need to be found. There are ideas out there.

**Professor McInnes:** The WWF report takes a rather narrow view of electricity in the future, in that its starting point is for Scotland to have 100 per cent renewable electricity rather than for it to have electricity that is affordable, secure and increasingly low carbon.

If we go back to 2012 and add up the contributions of nuclear energy, wind, hydro and the other renewables, we find that they exceeded our domestic consumption. If we take the Scottish Government's matrix of looking at domestic consumption as the starting point, we could argue that Scotland is low carbon at the moment and has been for several years. The issue is that we will lose roughly 17 terawatts of electrical output each year from Hunterston and Torness come 2023 if both those plants close then. I am pretty sure that Torness will continue to operate into the 2030s.

The reason why we are talking about security of supply is because we are at a starting point of zero nuclear in maximising renewables, rather than taking a systems-level view that optimises for cost, security of supply and, increasingly, low carbon. I would exercise caution on the WWF report because it takes a very narrow starting point for electricity supply in Scotland.

**Dr Walker:** I back that up and support what Professor Arbon said. Electricity is only a small part and it is the one that is easiest to decarbonise. As Professor Arbon said, transport and heat are almost entirely fossil fuel based.

I also back up what Professor Bell said. Different types of electricity supply and generation have different characteristics and functions. The word that was mentioned a few times as we went round the table was flexibility, which is not necessarily rewarded in the current market structures. There are things such as inertia, voltage control and reactive power. Engineers are intelligent and innovative people and we will find solutions to those things, but it will take time. Engineers need to be given time to find the optimum solutions, particularly as the heat, transport and electricity sectors are merged. That is not a trivial task for engineers. Yes, we should be ambitious, but we should be realistic as well.

**The Convener:** We have heard three similar views. Does anybody take a contrary view? No? In that case, I bring in Dennis Robertson.

**Dennis Robertson:** I wonder whether we can expand the discussion on flexibility and interdependency in the network. From the evidence that we have heard and the initial discussion this morning, it is clear that there is some interdependency in Scotland. It does not stand alone and there is great reliance on GB. We have also heard about the possibility of an energy union in the European Union. Will domestic investment within GB be diverted because the European market is perhaps a better place to invest? Will the flexibility, reliability and security of supply be more reliant in future on that connection with Europe than on our domestic interconnection and supply?

My second question is about skills. I think that it was Professor Bell who mentioned the workforce in his submission. Do we have the skilled workforce to ensure security of supply for the future?

**The Convener:** Professor Bell, do you want to start?

**Professor Bell:** Yes. As I say in my submission, I have some concerns about the through-flow not just of professional engineers but of skilled craftspeople, fitters and technicians. The "smart grid" includes things such as demand-side management and demand-side response, and all sorts of other technologies bring challenges.

Much of the industry talks about the need for skills and about a shortage of engineers. There was something on the "Today" programme this morning on the subject. In my experience of working with a number of companies in the electricity sector, the commitment seems to waver from one year to the next, depending on exactly what last year's results were. That is a big subject in itself.

In respect of European interactions, there are studies that say that, if European consumers share security of supply or reserve capacity across Europe, it saves a hell of a lot of money. I cannot remember the exact numbers in any one study, but we are talking about hundreds of millions of euros a year. Of course, there is a political dimension to that, which is about reliance on capacity from another country.

As we have seen, the Department of Energy and Climate Change has gone for a capacity market in Britain, the French have gone for their own capacity market and the European Commission has taken to print saying, "We don't like that and we don't think it's in European consumers' best interests with regard to affordability." There are choices to be made in that respect.

I was going to pick up on the other point that you made, Mr Robertson, but I have forgotten what it was.

10:30

**The Convener:** It was about skills and the workforce.

**Professor Bell:** That is definitely an issue. I know that initiatives have been put in place but, to be honest, I feel a bit frustrated that the talk is not always matched by commitments from parts of the industry to graduate recruitment, apprenticeships and so on. It seems to come and go a bit.

**The Convener:** Does anyone else wish to comment specifically on the European grid or the workforce? If not, I can bring in plenty of other members to develop those points.

**Professor Arbon:** On the skills issue, speaking as someone from an industrial rather than an academic background, I can tell the committee that I have grappled with this problem in Scotland for 30 years now. The problem is that private companies can take on only as many people as they can afford, and if we are to take on apprentices, graduates and so on, we have to see a future for them in order to be able to afford them. It is one thing having universities and colleges churning these people out, but it is quite another having a market for them. Now that I am working in academia, I am constantly concerned about the number of people leaving universities who do not have jobs to go to in what is a needed profession. This issue is much bigger than simply providing people with the skills that they need; there needs to be a demand for those skills.

**Dr Walker:** The Royal Academy of Engineering recognises that skills are needed in all sectors. Industry has told us that it needs people at all levels from technicians onwards. I hope that the job prospects are there but, again, that is a huge

issue and one on which I am trying to co-ordinate quite a major effort.

**Dennis Robertson:** I have not heard anything about the impact of that on future security of supply.

**Dr Walker:** I am not sure that anyone has told me that they feel that actual investment or services are at immediate risk. It is more of a long-term issue. To date, most employers have been able to find staff with sufficient skills from somewhere, but that does not mean that that situation will continue.

With regard to the interconnector side of things, our work on the capacity margin and the Office of Gas and Electricity Markets's capacity assessment reports show that the role of interconnectors is one of the big uncertainties. For example, the France-GB link is an entirely separate entity that basically flows whichever way the price signals tell it to. What no one has been able to say is whether, in times of stress, the interconnector can be relied on to provide energy, or at least not to take any energy away. We probably need to have more of a look at the market conditions that oversee the interconnectors, which are basically just point-to-point commercial arrangements.

**The Convener:** I believe that Mr Galloway wants to comment on the skills issue.

**Brian Galloway:** On Mr Robertson's original point about investment in the European context, I want to make three comments. First, the fact is that companies do what they are good at. For example, in the UK, Scottish Power has been spending a lot—more than it has ever spent, in fact—on energy infrastructure, and as a result we are strong in renewables and distribution and transmission networks. There is no sign, certainly at the moment, of that investment dropping off.

Secondly, member states, too, do what they are good at, and they should seek to capitalise on their areas of natural advantage. In Scotland, that has a read-across to onshore renewables and ensuring that we keep a focus on that.

However, even if we were able to address those two points, we would still need some local storage and flexibility solutions. Ideally, we would prefer some thermal plant alongside intermittent renewables, but the investment story is still reasonably robust.

**The Convener:** Do you want to come back in on that, Professor Bell?

**Professor Bell:** There are two perspectives on investment and Europe. I remember speaking a few years ago with some people from Germany who were expressing exactly the same concerns and saying that a more integrated European energy market would draw investment away from Germany towards Britain. It depends a bit on how the markets work.

The European Commission perspective is that there are fantastic renewable resources in the British Isles—wind, wave and tidal—and they should be realised and exploited to the benefit of European consumers and meeting European climate targets. There are good solar resources in the south of Europe, too. From that viewpoint, it is about which resources are where and how to optimise access to them. That requires network investment. That is one of the bigger challenges—getting planning and revealing the mechanisms that will reveal the need for and the right levels of investment.

Alternatively, there is storage—that point has been made by a couple of people. Storage is still very expensive, and networks are usually cheaper at the moment. It provides some other things, though, and the costs for some types of storage technology are coming down.

More fundamentally, coming back to the GB context, a few people are expressing concerns that the market mechanisms that we have might not be revealing the need for storage and rewarding investment in a way that, arguably, they should. I have not thought about it enough to tell you exactly which way it should go, but there seems to be recognition that there is a question to be asked.

On skills, specifically in relation to security of supply, there are some particular technical challenges. My perspective as someone who works with the network companies as both an educator and a researcher is that I am not sure that the technical expertise has been replaced over the past few years. That is a personal view; I have discussed it with senior people, such as people at National Grid, who do not agree with me.

**Dr Owens:** I would like to make a couple of points. First, I want to return to the possible skills shortage. Under another hat, I am a director of recruitment for the school of energy, geoscience, infrastructure and society at Heriot-Watt University, so I am intimately involved in the recruitment of students at undergraduate and postgraduate levels. The job prospects for engineering graduates are extremely positive. Petroleum engineers, in particular, fly out the door, although changes in the oil price might modify that in the future. Many civil engineers and structural engineers go off to work in the energy industry, and the employment rate is very high.

Where we have trouble recruiting students is into the postgraduate market to do specialist MScs. The numbers can be disappointingly low. Last year, the Scottish Further and Higher

Education Funding Council introduced some scholarships that enabled us essentially to double the numbers on some of our courses and programmes that relate to energy skills. By supporting postgraduate study, we can certainly upskill the workforce and have an immediate effect.

On the issue of cost, storage is expensive. In December, I was at a conference in Australia to talk about storage, and people there are particularly interested in photovoltaics. They now think that photovoltaic energy is competitive with gas-fired generation. However, when we add storage to the mix—because the sun does not shine at night or in the middle of a thunderstorm—the price doubles. Someone has to pay for that, and in the end it is the consumer. We have to bear in mind that the people who pay disproportionately more for energy tend to be the poor, and we cannot fail to notice that storage can well have an effect in the long run on their energy bills.

**The Convener:** Thank you. A lot of members want to come in. I will take three members initially to get points and questions, and then we will go back to the panellists.

**Gordon MacDonald:** I want to go back to Professor Harrison's opening remarks, which seemed to have general agreement around the table. If I picked up the point correctly, he said that we might not need additional thermal capacity in Scotland and that we can be dependent on the rest of the UK. My understanding of the situation is that the de-rated capacity margin for the UK is 4 per cent and the interconnector with France and the Netherlands is running at capacity importing electricity into the UK.

The numbers that I have seen for England's consumption of electricity show that it is dependent for 10 per cent of those 266,000GW hours on imports from Scotland, Wales and mainland Europe. Where will that electricity supply come from if we do not build the baseload capacity in Scotland?

**The Convener:** We will hold that thought for a moment.

**Lewis Macdonald:** I have a couple of questions, the first of which is related to Gordon MacDonald's. The market capacity mechanisms are designed, as Gordon said, to ensure that capacity in GB does not fall below 5 per cent but, clearly, it can fall to that level. Is there a real risk that we will end up not with the lights going out but with power being rationed on price, in effect, because of market mechanisms at times when our renewables are not generating? That would mean that consumers would still be able to put the lights on but that the cost of doing so would peak in unacceptable ways.

We are a very long way away from having a European electricity system that is comparable to the GB system but, even when we get there, many of the climate changes and weather patterns that are predicted for these islands are also predicted for much of northern Europe. Will the ultimate outcome of that not be that we will turn to a coal-fired plant in Poland, for example—I use that example because we have Polish visitors in the gallery—to meet low supply from renewables in Great Britain? What would be the price effect on consumers, and what would be the climate benefit?

Secondly, Edward Owens mentioned photovoltaics in Australia. We have a renewables mix for electricity generation that is largely dependent on wind. Should we look more at the potential of other sources, such as solar energy, and try to grow diversity not only between low-carbon and other sources but within renewable generating potential?

**Chic Brodie:** Some of my questions concern European connection. If we look at the risk assessment, we see that we have not only a potential political problem with Europe but a technical problem. As has been mentioned, the Northern Ireland connector has much-reduced technical capacity because of failure in the cables and there is nothing to say that cable connections from the Netherlands, Belgium or elsewhere will be secure.

Dr Alan Walker mentioned that we need pretty massive investment. National Grid is a private company and, although it made £3.7 billion of operating profit in the previous financial year, it is increasingly investing in New York, Massachusetts and other places. Do the witnesses feel secure about the opportunities for investment? Some of us would like to see much more investment in renewables. How do the witnesses feel about the availability of investment, given that Europe will have to consider its own investment and our National Grid is increasingly investing elsewhere? Does that pose a risk to longer-term supply?

**The Convener:** I will start with Professor Harrison. I will summarise the questions to remind everybody of them because I am keen to get different views on them.

Gordon MacDonald's question was about whether there is sufficient UK capacity. Are we hitting peak and the prospect of brownouts?

Lewis Macdonald asked about the impact on the European market. All European countries face the same challenges as us, so does it matter much if we interconnect with the rest of Europe or will we end up importing coal-produced electricity from Poland? He also asked about the price to the consumer if we rely on renewables. If they are not

at peak, does that drive the price up? There was also a question from Lewis Macdonald about whether it might be better to pursue other renewable technologies—for example, solar—rather than to focus purely on wind power, in order to spread the load. Is there too much focus on just one technology?

Mr Brodie's question was about capacity and interconnection. There is also the question of investment: is there confidence that we will see the investment here in the UK, as opposed to competition from elsewhere?

There is a lot to think about. Professor Harrison can start off.

10:45

**Professor Harrison:** Thank you. How long have we got?

I will try to pick up on those points in some sort of order—I am not sure whether it will be a logical one. I will start with baseload. Ignoring issues such as voltage control, stability and inertia, as long as there is enough transmission and the transmission links between different parts of the country are strong enough, it does not, ultimately, matter where the generation is done. It starts to matter where there are limitations on the network, which there are; they exist in Scotland, across the Scotland-England border and further south. The challenge is this: what would incentivise a thermal generator to locate in Scotland, as opposed to in the north of England, the south of England of wherever? We can perhaps pick up later on issues around locational pricing and connection pricing. The issue is that, if the consideration is purely about price, there is no logic to proceeding. If there is something about security, there has to be a connection, if it is not possible to rely on other flexibility options. We have heard about quite a few of those.

To what extent can we rely on demand-side management, storage and interconnection outside the UK to replace thermal generation? That is the ultimate question. At the moment, we do not have a huge amount of experience of demand-side response beyond what already exists by way of interruptible contracts and triads. If we can rely on those, we can do a lot. A lot of proving needs to be done at distribution level and also at transmission level.

I will mention EU synchronisation—if you like—of wind and so on. There is certainly spatial synchronisation. The smaller the area, the more likely there is to be a high correlation between the output of wind in different places. The bigger the area, the less correlated those outputs are, but there is still some correlation. It is possible to have relatively rare atmospheric conditions such that we would get relatively still conditions over much of northern Europe—although the air is not completely still. That is rare, however.

That takes us to the crux of the issue around renewables: what do we do when the wind does not blow? It is possible to operate a mixed system that burns fossil fuels, or we can move much further—as, essentially, we have been mandated to do—which means relying on renewables most of the time, but with options for when the wind does not blow. I do not think that there is an inherent contradiction in that. It is a matter of whether people want to pay for fuel or for capacity. That is probably the issue.

I could go on, but I will let somebody else speak now.

**The Convener:** That is fine. Your points are very helpful.

**Lawrence Slade:** I will add to some of those points. Someone mentioned resilience. In considering the thermal capacity of UK as a whole, it is interesting to note that, over the period from December 2013 to February 2014—the most recent numbers that I have for winter performance—the actual loss from thermal capacity, unplanned, was less than 0.3 per cent in terms of the total context for GB capacity. It is important to consider that. The plant that is running across GB, wherever it is based, is actually very resilient—it is there when it is needed. We all need to understand that.

I will pick up on the point about affordability and about how everything works in a European context. We have raised concerns around the viability of European interconnectors and about what exactly they will offer from the GB and Scottish perspectives—where the flows are governed, how the flows respond to market signals and so on. Those are very important elements. Energy UK is undertaking a fairly large piece of work to examine the role of interconnectors in the market, which we will be quite happy to share with the committee once it is published later this year.

I have a final point, which we have touched on; it was mentioned that affordability has not really come up. The industry, the Scottish Government and the European community need to address the expense behind all the services and new generation. There is no doubt that renewables—wind energy in particular—are making tremendously valuable contributions, but we need to ensure that everyone understands the costs that are associated with those and how they will be paid for over the longer term.

Ultimately, when we look at security of supply issues and the trilemma of affordability, sustainability and security, we cannot ignore

energy efficiency. As a development of that, we cannot ignore the demand-side response. Unless you deal with the energy efficiency of housing and building stock, you will not address the root causes of some of the fuel poverty problems that we face.

**Brian Galloway:** There are two key questions when we look across the different aspects of generation, investment, the role of markets and affordability. One is whether we have the pace of the transition right. That is quite a difficult question to answer. Basically, is the rate of closure of coal and older gas plant being adequately matched by investment in new gas plant, new renewables, new nuclear energy and interconnection, in order to piece everything together? Currently, there seems to be comfort that the assessment is right. National Grid, DECC, the Office of Gas and Electricity Markets and others have roles. There is transparency around how that is assessed, and we will continue to evaluate it annually.

The second question around markets is whether the capacity mechanisms can deliver. It is clear that we have the early stages of the Great Britain capacity mechanism, which has gone well. We want that to continue. Other European member states are grappling with those problems and looking to introduce their own capacity markets. That gets us into the wider European context in respect of how we mesh those markets together, which will not be very simple. There is a host of market arrangements, taxes and levies that are inconsistent across member states, and it will take time to make all of that work.

Ultimately, procuring capacity has a cost and scarcity has a value. Therefore, there will be an impact on consumers. Currently, that impact is relatively modest, but we need to see how that goes as things play out in a wider European context.

**The Convener:** Can somebody pick up Gordon MacDonald's question?

**Professor Bell:** I am happy to do that.

Historically, capacity margins have been a kind of metric for whether there is enough generation to meet peak demand. The de-rated capacity margin is another variation on that. It is right that some National Grid scenarios suggest that the margins will get small in the next couple of years. The question to ask, of course, is this: how small is small? At what point do we start to squeal that it is too small?

The approach to the capacity market that DECC and National Grid have taken between them is to measure things in terms of loss-of-load expectation; I think that Professor Harrison has talked to the committee about that. It is a more precise measure. We have to choose a particular threshold and say what is and what is not acceptable. That has, supposedly, been informed by some economic analysis. By coincidence or otherwise, the threshold is the same as France's. The capacity mechanism is supposed to deliver that from 2018—we have already talked about that—which is when the first contracts will take effect. There is, of course, a question about what happens in the interim. The committee can get National Grid in; I am sure that it will tell the committee directly—

**The Convener:** It is coming.

**Professor Bell:** Good. National Grid will tell the committee directly that it has things in place to manage the transition. It has, for example, the supplemental balancing reserve, which it believes will work. A valid question to ask it—the question has been asked—is about the place of demand-side management in that and whether it is being undervalued. As Professor Harrison said, that has to be proved. National Grid is taking a cautious approach—some would say overly cautious—to accommodating that and comparing it with generation capacity in that market. A valid question to ask it is what will happen in the interim, between now and the introduction of the capacity market. My judgment is that the threshold that is set for that market is not too low.

**Dr Owens:** Demand-side management has been mentioned several times. I have some experience of that. Demand-side management can be as simple as a participatory process. If people are provided with information about the availability of green energy, those who are motivated by environmental issues are likely to modify their behaviour. That is a very low-cost solution. It is not a big solution but it could have an impact on peak demand.

My research group has demonstrated that recently at the Findhorn Foundation in Morayshire, where it had a measurable effect. Since March, we have been varying the price of electricity to the participants—essentially, we are rewarding people for changing their behaviour. That takes the form of charging 17p for a kilowatt hour when the wind is not blowing, reducing to 5p when the wind is blowing. We recognise that there is going to be a surplus of demand. The variable tariff has had a very measurable effect. People are now twice as likely to use their washing machine when the wind is blowing as they were prior to us starting that experiment. The system would be very cheap to roll out nationally.

What is needed, however, is a change in the way we sell electricity. A new business model is needed that acknowledges a future in which there is intermittent generation. The smart-meter roll-out provides an opportunity, because we can then

measure electricity use hour by hour and reward people for participating.

**The Convener:** That is what Lewis Macdonald was asking about: the impact on bills.

I want to go back to what Professor Bell said in response to Gordon MacDonald's question: if I noted it correctly, you said that the capacity margin that has been set by the National Grid is not too low. Does anybody disagree with that? I take it that the answer is no.

**Professor Bell:** That is good.

**Dr Walker:** To follow up on the point that Dr Owens made, once we get smart meters in, we need to move to the possibility of having many more tariff systems. Our people on the retail side have, however, said that they have struggled at times to get a third tariff introduced. They had worked with the normal tariff and economy 7, but when they tried to bring in a third one, it was a real struggle to achieve consumer buy-in.

We have had fixed tariffs for a long time. Spikes occur, but they occur in the wholesale market. There seems to be a fear of spikes, which is why the capacity mechanism came in. However, the spikes indicate that the market is functioning as it ought to function and as long as the spikes are very narrow, the cost to the overall system is not significant; it is the area under the curve and not the height of the curve that is important. Once we have moved to smart meters, the possibilities will increase. We should not, at the moment, be scared of spikes because they indicate where investment is needed.

In terms of global investment, you will have to ask National Grid about investing overseas. I am sure that it will have very good reasons to give you for that—one might well be that it allows it to play with the different and much smarter grids that are developing in the United States, and to learn lessons from that.

On overall investment, there is someone—I would have to look it up; I cannot remember whether it is KPMG or someone else—who has rankings for how GB is seen as an investment market in comparison with other countries. It has suffered a little in recent years from uncertainty as EMR was going through, and with the elections. It dropped one or two places in some sectors, but it is still seen as a reasonably good market to do business in.

As long as we can keep that political certainty, and, as somebody said, bed in EMR to see how it works, the investment will come, we hope. The investment has to come from new places—hedge funds and pension funds—and companies need to understand how those new mechanisms work and to reduce their risk assessment a little.

**The Convener:** We have not heard from Professor Arbon for a while. I will bring him in first.

**Professor Arbon:** Thank you. It is very difficult to disagree with what my colleagues have said.

I want to go back to what I said right at the beginning of the session. I feel that we are trying to address a very large problem from the viewpoint of the smallest component, which is electricity. Unless we take a truly systems view of energy, I do not see how we can solve the problems.

11:00

Unfortunately we have spent a lot of time talking about EMR, which is a classic example of the problem: EMR is "electricity market reform", which pretty much ignores everything else. That does not mean that it is wrong; it means that it ignores 80 per cent of the market, and security of supply applies to 100 per cent of the market.

I feel that there is a grave danger in just going down the route that we have always done in the UK and in Scotland. It is the opposite of the systems thinking in, for example, Denmark, where all forms of energy are considered to be part of an integrated whole and Government legislation reflects that. They have a very desirable situation.

Heat energy is by far our biggest area of demand in Scotland. A new IMechE heat energy report is coming out in the next few weeks in which we consider the situation in Scotland.

I also want to say that in the UK we talk a great deal about affordability but do not seem to look at how our energy is produced. Electricity in particular is still produced predominantly in very old power stations, which are sunk assets. When we get around to replacing those thermal power stations one way or another, their replacements are likely to cost an awful lot more.

We need to have a realistic view of costs. Of course none of us wants costs to escalate, but we have to pay for what we do. That became very apparent to us when we were doing the energy storage report. It is very difficult to make a financial case for energy storage, but we do not see how the system works without it. That is the kind of real dilemma that we have to face.

**The Convener:** Thank you. Before other members come in, no one has responded to Lewis Macdonald's question about renewables in Scotland. Are we are putting too much emphasis on wind? Should we be looking at a broader mix?

**Professor McInnes:** In terms of the mix, if we were to choose one renewable technology for Scotland, it would be onshore wind. It has the lowest levelised cost, certainly compared to solar power at our latitudes.

We can look at other European countries' experiences. In Germany, where there has been a really big push for solar, they get spikes of very high output at midday on sunny spring or summer days, but the net result, I believe, is that investment of something like €300 billion results in about 5 per cent of electricity coming from solar power. That corresponds to about 1 per cent of total energy; as Ian Arbon said, electricity is just one slice of the total energy budget.

If Scotland is going to push for renewable energy, onshore wind is the one to push. My concern, which I expressed earlier, is that there must be an appropriate mix of energy sources. Just now we have a mix of nuclear, some fossil fuel, hydro and wind. I think that we have been skirting around the issue; let us just get to the point. What we are really talking about is the fact that we are closing down all the thermal plants, if we do nothing else. That is the transition. It is not necessarily a transition to low carbon, because Hunterston and Torness already produce copious low-carbon electrical energy. We are talking about a reconfiguration of our energy supply from one that is dependable to one that is intermittent. Storage and interconnection are the things that we are trying to build around that in order to make a square peg fit into a round hole.

We can talk about investment in storage and in interconnection capacity, but it is a cost, and that cost is borne by the consumer, either directly through electricity bills or indirectly through the increased costs to business, which are passed on to consumers.

I am not against renewable energy at all, but I worry that we are overegging onshore wind to the long-term detriment of affordable electrical energy and not just in Scotland, but UK wide. Again, we can strengthen interconnection to elsewhere in the UK and the UK can strengthen interconnection to Europe, but the buck has to stop somewhere. We need large-scale thermal generation somewhere in the grid. It does not matter how smart your smart grid is, you still have to put joules of energy into it somewhere.

**Professor Harrison:** I want to pick up on a couple of those points. The issue of cost is very important and the key thing is that, when it comes to all the costs and the decisions that we make based on them, people are invariably reducing it to pence per kilowatt hour. If you look at the evidence, you see that, by and large, the costs are all roughly the same—we just pay in different ways. Nuclear has expensive capital costs, but its fuel costs are modest, whereas wind is almost all capital cost and gas-fired is almost exclusively fuel costs. There are uncertainties associated with those.

There is an enormous sense of wondering which you pick. The answer is that you cannot pick one on a single basis. If you go down the gas route, you guarantee fossil-fuel emissions. I am reasonably agnostic about nuclear power. However, the important point is that, whichever ones you pick, it will cost you. That is something that we have not dealt with properly. There is no magic bullet. Reduction in energy consumption is critical and is always left behind. It is not sexy and it is hard to do. However, that is what you need to focus on. If you can reduce your energy consumption, everything else gets disproportionately easier—even the balancing and bringing in combined heat and power. If you do it in a sensible way, it becomes much more straightforward.

**Professor McInnes:** We have levelised costs of energy and systems costs. My concern is that we are thinking about levelised costs—the pence per kilowatt hour from wind, gas and nuclear—but they are not representative of the total system cost. If you are building in storage—interconnector capacity—it is the total system cost that has to be paid for somehow and the levelised costs are very misleading, because when you are trying to compare baseload nuclear with intermittent wind, which requires storage connection or gas plant back-up, that is a pretty big hit on top of the levelised cost at the substation.

**Professor Harrison:** That is undoubtedly the case. If you look at the studies that examine that concern, there is not a huge amount of difference between the energy generation options; you are simply paying in different forms. The obvious thing here—and this picks up on Ian Arbon's point that there is no business case for storage—is that there is a business case for storage, but it is on a system level, which is why people built 400KW lines across north Wales and built Dinorwig. There was no real need to do it, but it was there to support the nukes because there was seen to be a strategic need to allow the nukes to operate during periods of low demand in the summer.

The way the market operates means that in some respects it misses the point. That is the issue. When deciding where to move to next, you need to think holistically. I think that we agree.

**Professor Bell:** I support what Professor Harrison has just said. There are studies that try to address the whole-system cost in the context of electricity, to include the cost of operating the system. As Professor Harrison has just implied, and as Professor Arbon was saying, the particular market mechanisms might not be there to drive the investment into storage, although it looks most economic from a whole-system point of view. That is a specific challenge.

Professor Arbon is right to say that heat is a huge challenge. As Dr Walker said earlier, electrification of heat looks like a viable option; we are already decarbonising electricity, which is part of the reason why we are going down this road.

I will dare to step outside my specialist subject. I am not an economist, but I was at All-Energy 2015 last week and, in various conversations about decarbonisation of heat, district heating and combined heat and power, I was struck strongly by the fact that the investment model is not there. There were a lot of case studies from Scandinavia. They seem to involve municipal or Government investment, where the investment could be recovered over a long period of time in a way that private sector investment perhaps was not able to tolerate. Professor Arbon might have more knowledge than I do on that point and may be able to expand on it.

**The Convener:** As everybody is talking about whole-system models, it is interesting—some of you might be aware of this—that on Monday, the Scottish Government published a tender notice for a whole-system energy model for Scotland on the public contracts Scotland website. It states:

"The Office of the Chief Economic Adviser (OCEA) of the Scottish Government (SG) wishes to commission a model of the energy system in Scotland, including all processes or investments carrying the potential to impact upon the level of greenhouse gas (GHG) emissions or removals in Scotland",

to

"simulate investment decisions"

and so on. The notice continues,

"The model and any scenarios supplied with it will be robust; underpinned by research evidence and capable of standing up to challenge from the academic community and other stakeholders",

so you might want to tender for that piece of work.

**Professor Harrison:** Is that recent?

**The Convener:** The notice was published on Monday.

**Professor Bell:** That is very interesting because it sounds like a reissue of a tender that came out a few months ago, so perhaps the Government has failed to identify a preferred bidder.

**The Convener:** Nobody had the expertise to do it, perhaps.

**Professor Bell:** I was involved in a few discussions with people who were thinking about tendering for it and who seemed to be the front-runners. My initial view was that it seemed hugely ambitious, given the amount of money that was on offer and the period of time. If someone did not already have something that met the requirement, they were going to struggle to deliver it.

There are various initiatives across the UK trying to do whole-energy-system modelling. A lot of those have been commissioned through the UK energy research centre, of which—as of last May—I am a co-director. I know that the Scottish Government was talking to University College London, among others, about some of that capability; there is another research council-funded consortium of people trying to develop tools and facilities to get that kind of capability.

From my perspective, some of the capability needs to be developed further; it is perhaps a bit crude in regard to some aspects of the whole energy system and incredibly detailed in regard to other aspects. People are attempting to do it. It is good that there is a recognition of the whole-energy-system importance of electricity, heat and transport.

**Dr Walker:** That is absolutely right, but the reality of applying those engineering solutions in the real world does not always match with the models. Politicians have to understand that as well. What the models and scenarios say will not necessarily happen in real life.

We are calling for a much broader demonstration of the whole system at the community level so that we can bring in electricity, heat and the transport system and start to understand how they could interact together, particularly once the behaviour of users and customers and the different billing mechanisms that might be used are taken into account. In moving from theoretical modelling to the real world, there are very often big discrepancies that we need to understand.

Professor Arbon is absolutely right. We get sucked into the electricity system a bit too much and we do not really understand yet how all the systems will work in a truly sustainable, low-carbon way. We think that we know how it is all going to work but, in reality, it could be a lot more complicated, so the real-world applications are very important.

**The Convener:** Three more members want to come in, so we will do what we did last time and take each in turn, starting with Joan McAlpine.

**Joan McAlpine:** I was interested in the exchange of views between Professor McInnes and Professor Harrison. Professor McInnes, you said that onshore wind is cheap but that there are added costs when it comes to storage. Scottish Power's submission talks about the potential of cheap onshore wind in Scotland, with 130MW awaiting planning decisions and the potential for another 800MW, depending on onshore wind development. However, it strikes me that, as

Professor Harrison said, there are costs to every form of generation, and it seems to me that those costs can be distorted by politically driven decisions. I accept that onshore wind is cheap, but we need to invest in storage. I wonder what people's views are of the Conservative manifesto, which makes it clear that the UK Conservative Government does not want to see the development of any more onshore wind, and how that might distort the market.

11:15

**The Convener:** To be fair, I think that what it says is that subsidies will be removed by 2020, which is a different issue.

**Joan McAlpine:** Excuse me, convener—I directed my question to the witnesses. [*Laughter*.]

**The Convener:** I was just correcting a factual point. That is all.

**Chic Brodie:** Nice try.

**The Convener:** I call Richard Lyle.

**Richard Lyle:** Oh—sorry. I thought that Joan McAlpine's question was going to be answered.

**The Convener:** We will do what we did before and take a number of questions together.

**Richard Lyle:** I will make a comment and then ask a couple of questions, which are for Lawrence Slade. For a number of years, Scotland has been a net exporter. That is the point that Scottish Power always used to make to me when I was a councillor, and in 2013 we exported a record 28 per cent of generation. My concern is that, if all the thermal generating plant is shut or taken away, we will rely on England, which—dare I say it—is having problems as well. I mean no disrespect, but people do not rely on their next-door neighbours to pay their bills, and I think that we could face a problem if we rely on England.

Mr Slade talked about energy efficiency, renewables and so on. During the election, when I was going round to houses, I saw quite a number with solar panels on the roof to reduce electricity consumption. Should we encourage all builders to put solar panels on new housing stock when it is built? We talk about insulation, but that only works to a certain degree. Should we also encourage councils to upgrade their council housing with solar panels?

My other question is for Dr Owens. We encourage people not to throw litter on the road, but should we also be encouraging people to reduce their electricity consumption? In that regard, the cost of low-energy bulbs can be an issue. We are talking about £5 a bulb. Could we encourage manufacturers to reduce the costs?

**The Convener:** I ask people to hold that thought and I will bring in Patrick Harvie.

**Patrick Harvie:** My problem is that every part of this conversation is sparking off another 15 questions and I want to ask them all. I will try to pin it down to two questions, which I think are related. The first is on managing and reducing demand, and I ask it particularly with reference to what Ian Arbon said about thinking about the whole energy system. This relates to heat, but also to transport. We do not talk about transport policy and planning in terms of managing energy demand, but we should do. We will increasingly have to do that if we electrify, but we should be doing it now anyway.

It seems to me that a host of behaviours and technologies are emerging in relation to energy demand that are going to determine whether we are successful in addressing all three aspects of the trilemma. Dr Owens talked about the behavioural aspects and his experience at Findhorn. I dream of the day when the whole of our society has the level of environmental consciousness of the Findhorn Foundation, but we have a hill to climb to get there. That is a dramatic level of buy-in compared with where our society is at.

We also need to consider the issue in relation to smart grid, storage, distributed generation and so on. What role should Governments play in ensuring that these things happen, rather than just trying to set up market signals and hoping that they play out well, which is not always happening at present? What responsibility do Governments have to plan and direct this kind of transformation rather than simply leaving it to the market? Are we doing enough to ensure that the different areas of transformation result in good-quality, lasting jobs and a wider economic benefit for Scotland, rather than our importing batteries from Tesla in the same way that we are importing turbines from other European countries that stole a march on us?

My second question is related to that. Mr Galloway talked about the rate of change. We are losing certain kinds of generating capacity and we are seeing investment come, but not necessarily at the right rate.

That relates to the division of responsibilities between Governments in making decisions to plan that transformation, and the rather unfortunate situation of trying simply to set up market conditions and seeing whether they play out. It may be that people respond to that by saying, "We wouldn't start from here, but we're stuck with it." I would be interested to hear the responses to that point.

**The Convener:** We have a range of questions: we have Joan McAlpine's questions about the future of onshore wind and relative cost; we have Richard Lyle's question about whether we want to rely on imports or whether we should have our own capacity here in Scotland; there are the points about energy efficiency in new housing stock and lighting; and there are Patrick Harvie's questions about the role of Government and the rate of change.

I invite you to comment on the point about onshore wind, Professor McInnes, as that was addressed to you.

**Professor McInnes:** I am not saying that onshore wind is cheap; I am saying that it is the cheapest of the renewables that Scotland has at hand at the moment, compared in particular with wave and tidal, which, as we have seen, have had troubles in being developed on a commercial industrial scale.

If we are choosing a renewable technology that Scotland can develop, onshore wind is certainly the cheapest. My concern is about the extent to which we are focusing on renewable energy in Scotland to the detriment of thermal power-plant generation. That is the purpose of the discussion on security of supply. We are transforming our low-carbon nuclear power, which is a huge component of our electrical energy output, and we are replacing that reliable, dependable 24/7 baseload with intermittent wind power. That is my concern—we are swapping one for t'other.

**Joan McAlpine:** I do not want this to be an ideological discussion about thermal versus renewable. The committee has taken evidence that shows that, because of the regulations being set at UK level, even if we wanted to build a thermal plant, it would not be cost-effective for the generators. We might not even get a new gas plant. That is a problem with regulation.

Professor Harrison briefed us last week. It was interesting to hear from him that Germany, which has a big investment in renewables, uses thermals as a back-up for the times when there is a crisis. We cannot do that here in Scotland, despite the opportunities for renewables, because the way in which the electricity market has been set up by the UK Government means that we cannot operate a thermal plant.

**Professor McInnes:** Yes—it is a political challenge to have the conditions whereby there are good grounds for investment in new thermal plants.

**Joan McAlpine:** The issue is not about the Scottish Government favouring renewables over thermal; it is about the UK Government's regulatory system.

**Professor McInnes:** It is also the case that we have taken a position whereby the starting point for the discussion is having no new nuclear in Scotland. Whether the framework is there for that to happen in the future is an open question, due to the market conditions, but the political starting point is that we are basing the discussion on the idea that there will be no nuclear build in Scotland. We are therefore having to fill the very large gap that will be left when Hunterston and, eventually, Torness come offline. We have to fill that gap with something, and we are trying to fill it with intermittent wind alone. That is my concern for the future.

**Joan McAlpine:** Sure.

The UK Government is going down a different road with nuclear. As regards investment, I think that the subsidy for Hinkley Point will be £35 billion. We could address some of our intermittency problems by investing in storage, but we cannot do that, because of the way in which the market is set up. I would imagine that the subsidy would be considerably less for investing in storage. I would be interested to hear what Scottish Power thought of that.

Because of how the UK system is set up, it favours—for political reasons, I believe—investment, or subsidy, for nuclear over subsidy for storage, which would be quicker here. We could have a road-to-Damascus conversion to a nuclear power policy tomorrow, but that would not solve the immediate problem. What would solve the immediate problem is giving the go-ahead to the pump storage systems, which we could proceed with quickly if there was a different regulatory system at the UK level.

**Professor McInnes:** To compare storage with baseload thermal generation is to compare very different beasts. Pump storage typically provides storage for a matter of hours but, during winter periods of high demand, there can be many days at a time of almost zero wind speed across Scotland, the UK and, sometimes, much of western Europe.

If we are looking to the long term, the new nuclear plants that are being invested in in the south will have a design life of about 60 years but they will probably run for longer than that, whereas wind energy developments have a design life of 20 to 25 years. The investments in nuclear in the south are therefore extremely long term. The new nuclear plants in the south will potentially produce low-carbon, reliable energy right to the end of the 21st century, whereas our very significant investments in onshore wind are much more short term. We come back to the question of what we will do in the future, given the short design life of wind relative to that of nuclear, but that is a bigger issue to discuss.

**Professor Bell:** Whatever the motivation was for UK policy, we can always have a discussion with companies, policy makers or whoever about whether it was a conspiracy or a cock-up. The UK Treasury, DECC and Ofgem can of course speak for themselves, but my understanding is that the motivation—certainly on the part of Ofgem—for the regulatory and market arrangements that are in place was achieving the lowest cost of energy for GB consumers. Whether it delivers an answer that you agree with, that is what was intended.

There is always a need to review the mechanisms that are in place and to change them if we think that they are not working in the way in which we intended. I think that the role of storage and how it is valued in the market arrangements is an example of where it is time to review and think carefully about what is in place.

I think that it was Mr Lyle who asked why we should rely on England, given that it has all sorts of trouble. England does not have all sorts of trouble, but there are the usual suspects who like to say in the press every autumn, when National Grid publishes its winter outlook, "Oh, it's a disaster! The lights are going to go out." We can never say never, because there is always a risk and an economic balance to be struck on how much we want to pay for additional reliability but, by international standards, there is no crisis situation in England.

We have already talked about electricity market reform and the capacity market, and what it is supposed to do. The first round of auction seems to have been successful, but we will see how it gets delivered. In the meantime, we can ask National Grid about what it is doing on supplemental balancing reserves and various services like that. However, speaking as an engineer, my understanding is that the risks are not excessive for GB as a whole and that the regulatory levers are in place to ensure that, at least at a bulk level or a transmission level, consumers in Scotland have access to the electrical energy that is available in England that will give a sufficient reliability of supply.

I think that the network bits of the regulations could be clearer and better articulated—because of how they were written, certain things have been missed out—but, broadly speaking, they go in the right direction. Of course, people's experience of the reliability of supply also depends on distribution networks, and there are particular challenges in that area, but I do not think that saying that it will be a case of relying on England when it is in crisis is a fair assessment of the actual situation. However, as has already been said, there are bigger challenges beyond 2020 and it is absolutely right to ask questions.

**The Convener:** Lots of people want to come in, but Mr Rieley has been very quiet so far.

**Michael Rieley:** Unsurprisingly, I will start with the issue of onshore wind. Onshore wind is the cheapest form of renewables generation, and the outcome of the CFD auction has shown the competitive advantage that Scotland has in delivering that technology. Removing support for onshore wind would be contrary to the process of electricity market reform that we have gone through in creating a competitive allocation of support for renewable technologies.

A point was made about encouraging people to lower their energy consumption, and there has been a lot of talk about demand-side response. I think that those two things can go hand in hand. There is a very good example of communities benefiting from having a more active involvement in responding to price signals. The roll-out of smart meters is a step in that transition, but smart tariffs must go hand in hand with that.

I agree that now would be a very good time to open up the discussion on whether the regulatory framework is right to allow us to accrue those benefits. That discussion should include identifying where those things can add most value. Demand-side response could evolve in a number of ways across the network either at an aggregated level or at a much more localised level, so we need to think about how we can make it work for our consumers.

11:30

**The Convener:** That is an interesting conundrum. On the one hand, consumer groups are putting huge pressure on power companies to simplify the tariff structure but, on the other, you are talking about going in the opposite direction.

**Michael Rieley:** It is an interesting conundrum. There must be simpler tariffs, but I guess that the question is whether we need fewer or more simpler tariffs. I do not have the answer to that. It is a question that must be opened up and considered.

**Professor Arbon:** In listening to the conversation, I am reminded that 40-odd years ago I started my career supplying what we would now call biomass-fired CHP plants to various countries around the world. Although they were manufactured in the UK, they were not sold in the UK. We have had that expertise for an awful long time. The one word that has been missing from the conversation so far is "biomass".

Biomass is renewable. It jolly well should be sustainable if we do it properly. It is dispatchable in electrical terms, and it is thermal, so we can provide heat energy from it. It seems to tick all the

boxes, yet it is ignored. Biomass also lends itself ideally to distributed systems, so there is no need to look at the global network system. That seems to be a direction in which we want to head, although it is fraught with difficulties.

A simple solution to a lot of the supply-side issues could be in biomass-fired and waste-fired CHP plants, and I would commend that. I certainly support what has also been said about energy efficiency. Perhaps a decade ago, the Institution of Mechanical Engineers produced something called "The Energy Hierarchy", which I know that I have spoken about before in this building. It does not look just at energy efficiency, which is a bit of a catch-all phrase; rather, it looks at the first tier of energy conservation and the second of energy efficiency. We must look at those activities before we consider different supply-side possibilities.

I just wanted to say that in support of what others have said. It is not as though we have not known that for a long time, and it seems to be the right way to start.

**Lawrence Slade:** I want to respond to Mr Lyle's questions in particular. We look at energy more as a geographical market and network, and a lot of people who are here today have said similar things. It is not so much about looking at a market for England, Scotland, Wales or Northern Ireland; it is more about looking at the whole market and taking a whole-system approach across the geographical area. We rely on investment into the whole system and on it containing an appropriate mix of generation sources so that it can securely supply consumers throughout the whole region. That is the first point, and that has been reflected on this morning.

It is also key that the frameworks are in place to ensure that, from a company's point of view, there is long-term investment certainty so that it can continue investing in the networks and capacity. Over the next decade or more, the signals that a return can be got from investing in X market and that that will deliver the security and the electricity that are needed will be essential. That is key, which is why I said that EMR must be given time to bed down. We should monitor it and tweak it rather than make significant changes on that front.

It has been said that energy efficiency is not a sexy subject or one that is spoken about in the evenings, but it is important. One of the ways to get round its reputation is to change the story. We are talking about waste. We are not talking about saving energy; we are talking about stopping the waste of energy and money, and that plays out more strongly with consumers than other arguments. It is also a question of telling a story about how energy efficiency does not limit someone's quality of life and how it improves their lifestyle. We all have to get better at communicating those different messages if people are really going to buy in to the argument.

It is also worth remembering that there are other advantages to providing people with warm, healthy homes. This may be slightly off-topic, but there is a significant saving further down the line. An increasing number of studies show that, if fuel poverty is resolved and people have healthy homes, there is a significant cost benefit for the health service. That is obviously of vital importance at this time as we consider budgets. There are a lot of extra things that we could do in that area.

We can do a lot more about what new homes are built with and about energy efficiency products such as solar panels. A different body is responsible for building regulations, and pressure needs to be applied there. There is also a valid conversation to be had about what is done with public subsidy, whether it is paid through general taxation or carried on energy bills. How transparently that money is spent and how it is targeted are vital.

In addition, how is the able-to-pay market incentivised? We do not want to be subsidising someone who can afford to put solar panels on their roof. We want the subsidy to go to those who cannot afford to improve the quality of their homes. Those are extremely important aspects of what the Scottish Government needs to be—and indeed is—looking at.

On smart meters, which have come up a few times in the discussion, it is worth noting that there are several live studies across GB where there are clear indications that, with the right communications with the consumer, demand shifts and reduces after smart meters have been installed.

The point that Mike Rieley made about how to communicate with consumers about usage and that change is key. There are examples from California, Australia and, nearer home, the Netherlands in which communication has not been done properly and there has been massive negative opinion about smart meters. It is important that, before we take a time-of-use tariff approach, consumers understand how it will work and how they can benefit from it.

**Brian Galloway:** I will try to deal with two points, one from Ms McAlpine and one from Mr Harvie.

First, on investment models, I said earlier that companies tend to do what they are good at, but they also do what markets allow them to do on meeting demand, price discovery and, ultimately, profit.

On the electricity side, a combination of policies and regulation seems to provide a large part of the solution. Electricity market reform is a good example of bringing forward low carbon generation, notwithstanding some of the political challenges around onshore wind that have been mentioned. Those mechanisms can also work for storage, tariffs and smarter markets. To assume that the same large companies will solve all those problems is probably unrealistic and, therefore, not worth while.

Where those mechanisms are not there—around renewable heat, alternative transport and, perhaps, community energy—I think that what Mr Harvie says is right. We need to explore alternative investment models rather than being disappointed with the outcome and then putting out policy statements and setting targets in the hope that delivery takes place. We need to look differently at some of those questions.

Secondly, on pumped storage, the key positive from today is starting the conversation about what needs to happen. Our initial view is that the technology can be cost competitive on a large scale but, as has been pointed out, the question is: what is the comparison? Interconnection and thermal generation are different, but our initial assessment is that pumped storage can be part of an overall system solution. It ticks the flexibility box, it certainly helps the network and it helps to spread the decarbonisation message with regard to, for example, reducing curtailments from wind farms. Siting is clearly a key issue given the large environmental questions that arise with such developments.

The three things that we need to do are, first, to get the conversation going and build consensus on storage as an important part of the total energy system; secondly, to look at the barriers to investment and the reasons why companies cannot invest in the technology under the current market arrangements; and thirdly, to think about what those arrangements or the regulatory framework might look like.

Again, this is an initial assessment, but the cap and floor regime that is being developed for the new interconnection might be one idea to consider. In that approach, the cap protects consumers and ensures that the overall cost is manageable and the floor ensures that investors do not lose their shirts, with the outcome hopefully being somewhere in the middle. In short, there are things that we can do about storage, but other areas such as renewable heat might require a different approach.

**Dr Owens:** I would like to pick up on several issues, if the committee will be patient with me.

**The Convener:** We have about 20 minutes left, so we can be patient.

**Dr Owens:** You will be pleased to hear that I should not need 20 minutes.

First, I back up Joan McAlpine's comments about thermal generation. It is a bit hypocritical of people to expect a thermal plant for backing up intermittency to be built in England rather than in Scotland. After all, we are going to need it in one way or another. I often hear the comment that the renewables industry generates jobs in Scotland. I am sure that it does, but so does thermal generation, and if we are going to rely on fossil fuels anyway, we might as well have the plant in our own country. However, as I understand it, there will be additional connection costs. As I am not a poles-and-wires person, I am not an expert on that, but others in the room are.

Secondly, with heating and hot water for the built environment accounting for 40 per cent of energy use, many European cities have large district heating schemes, some of which are fed by biomass boiler systems. We do not really do that sort of thing in Scotland, but we have potential to do so and it could make a massive impact, as we would be targeting 40 per cent of our total energy use instead of the 25 per cent of energy use in the electricity market. Indeed, I understand that the heating and hot water figure in Scotland is 50 rather than 40 per cent.

Thirdly, Michael Rieley is right to say that variable tariffs will complicate things, but the fact is that we have a really poor record of communicating to the public about energy. To see that, we need only look at our interfaces with energy. My mother, who is in her mid-80s, has just had a new boiler installed through some Government incentive, but the control screen is the size of a matchbox and she cannot read or understand it. Instead, she uses the big on-off switch or keeps hitting buttons until she hears the boiler going on—which, given that she is old and deaf, is very difficult for her.

The interface between the systems is important, and we need to think about how we communicate those things. If demand-side management takes off, we will need to do it in a smart and graphical way to ensure that people understand it clearly. Engineers tend to worry about numbers and little squares, but this is really about pictures, communication and ergonomics. It is not just an engineering problem.

**The Convener:** I will take a brief comment from Dr Walker, and then we will need to move on.

**Dr Walker:** I actually have two brief comments, convener.

Biomass has just been mentioned, but one thing that we have not talked about yet is carbon capture and storage. With Peterhead—I hope—going ahead as one of the two CCS schemes, we really need to find out whether it works, how the business case and the efficiencies work and so on. If it works, the UK, and Scotland in particular, could take a global lead with regard to job and wealth creation, and if you matched it with coal and biomass-fired plants, you could get negative emissions, which would be particularly useful for the climate.

I also want to make a general point about the message and what Government can do. Government does an immense amount in relation to the energy system. If we just look at the building of new homes, it enforces the regulations on efficiency and standards. Companies that we have spoken to have said, "We wouldn't do this if the Government didn't tell us to", so Government has to push such things.

More than that, we have to see the energy system as a partnership between Government and industry. Only by doing that will we be able to transmit the message. As we have all seen, it is a complicated system and one that a lot of change is coming to, and the more that we can bring consumers and the public along with us, the better chance we have. That is going to happen only if there is a partnership and a joint message from Government and industry. At times, Government and industry have played off against each another. I appeal to the politicians here to go for a partnership with industry in order to make the changes that are necessary.

11:45

**The Convener:** I am conscious of the time. We have 15 minutes left and a number of members want to come back in. Johann Lamont will start, as she has not had a chance to ask a question yet.

**Johann Lamont:** Given how little I know about the issue, it is more difficult for me to ask a question. I absolutely relate to Dr Owens's mother. [*Laughter*.]

I am interested in the frustration, which was expressed in particular by Dr Arbon, that the conversation is not the real conversation and that your reality is knocking up against public perception and political perception. How do we deal with that? What role do you as professionals have in dealing with it?

We have grave public suspicion around anything to do with energy, whether it is fracking, nuclear or renewables. There is public anger against the companies, which people feel have ripped them off. In that context, how can we have the rational conversation that the panel is clearly pleading for? What can we do about that?

As an example, we know that there have been proposals for wind farms in Scotland that the Scottish Government has refused because public concern has been so strong. How do we hold the line on having an energy policy that is consistent with rationality when at the same time, quite rightly, we have to respond to communities? How do we ensure that politicians do what they should be doing and respond to communities while also recognising that there is a bigger challenge?

I have a second point on something that we discussed briefly last week. We can have tariffs that recognise that people who are fuel poor are unable to use enough energy because of the charging, but if the charging is changed and they then use more energy, we have got ourselves into the wrong place. How do we make energy efficiency something that makes sense to people?

Many years ago, my granny was the first in her village in Tiree to get electricity. Until the day she died, she looked out from the croft to see whether anybody else's lights were on before she switched hers on. It was a natural thing to save energy and not to waste it. How do we get back, in this world, to people being able to see that it is a personal thing and that they can control the amount of energy that they use? How does technology add to that rather than confuse it?

**The Convener:** I am going to take very brief points from the other members who want to come back in.

**Gordon MacDonald:** I had two questions, but the first was mainly covered by Joan McAlpine.

The second has to do with a subject that Lewis Macdonald touched on: consumer availability of electricity. On one of my more bored days, I sat and read the Eurostat energy pricing statistics for the 28 EU members. I looked at the countries that had interconnectors with the UK. France consistently had lower electricity prices—they were 15 per cent cheaper—than the UK in the period 2011-13, and the use of renewables in France was 12 per cent as opposed to 4 per cent in the UK. We are talking about putting in an interconnector to Norway. In 2011-13, Norwegian electricity prices came down by 10 per cent; at the same time, UK electricity prices went up by 22 per cent. Are the market and the pricing mechanisms in the UK working to the advantage of consumers, bearing in mind that we are told that electricity bills are going up because of renewables?

**Richard Lyle:** My point is in response to what Professor Arbon said. We have to educate the public more about biomass, waste-to-heat and waste-to-power plants. The minute that someone says that they are going to put one of those plants

anywhere within a 30-mile radius of anyone, it as though they are putting a Trident nuclear submarine next to them—people do not want it. We have a great job in trying to educate the public that waste-to-heat and biomass plants can be put in locally and are safe.

**The Convener:** That is a very good point. It backs up the point that Johann Lamont made about the need for a public conversation around those issues.

**Dennis Robertson:** Security of supply is a long-term issue. Should we be ensuring that we have further investment in areas such as wave and tidal, offshore wind and so on, to supplement future demand, rather than moving down the road of, say, nuclear, or developing other thermal plants in Scotland? Are we really stepping away from that investment or should we be investing to move that technology on because it is there?

**Lewis Macdonald:** The sun is still shining outside, so I still hope to hear an endorsement of the potential for photovoltaics in Scotland. Someone commented that we do not do district heating in Scotland, but in Aberdeen we have thousands of council tenants on combined heat and power systems and that approach has been expanding in the past couple of years. The challenge is to retrofit when people are private owners of their homes. Does anyone on the panel have any suggestions on that issue?

**The Convener:** That is a lot of ground to cover in 10 minutes. Johann Lamont has said that we need a national conversation and asked how we can win over public opinion. She also asked how we can simplify energy efficiency to make it easier for people to understand. Gordon MacDonald asked why the bills are cheaper elsewhere and whether that is a fault of the systems in Scotland. Dennis Robertson asked whether we are ignoring wave, tidal and offshore wind and whether they could fill the gap, instead of our relying on nuclear or new conventional generation. Finally, Lewis Macdonald asked about district heating.

**Richard Lyle:** What about me?

**The Convener:** I was not ignoring you—you were agreeing with Johann Lamont's point, so they can be picked up together. Please give brief responses, if you can.

**Professor Bell:** I have a quick response on why other countries have cheaper electricity. In France, they have the benefits of investment in nuclear power for electricity. You could ask some accounting questions about where the decommissioning costs appear—I do not know.

Norway benefits from lots of cheap hydro power. I am not sure why their bills have come down recently. They want a wet or snowy winter with lots of snow melt to make sure that the reservoirs are full and have enough water for electricity generation. Having an interconnection to the Netherlands helps them to store and manage their water supplies. They can keep the water back, so the average cost might come down because they are not worried about running out of water and can use surplus thermal plant in the Netherlands.

**Lawrence Slade:** Our engagement with customers is about getting them to understand their electricity and gas consumption, if they are on the gas grid. Via smart and graphical interfaces—on an in-home display, a smart phone or a computer—people are now seeing how they use electricity and that is helping them to understand their usage. I am pleased to say that work is going on with the Royal National Institute of Blind People to consider how to bring interfaces in to help people with poor sight to understand their consumption.

I fully support the idea of a national conversation. As Dr Walker said, there has to be some kind of partnership between Government and industry, and there must be transparency in those discussions.

**Professor Harrison:** On the difference in affordability between this country and others, one of the key things about Norway and France is the role of the state in energy supply. As a result of that role, we see a difference in the discount rate—the cost of capital is generally much cheaper in state-owned systems than it is in the UK. That is one key area and, if it is stretched across a very long time, it makes a big difference.

My university has a vested interest in public investment in wave and tidal power, so my answer to the question on that area is yes. We obviously have something that has potential—arguably, tidal is ahead now. Do we let the technology get to the point that it reached with wind power and then let it go abroad, or do we stick with it and get on with it?

**The Convener:** Can you specifically answer Dennis Robertson's point? Will that fill the gap?

**Professor Harrison:** No, not in the immediate term, but very few things will fill the gap.

**Dennis Robertson:** We are thinking about the long term.

**Professor Harrison:** In the long term, you can get a very substantial contribution. It goes back to Lewis Macdonald's question about whether we get benefits from spreading things around, to which I think the answer is yes.

**Professor McInnes:** I will address the point about energy efficiency. This month is the 250th anniversary of James Watt's invention of the separate steam condenser. He had his insight in May 1765, wandering across Glasgow Green one

sabbath morning, as he recounted to his biographer. James Watt's invention was a revolution in energy efficiency. He improved the efficiency of the steam engine threefold, from 1 per cent to 3 per cent, and energy consumption soared. That kick-started the industrial revolution and gave us the modern prosperity and civilisation that many of us enjoy.

We should recognise that improving the energy efficiency of consumer electronics or other devices does not necessarily mean that we will use less energy in the future; we will just use it more efficiently. In the past, energy efficiency has been the mechanism through which energy consumption has grown, through a socially progressive mass democratisation of access to energy services.

**Dr Walker:** I am not sure that I have answers to some of the questions, but I absolutely agree with the point about energy-from-waste plants being difficult to get planning permission for. It is tragic to think about the situation with heat networks and retrofitting. Indeed, "retrofitting" is a word that should have been mentioned a bit more on the heat side. It is all very well to have heat networks for new build, but the vast majority of the buildings that we will be using in 2050 are already here. It is more difficult to retrofit them, but they account for a much bigger slice of the pie. People are doing a lot of work to fix that, but it is a hard nut to crack.

**Brian Galloway:** Everything that we have spoken about this morning, with the possible exceptions of energy efficiency and demand reduction, has a cost associated with it that would add to the current cost of the energy system. Lawrence Slade mentioned the national debate on energy. The costs and trade-offs are really important, and the sooner they are understood across society, the better.

**Dr Owens:** I return to the point about the diversity of generation. Diversity can mean many different things, including geographical diversity. A wind turbine in Cornwall will experience different wind conditions from one in Shetland, and that can mitigate the problem. We can have technological diversity—we can bring in PV or biomass, and tidal power will play an increasing role, although I am not so sure about wave power—it is further away, for sure. There is also diversity of demand within our economy. If different sectors of the economy need energy in different ways at different times, that can also help.

**Professor Arbon:** I will pick up on the point about education that was made by a couple of speakers. It is something to which I have had a lifelong commitment, and I bear the scars. I have literally been offered physical violence for speaking on behalf of using energy-from-waste plants in Scotland. Sometimes, sad to say, I have been opposed by MSPs. I now teach an MSc course at the University of Glasgow on the production of energy from waste, and it is starting to have an effect. I am pleased about that.

**The Convener:** I hope you were not threatened with physical violence by an MSP.

**Professor Arbon:** No—I tried to separate those two points.

**The Convener:** On that note, we have reached the end of our time. I thank all our witnesses. It has been an extremely useful and informative evidence session, and I am very grateful to you all for giving up your time and coming along this morning to share it with us.

11:59

*Meeting continued in private until 12:19.*

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