



HOUSE OF LORDS

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The Select Committee on Science and Technology

Inquiry on

THE RESILIENCE OF ELECTRICITY INFRASTRUCTURE

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Witness: Dr John Roberts

USE OF THE TRANSCRIPT

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Members present

Earl of Selborne (Chairman)
 Lord Broers (co-opted)
 Lord Dixon-Smith
 Lord Hennessy of Nympsfield
 Baroness Hilton of Eggardon
 Lord O'Neill of Clackmannan
 Lord Patel
 Lord Peston
 Lord Rees of Ludlow
 Viscount Ridley
 Baroness Sharp of Guildford
 Lord Willis of Knaresborough
 Lord Winston

Examination of Witness

Dr John Roberts, CBE, FEng, representing the Royal Academy of Engineering

Q150 The Chairman: Welcome, Dr Roberts. I am sorry that we kept you waiting a while. We were deliberating on our future report. Thank you very much for joining us today. I know that you join us very much as one of the co-authors of the recent RAE report *Counting the Cost: The Economic and Social Costs of Electricity Shortfalls*. We will hear, I am sure, during the course of the questions, about some of your findings. Indeed, we have had an opportunity, of course, to read the report. For the record, we are being broadcast. Would you like to introduce yourself, and if you would like to make any opening statement, do please feel free to do so.

Dr Roberts: Thank you. My name is John Roberts. I am a fellow of the Royal Academy of Engineering and have been since 2005. I worked with colleagues in the policy part of the Royal Academy to produce the report. Perhaps just to set it into context, if I may, in May 2013 we were requested by the Council for Science and Technology to produce a report on the supply capacity margin: in other words, the extent to which the supply of electricity will exceed demand. Our report was submitted to the CST in September last year and published in October.

Essentially we said that the margin by which supply would exceed demand was going to narrow very sharply, and we made some recommendations as to what the Government and the industry could do to mitigate some of those effects. Those recommendations were largely taken on board and put into place. As a consequence and a follow-on to that, in July this year we were asked by the CST to do almost a codicil to that report and to look in theory at what would happen if we actually had a shortage of electricity supply in the country and we had to have substantial outages. That was the substance of our report that you have mentioned, *Counting the Cost*. We did desktop research, we did workshops, we spoke to people in the industry and we have produced that report.

Q151 The Chairman: Thank you very much. I think we will be particularly concentrating on what you call the codicil rather than the original report of two years ago, and I recognise the difference. Your second report is not so much about the likelihood of disruption but about the potential cost of disruption. That we appreciate.

Let me ask a very general question to start. Could you tell us what the economic and social consequences are of interruptions to the electricity supply, and particularly to what extent electricity outages resulting from a shortage in capacity and an external shock to the system differ in their consequences?

Dr Roberts: I think they differ in a number of ways. Clearly, if there is an external shock to the network, a system storm or whatever, and there is a lack of available capacity, the net result is the same: there is no electricity. But the nature of those impacts on the system is quite different. If we had a shortage of generating capacity, that would be reasonably predictable and therefore could be planned for ahead of time, whereas outages, which would normally affect either the transmission or more likely the distribution systems—the wires—as a result of storms tend to happen very suddenly. You may be able to forecast a day or so ahead, but when they impact you are never really certain where they are going to impact. As we have recently had up in Scotland, tens of thousands of people can be off supply for maybe 48 hours. Those interruptions are less predictable. You can plan in general terms for them, but you cannot plan for them specifically. I think that is the fundamental difference.

The Chairman: How would you characterise the difference between planned and unplanned?

Dr Roberts: If you know that there is going to be a shortage, you can take steps to mitigate the impacts. For example, you can request power stations to maintain generation rather than switch off, you can communicate with the public, you can invoke arrangements with large industrial users to reduce demand and you can generally communicate with the public and alert them to the fact that there may be outages. In particular, the effect of an outage differs over time during the course of the day. Loss of power at night clearly does not have a huge impact on residential consumers, whereas loss of power, say, at 8 o'clock in the morning or 6 o'clock in the evening when people are coming home, putting lights on, cooking food and so forth, can have significant consequences. So by a combination of asking power stations to continue generating or by asking large industrial users to diminish their load at times of peak, you can mitigate the effects. You can peak lop, you can shift load, so you can minimise the actual impact that it will have.

Q152 The Chairman: One of the interesting observations in your report was that when people were asked about how they valued the prospect of a loss, the thing that they seemed to be most worried about was loss of data, the computer going down. That could be one second or several hours, but the effect would be the same, so duration of the outage is not necessarily a critical factor. Is that correct?

Dr Roberts: Duration can be. For individuals, for people with computers, as you rightly point out, a short break in supply can have the same damaging effect as a lengthy outage, but particularly in the case of manufacturing large industrial consumers may well have some resilience. They can get by; they have standby generation and so forth. They can get by for a few hours, but if an outage lasted, say, for 24 hours, the effects could be very damaging. So

duration is an issue, as is frequency. People may not like the loss of supply once a year, but they would get over it, but if they had frequent losses of supply, that would be quite different.

Lord Winston: You mentioned mitigating partly by informing members of the general public. I am not sure that I have declared an interest as an honorary fellow of the Royal Academy of Engineering, but I wonder how effective you think that is and how effective communication with the public will be in the event of outages or reductions.

Dr Roberts: I think it is to be tested in practice. That is the point. We have not had an issue of predictable outages since the three-day week in 1974. If you look at what happened in Japan after the Fukushima earthquake when they had to shut down all their nuclear power and they had a severe shortage of power, they mitigated the impacts quite significantly by very effective communication with the public in Japan. Whether that would happen in this country, frankly, you would have to find out in practice, but in general terms if the public are informed of what is happening and why, they tend to react more favourably than if things just happen out of the blue and they get no sense that anybody knows what is going on.

Viscount Ridley: On this question of duration of interruption, I think that in some ways we are more resilient now, because if the electricity went off now I would not lose anything from my iPad. Indeed, that is the way I operate at home. I am now on a laptop and no longer on a PC. I would get several hours on my telephone before it ran out of battery because it is a mobile phone, and even then I could get in my car and drive around in circles just to charge it. I have never done that, I promise. In other words, certainly as consumers we are not quite as pole-axed by a short-duration interruption. Indeed, I do not even need the light on, because I can read my books on my iPad. Is that true for industry as well?

Dr Roberts: I think this question of duration is very important. Compared to where we were in 1970 with the three-day week, we are obviously so much more reliant now on electronics and electrically-driven equipment. For industry, a lot more supply chains are now a lot less resilient. The financial services industry, for example, is hugely dependent on computing. When Hurricane Sandy hit Manhattan a couple of years ago and that was flooded, everybody's standby generation kicked in but then they ran out of diesel and they could not get the diesel into Manhattan because it was flooded. That was an issue of duration. They could manage for 24 hours, but beyond 24 hours they could not. I think it will impact different industries in different ways.

From an individual point of view, yes, my mobile might last for a short time. It depends on how resilient my mobile network supplier is and whether they have standby generation as to whether their network is going to work. I mentioned Fukushima. When the Fukushima issue hit, the mobile network in Japan collapsed, partly because it was inundated by people trying to make mobile calls but also because they did not have sufficient resilience.

Then again, everybody's central heating, even if it is gas, will not work without electricity. Maybe you do not mind having no central heating for a day or two, but after that it gets to be a bit tiresome, particularly in the winter. The point I am trying to get to is that modern life is just so dependent now in so many ways on electricity that loss of electricity for more than 24 hours is difficult. In this country we are so used to the fact that we have a very high degree of security of supply that not many people ever think about doing anything to mitigate it.

Lord Hennessy of Nympsfield: Do you think there is anything that we can still learn from the three-day week of 1973, 1974? The folk memory in so far as it exists is that with television going off at 10.30 pm the Government's popularity plummeted and the birth rate shot up nine months later. That is how people remember it, if they remember it at all. I remember that at the time there was a lot of talk of people rather remembering the war—a very high proportion of the population could still remember the war in the early 1970s—and being jolly with each other and talking on underground trains and so on, and the level of production held up remarkably well. There was a kind of feeling that there was still a considerable residual stoicism among the British people. Since then we have had a lot of studies that Maurice will know about, JK Galbraith and others, about the growth of a culture of contentment and how people get very jumpy very quickly if any of their normal supplies and services are jeopardised even for a few hours. I know you are not a social scientist, and perhaps that makes you even more qualified to talk about this, but do you think there has been a change in British society where people get rattier quicker?

Dr Roberts: I can remember the three-day week, because I was a very junior engineer in those days, and I was phoning people—I was based in Chester—telling them that they were going to be off supply for three hours at a time, and you are right that there was a degree of stoicism. It was not that long after the war. I think somebody characterised it as people moving from being consumers to being citizens and they think about banding together. My sense would be that if you look at what happened with the floods in the Somerset Levels and things like that, the public have a relatively lower tolerance level now. For the first few days it is interesting and life is a bit different. It is not quite a game, but it brings a society together and people exhibit the British spirit and all that kind of thing. That is great for three or four days, but if it carries on beyond that somebody starts to say, "Who on earth is charge here? Why is this still going on?". I think that tipping point is reached probably more quickly now, going back to the point I was making before, because we are now so dependent on electricity. If you go back to 1974, if you wanted to get money out of the bank you went into the bank, handed a cheque in and the man gave you some pound notes. Now we all use ATMs. There would be no ATMs. How would we manage with that? You cannot send the children upstairs to play with their computer games any more—all those sorts of things. As you say, I am not a social scientist, but my own view would be that life would change very sharply and that a lot of conveniences that people take for granted would not be there. I think that after a relatively short period of time someone would start asking questions, pointing fingers and seeing who is responsible.

We had the Christmas storms last Christmas on the south coast. It is interesting—and I know this from personal experience—that if there is a supply outage even due to a storm on Christmas day, people regard that as almost an insult, that somehow you know it is Christmas so why have the lights gone out, and they get very angry, very quickly. So my answer would be—I would not like to see us testing it in practice—that people would get very frustrated sooner than they would have done in 1974.

The Chairman: This is where I always have to declare an interest. I certainly lost my cool last Christmas day.

Q153 Lord Willis of Knaresborough: That is the third time you have reminded us of that.

When we began this inquiry we had a simple explanation that with supply over demand there was 4% resilience in the system, and that was adequate and there were back-ups even

if that 4% disappeared. It struck me that when the bank stress tests were announced this morning, the scenarios that they were incorporating into those stress tests were significantly more severe and significantly more sophisticated than what was happening with electricity, and yet electricity is at the heart of making sure that our banking system is resilient as well. When you were doing the report and the codicil, did anybody in government or elsewhere apply stress tests of that magnitude to the resilience question? If so, who were they and where is that evidence?

Dr Roberts: The answer is yes. The evidence is in the first report, the one I mentioned that we did the year before, because among other things I am involved in the financial services industry. I am chairman of a bank. When we did our report, I imported stress testing from my financial services experience. We looked at a 4% margin and then applied the kind of stress testing that you would apply in banking circles, which is to say, "Let us look back over the last five or 10 years and look at real events that took place that would really stress the system". We looked back at December 2010, I think it was, when we had 10 days of very cold weather and no wind, so that none of the wind-power renewables operated at all. We also looked back at May 2008 when on one single day, in a completely unconnected way, two major power stations, Hinkley and Longannet in Scotland, had operational problems and had to shut down on the same day, which caused a huge disturbance in the system. We asked whether, if that happened in the middle of winter when it was very, very cold—a day like today—and no wind, the system would survive. The answer was that it would be a very, very close call. That is incorporated in our report.

We said that at a 4% margin, technically speaking you would get by statistically but the resilience of the system was sufficiently eroded that the longer it went on, if you had two or three really abnormal incidents coming together at the same time, we could be in trouble.

Lord Willis of Knaresborough: But I would like to know whether the tests that you applied over that 10-year scenario the Government are applying as well. The tests that you applied over that 10-year period were unique over that 10-year period. If Japan had done the same over the 10-year period, that period would not have had Fukushima in it, because the idea of a tsunami hitting and knocking out its nuclear power stations I suspect was not there. Certainly John Beddington reported that that was not the case. I just wonder about going to that extra level, because the bank stress test, from what I was reading this morning, seems to have gone significantly beyond what a normal series of events would be.

Dr Roberts: The stress test that we did took account of real world events that really did happen and demonstrated that the system would be right on the verge of losing its stability. We could have envisaged even more extreme stress tests, but had we done so all we would have demonstrated was an even worse situation. I think that what we demonstrated to our satisfaction was sufficient to say that the Government should be aware of this and that National Grid should take steps to improve the resilience of the network. To have gone further would have been to emphasise the point even more, but I take your point.

Q154 Lord Rees of Ludlow: The loss of supply is probably predictable in the sense it is a Gaussian distribution and you can work it out, whereas I would have thought that the distribution network is vulnerable and you might imagine that there is a long tail of a small chance of some really catastrophic effects to the wider network. Do you think that is something that we should worry about more? In that context, do you think we are spending enough on the resilience of the distribution network and on back-up generators for

elevators in skyscrapers and things like that, without which a city could not survive for more than a few hours?

Dr Roberts: I would distinguish between resilience of the generation side of the system and resilience of distribution.

Lord Rees of Ludlow: The latter, one suspects, might be less Gaussian and a bigger chance of a long tail.

Dr Roberts: Yes. I think we are spending a sufficient amount on the distribution network. We have just completed the price review for the distribution network with Ofgem, and that will come into effect on 1 April. I think that makes sufficient allowance for investment in the network to maintain the resilience of the network. As far as the supply is concerned, I would have the concern that the supply margin is quite small now. On your point about a Gaussian distribution, I think what we are worried about are the Black Swan-type events that suddenly happen and whether we have sufficient generation. I would argue perhaps that we do not, but—and this is, I think, the core of the report that we have just produced—we do not really have a good sense of what the costs would be if we did have those sorts of outages: hence, we do not have a benchmark against which to judge how much we should spend, because system security comes at a price. At the moment the public at large are very sensitive to electricity prices, almost to the point, I think, where they say, “I am paying this much a year for my electricity. I expect you to make sure that it is there all the time. That is what I am paying for, am I not?”. Saying, “No, you have to pay some more now to make sure it is there”, might not go down very well, even though it may be entirely justified in technical and economic terms.

Q155 Lord Peston: The general rubric of the questions that we are asking you uses the phrase “economic and social consequences”. More or less everything you have said, to my ear as an economist, sounds like economics. Can you tell me where we draw the line between economic and social policy purposes?

Dr Roberts: That is difficult. “Social” in the narrow sense would be the impact on domestic consumers, where there is not necessarily an economic impact but simply the inconvenience factor, but in a very large sense. Beyond that, if there were economic impacts of an inadequate or unreliable electricity infrastructure, that could then result, for example, in a lack of direct inward investment and the UK getting a reputation of being an unreliable place to site factories. That in turn could clearly have social effects, because of what it would do in terms of GDP and employment and so forth.

Lord Peston: Yes, but you define “social” simply as households, whereas in social science that would not be what most would have thought you would have had in mind. They would have thought that you would discuss inequality: namely, whether the rich get hit more or the poor, or particular social groups such as the elderly, particularly those who are at risk medically. Do you have any cognisance of any of those effects? To take an obvious example, I gather—happily it does not yet apply to me—there are elderly people who do have medical problems and they have a button that they can press to get an immediate response and attention, which may save their lives. I assume that that button depends on having some electricity. Should not someone be looking at that kind of question when we ask what the right amount of capacity is, both generation and distribution, within our society? Some of us would not give a damn if the City of London—I have said this before—could not operate for

a few hours, but we would certainly care terribly if an elderly relative died as a result of their button not working?

Dr Roberts: Yes. As the Chairman said, I am not a social scientist.

Lord Peston: No, but I am just wondering from your experience what you expect.

Dr Roberts: In my experience, first of all, at the local level with distribution, vulnerable customers are known to the local distribution company, so they know if there are people who have problems and they can sometimes do something about it. The problem would be if you have major outages. I think the scenario that we are talking about here would be national rolling blackouts. In those circumstances I do not think that the local distribution companies would have the resources to deal with that. If there is a local outage because of a storm, they know where the vulnerable customers are; they have standby generation that they can bring into effect. But if we were, as we were in 1974, switching people off in large blocks, that would not be possible. Within that, though, significant installations like hospitals would be kept on supply, because they have dedicated supplies. But if we are talking about the people you mentioned, vulnerable residential domestic customers, that would be very difficult. I quite take your point. I do not think that I am adequately informed to comment on it.

Lord Peston: No, but would you agree that it is not a question we can neglect?

Dr Roberts: It is a very important issue, I exactly agree.

The Chairman: To be fair, in your report you do deal with some of the specific social and psychological issues, do you not?

Dr Roberts: I think we made the observation that in those circumstances one would hope that local communities would come together, that that social side of the issue would be addressed, but clearly it was beyond our terms of reference to make any recommendations on that.

Q156 Lord O'Neill of Clackmannan: I was interested in what you said about the stoicism, almost, of the Japanese people. I was in Tokyo on the day of the tsunami and it was quite clear that nobody knew how serious it was. Nobody knew it was 9.3. They just knew that it was a big earthquake, but there was a sense of awareness that the public—there are 200 earthquakes a year in Japan. The public are trained from school age to take account of potential problems. So the first thing I would want to ask you is whether you think that we should be trying to explain to people that we are potentially vulnerable, without being accused of scaremongering?

Dr Roberts: I take your point about the Japanese and earthquakes. The point I was trying to make was that because they then decided to shut their nuclear stations down and had a shortfall of electricity generation, and because they communicated that very effectively, I think they managed to cope with it quite well. From our point of view writing the report, what that pointed to was the importance of clear and sensible communication from the centre.

When we wrote our report last year and made the observations about the potential narrowness of the supply margin, we were saying in essence that certain things had to be done. That report got quite a bit of coverage in the media. I think it is a fine line between making people aware of the issues and scaremongering. For me, the most important point is

to make the public at large aware of the fact that we need to make substantial investment in our electricity infrastructure. Apart from the decarbonisation point, which I put to one side, simply put we have an infrastructure that is ageing. Many of our power stations were built in the 1960s with an economic theoretical life of 30 years, which is now well exceeded. Ditto a lot of our distribution networks were built in the 1960s, again with an economic life of 20 to 30 years. So we need to invest a lot of money in our network as a whole to make it more resilient, and we need to communicate that message to the public at large: they may not like it but electricity is going to get more expensive if you want to enjoy the level of resilience that you have enjoyed to date.

Lord O'Neill of Clackmannan: You mentioned the case of the Manhattan financial services running out of diesel. Do you think that the National Health Service, or for that matter the railway companies, are aware of the need for support generation on perhaps a potentially longer period? Do you think there is a consciousness of the threat to essential services by the providers of these services?

Dr Roberts: I cannot speak with any knowledge of the health service or some of the others. I can only speak with knowledge of the financial services sector. I think that everybody thinks that 24 hours is about enough, so to have the capacity to run for 24 hours is sufficient and within 24 hours somehow or other everything will be all right again. That I think is potentially unrealistic. When you think of how much money is at stake if the computers shut down in a large bank, we are talking billions if not trillions. Look what happened when Lehman's fell apart. There is a huge amount of trades out there. It would be chaotic. When you talk about resilience and back-up, I do not honestly believe that anybody really thinks much beyond 24 hours.

Lord O'Neill of Clackmannan: The consequences of that for investment would appear to be dire if we were in a worse position than other countries. We are obviously more vulnerable because we have a higher dependence on financial services, for example. To what extent did you pay any attention to future investment in the UK? You mentioned it en passant but you did not put any figures to it; you did not put any forecast. Could you be a bit more explicit there, please?

Dr Roberts: Sure. We spoke to a number of industrialists about resilience and security of supply. Putting it in qualitative terms, not quantitative terms, they basically said, "Whereas a few years ago we would have taken security of supply as a given and we would not even think about it, now it is an issue and it is coming up the agenda". A number of companies that we spoke to had done surveys to look at cost benefits at each of their sites to work out whether it is beneficial to incur the costs of putting in back-up supplies, because what would be the cost of an outage. My sense would be that we have had a number of natural disasters over the past few years with floods and storms and whatever, and industrial consumers are very aware of the fact that many supply chains now are very thinly stretched. Everybody works on "just in time", so they need to think very carefully about making investments to make sure that they have their own resilience. That is certainly coming up the agenda. We could not put numbers on it, unfortunately, but what was interesting to me was that if we had conducted those interviews 10 years ago, it would not have featured at all.

Q157 Lord Dixon-Smith: I always have difficulty with this sort of subject because I have always regarded the electricity industry in two ways. The actual supply is not a stream, as far as I am concerned, it is a lake, and you have to keep the level in the lake high enough. By and

large, that side of the industry works extremely well. But the interruptions come almost entirely on getting it from there to the customer, most of which are, of course, as a result of natural events about which we can do nothing, and can occur at random and very unpredictably. I did find myself wondering whether in fact one could overcome some of this difficulty by a greater use of interconnectors, which can, of course, bring in supplies from outside. However, if the problems are largely local, that would not really help very much. I wondered if you could comment about that as a possibility.

Dr Roberts: Yes, that was something we looked at in our first report that we produced a year ago. There are four gigawatts of interconnection between us, the continent and Ireland. The problem is that the electricity that runs on those interconnectors is subject to purely commercial contracts. If, for example, we had very cold weather here in the UK but equally cold, or even colder, weather in continental Europe, commercially it would make more sense to send the electricity to France than it would to keep it here. Interconnectors have their use, but only up to a point.

I take your point. In theory, since we have been part of the EU the whole of Europe we are supposed to be more interconnected, because in the long run that would be economically beneficial. However, you just get involved in kinds of national interests and so forth, and that really has not happened to the extent that it should.

Lord Dixon-Smith: That gives rise to a slight secondary question: are we right, either in the short term or the long term, in regarding ourselves as an “island”, as we historically are, in a world that is increasingly interconnected?

Dr Roberts: I think the theoretical answer, if you like, is that we should be more interconnected, because by definition that spreads the risk. But the commercial aspects of that are probably more difficult, because obviously it is very expensive to lay submarine cables to connect us to other parts of Europe.

Q158 Lord Broers: I would like to ask a general question, which is partly a social question, and to address some of these issues. Industry as a whole is sophisticated in its use of electricity. The normal consumer is not. The market has not really developed as it has in other places, for example in transport. We all remember the day when the price of an airline ticket between here and New York was a fixed item. Now we know that it changes by the minute and by the hour. The insurance industry is more sophisticated. After all, what we are talking about here is really insurance. You know when you buy a car policy that if you take a larger excess you will get a lower premium. You can insure more or less just your windshield, or not. All of this could happen in the electricity market. The individual consumer could decide that they would be perfectly willing to accept outages at certain times of day. They would be quite willing to accept a long-term outage, prepare themselves for that, and balance that off against a reduction in cost.

I notice in the States now that a lot of my perhaps more wealthy friends have put huge gensets in their houses. I know lots and lots of people who have now done that because they are not going to have a large outage and they can balance it. It costs them \$25,000 to put that thing in. They will put it in because they just do not want to be left for weeks, as they have recently. Did you look at the potential for a dynamic market like that, because it could reduce costs potentially, and it could increase resilience?

Dr Roberts: We touched on that in the report. That sophisticated time of day pricing needs smart meters. At the moment we do not have the information, and the suppliers do not have the information that would enable them to have that kind of sophisticated pricing. We mention in the report that our intention is to roll out smart meters across the country by about 2020. When everybody has a smart meter the electricity companies will have that information and they can put the pricing in place, which will give people much clearer signals about the way the price of electricity varies across the course of the day. Then they can take steps if they want to avoid high price electricity, and by extension even to the point that you suggest: that they put in their own generation as an insurance against outages.

I come back to the basic point that I made a bit earlier, though, that most people at the moment regard what they pay for electricity as more than sufficient to make sure that they get a 100% secure supply. There is an educational process that has to be gone through to get people to the point where they would be prepared to make a personal investment in some sort of standby supply. Certainly, having smart meters and more information means that in turn you can communicate with the individual consumer and explain to them what the cost of the usage is and how best they can manage their actual consumption to get the lowest overall cost of electricity.

Lord Broers: Are you concerned that those smart meters will in fact be able to do those things? Are we going to get an overall standard that is satisfactory?

Dr Roberts: The meters per se will not be able to do that. What I think we will have available to us is a volume of information that presently is not available. In part, from a computing point of view, it will be a systems integration exercise to put the systems in place in the electricity companies that enable them to analyse the data and to have the sophisticated pricing that you alluded to, for example with iPhones now and so forth, compared to how we used to be with black Bakelite telephones, where the pricing was absolutely uniform. Now it is a lot more sophisticated. I think we will move to that position. That will be for the supply companies. As far as the distribution companies are concerned, the ones that own the network, I think that will be a bit further behind, because at the moment our pricing is universal. It is sort of postage-stamp pricing. Every customer pays the same for the distribution business.

Lord Winston: I wonder whether anybody had made a national inventory of the emergency power that is available for places like hospitals and other organisations, and whether or not that might be a good thing.

Dr Roberts: It would be a good thing. Nobody has done it. It is starting to happen. There are commercial organisations out there now that are in contact with large organisations. For example, some of the big supermarkets all have back-up generation in their stores. Aggregating all of that, they can sell that to the electricity generators as an amount of back-up generation that could be available, and that can be sold to the generators as an economic proposition: "You pay us the money and we can bring this back-up generation into play". It is beginning to happen on a commercial basis. But some kind of index or database right across the UK of the back-up generation to my mind does not exist, and it would be a very useful thing if it did.

Lord Winston: Would it be worth this Committee suggesting that?

Dr Roberts: I think it would be a sensible suggestion, yes.

Lord Winston: Okay.

Dr Roberts: I think that the responsibility should lie with the electricity distributors or with National Grid, or both, maybe with Ofgem overseeing it. It is the kind of information that we simply do not have. If there is one message that comes out of our report, it is that we just do not have the information about any of these issues that we should have.

The Chairman: Thank you. That is helpful.

Q159 Baroness Sharp of Guildford: I am thinking about last weekend's failure of NATS. One can see the chaos that can result from a computer failure if they do not have the standby generating capacity. Obviously they have standby, and as you were saying even the supermarkets have it. Last week we heard about what was happening in the American market and the PMJ Group, which has, as you were suggesting, this smarter system. Are we not developing that smarter system through the capacity market? Is this not precisely what we are trying to do by the introduction of these new market systems into the electricity market?

Dr Roberts: It is one of a number of measures. I think what was deficient before with the economics of the electricity system was that it never rewarded capacity. It assumed that generators could earn enough money simply by generating electricity and selling it to reward the investment. But recognising the fact now that we have more and more renewables, particularly wind power, which is intermittent by its very nature, there was nothing in the economics of the system to reward generators for owning generation and just having it available for the days when the wind did not blow. That is one of the measures that is moving in the right direction. Smart metering will be another one.

Baroness Sharp of Guildford: The two come together, really.

Dr Roberts: It all needs to come together. Sometime out there, maybe five or ten years down the line, we will have a far more sophisticated, information-driven system. We will have what people conventionally refer to as "smart grids", although what exactly constitutes a smart grid is open to debate. We certainly need to move from a system that is essentially passive at the moment, where electricity generating just flows, to one that is actively managed. That is a big transformation. I think back to the point that I was making earlier about the need to invest in a more modern, resilient system. That is going to be a significant amount of money, and that will have an impact on the price of electricity in the short run.

Q160 Lord Broers: I congratulate you on the report. It is a very comprehensive compilation of everything that one could put one's hands on. At the same time, it leads to a series of questions, and these are my questions. Are current methods for quantifying the cost of electricity outages, particularly the value of lost load, fit for purpose? Is value of lost load still a good indicator, and how does it compare to the alternatives? How uncertain are VoLL figures? To what extent can uncertainties be reduced? Finally, what are the risks of basing policy decisions on VoLL, for example decisions about capacity procured through the capacity market?

Dr Roberts: A number of questions. I will try to give you a broad answer, and then, if I have not done enough, perhaps you can tell me. Value of lost load is the conventional measure of trying to put some kind of economic value around interruption of the supply, and as the report says there are two basic ways to do it. You ask people, "How much would you pay to

keep your electricity supply on?”, or alternatively, “If your electricity supply was disconnected, how much would you require by way of compensation?”. You get two slightly different answers.

I think the problem in this country is that the vast majority of people have not experienced a long-term supply interruption. When you ask them what value they would put on it, it is a very subjective answer that is in no way grounded in experience but is purely subjective. As we have been discussing in the course of this morning, the actual economic and social impact of electricity outages varies hugely with time and frequency. Just asking somebody, “If your electricity was off for an hour, what would it cost you?”, is, I think, not a hugely revealing question.

There are other ways to approach this, particularly, as we say in the report, through revealed values, which you get by looking at such situations that we have talked about. There was the Japanese experience. There was the Californian experience in 2000 when they had extensive blackouts. That cost the Californian economy \$40 billion, as well as a ratings downgrade. If you look at real events and do the analysis post-event, you get a far better understanding of the economic impact, which is perhaps slightly different from the individual customer's perception of what they think it is worth. It is a way of thinking about the cost of the loss of load.

I think we need to do a lot more research. Very little research has been done in this country, as our report points out. There has been one Ofgem inspired piece of research, which was done by London Economics in 2013. That is the only piece that we could find in this country. The rest of it has been done elsewhere in western Europe. We do need to do more research: a combination of trying to establish what the cost would be for individual consumers, small businesses and large businesses, but also looking at what has happened in the real world—at the significant events that have happened elsewhere, both in Europe and in other parts of the world, and after the event to get a hard database of evidence.

The capacity mechanism that is taking place today will go some way to give us another answer, although I think the answer that it is going to reveal is more about the cost of building generation rather than the cost of not having electricity. But it is all part of the overall economic case, if you like, for investing more in generation to increase the supply margins. I hope that has answered your question.

Lord Broers: Yes, I think it has. I suppose what you are saying is that there is nothing wrong with the concept of value of lost load. It is a matter of whether you have the right value for it in the right circumstance. We have heard from some economists like David Newbery that this is all being overpriced.

Dr Roberts: The numbers that you get out of it are an order of magnitude different from the actual cost of electricity if you buy it, and I think that is to do with perception and the point I was making: that most people have never really experienced a significant loss of supply, so they just try to imagine what they think it would be worth to them. Value of lost load is often presented as a single point number, but it is actually a range of numbers and a range of values. When somebody does system planning and looks at the economics of investing more in energy security, they need to have that range in mind and not really think necessarily of a single point number, because that could be slightly misleading.

Q161 Viscount Ridley: You have made the point very eloquently that we are much more dependent on electricity than we were in the days of the three-day week, and that we would suffer a lot more if we lost it. Is there a risk that government policy going forward in two ways makes this problem even worse? On the one hand, it commits us to intermittent sources of electricity that are much more dependent on the weather, so it increases the risk of problems, and on the other hand it commits us to moving heating and transport on to electric. In the future, when I wake up to find that the lights have been off all night and I need to charge my phone, I cannot even get in my car and drive it because it is an electric car. Is that a problem? Is the electrification of transport going to make our dependence higher and our resilience lower?

Dr Roberts: I think your question exemplifies what is known as the “trilemma”, which is that there are three key issues here. One is security of supply, one is green supply, and one is price. The reality is that you can have one or two, but not all three, and it is all a trade-off. We are committed by law in this country to reducing the amount of carbon in our economy as a whole by 80% by 2050, which implies the sort of things that you have just been talking about. If we want to have a decarbonised electricity infrastructure, the choice, certainly if you get towards 2050 and the 80% target, is that you use hydrocarbons either for heating or for transport, but not for both. That then implies you have to have electric transport and that you need to invest more by way of security, particularly given that, as you rightly point out, as we decarbonise we will introduce more and more intermittency into the system. What then follows is that the third point, which is the economics of supply and having cheap energy, does not exist anymore. That is an expensive solution, and that, I think, is outside of my realm. That is a policy solution for politicians, not for a simple engineer like me.

Lord Rees of Ludlow: Just going back to the value of lost loads criterion, would you agree that that probably underestimates what people are really prepared to pay, first because of the reasons that Lord Ridley suggested, but also because if people are asked what happens if we lose electricity, they think of losing it in their house? They do not realise that they will have a personal loss if it cuts the transport, the deliveries to supermarkets, and all those things. For the individual, surely the downside is far greater than just losing it in their residence. They probably do not think of that when they answer your question.

Dr Roberts: I think it is fairly debateable. It is very much down to perception. An interesting study was done in Munich a few years ago that followed on from a big outage in the city of Munich. They found that before and after, people's view of the value of lost load went down because they found that it was not as bad as they had thought it was. However, there have been other studies in different situations, for example in Norway, where exactly the opposite happened: it was a lot worse than people expected.

What I draw from that is that it is highly individual, highly perceptual. Yes, I take your point. I think most people would think about not being able to watch “Coronation Street”, but they would not think about the ATM and their mobile phone not working. That brings me back to the point that the interconnectedness of our entire society makes some of these value of lost load estimates highly suspect. I think the real answer is a lot bigger.

Q162 Lord Patel: My question mostly concerns our understanding of the economic and social impacts of the interruptions to electricity supply. The last three questions touched on some of it, but my key ones are these. How good is our understanding of the social and psychological impact of interruptions? To what extent is it possible to learn from other

sectors, such as transport? Lord Ridley covered some of this. How will the changes in the electricity system, such as the electrification of heating and transport, affect the impact of disruption? And are there any international comparisons that we can learn from?

Dr Roberts: The first thing I would say is that our report tried to deal with the hard engineering and, to the extent we could, the hard economics of loss of supply. We did not feel able or qualified to talk about the social impacts. Trying to draw comparisons from loss of other essential services in the UK, such as transport, is not particularly representative. Just to come back to the previous question, I think I could live without the Tube, or buses, or a train more easily than I could live without electricity, because of the things we discussed about the interconnectedness.

Your point about international comparisons is well made. We looked at six examples in the recent past of losses of electricity on a substantial scale in what you might loosely call first-world economies. What is clear from that is that the effects are substantial. The economic impacts are much bigger than one would expect. We did not look at the social side of it, and we found that there has not really been an enormous amount of analysis of those events after the fact. What people tend to look at is why it happened. What was the engineering explanation, rather than what were the economic and social consequences?

The best study that we looked at was California in 2000, which is mentioned in the report, when they had a very hot summer, everybody turned up the air-conditioning, and for a variety of reasons to do with the regulation of electricity and the environmental protection laws in California, they just did not have enough generation and the whole system collapsed. It took them several months to get it straight. That cost the Californian economy \$40 billion, and that impacted on only one and a half million people. The Californian State took a ratings downgrade.

Now, if you think of the impact of that on the cost of funding and what in turn that would mean for the voters in California, it is quite significant. We need more of that sort of analysis and information from those kinds of international comparisons to formulate a better view for ourselves. We do not have it at the moment.

Q163 Lord Hennessy of Nympsfield: Do you have in your head, Dr Roberts, your own personal version of catastrophe theory, of the very worst that could happen to our beloved islands in terms of electricity supply and the knock-on?

Dr Roberts: Honestly, no. Having lived through the three-day week and been part of it, if you like being involved in it, I think it is common place to observe that in fact the GDP of the country improved because everybody really pulled together. To be honest with you, the closest I can get to that is thinking about what it is like just to have a normal outage that maybe lasts for a few hours, and how utterly inconvenient and awful it is.

The one thing that we have not touched on, and the one thing that we found in our report, was that there was only one incidence of social unrest following a major outage, and that was in Brooklyn in 1970. The analysis that we looked at assumed that it was more a reflection of underlying social issues rather than the loss of electricity. My belief would be that even in the worst case scenario we would find a way back within a few days—fairly quickly. Beyond that it is verging almost on the unthinkable.

Lord Hennessy of Nympsfield: The studies about the three-day week that were done in Whitehall are, I think, declassified now. If I remember rightly, another couple of weeks and

we would have been in real trouble. We were getting to the rim of all sorts of knock-on effects, and so the jollity—the “put out more flags” feeling—would have dissipated, as you said earlier.

Dr Roberts: It could have done, yes. On the social unrest aspect, if you talk about worst nightmares it would be the fact that the police force and so forth, the powers that be that would keep law and order themselves, would be severely disabled by the lack of power. Then I think it could be an horrendous scenario.

Lord Willis of Knaresborough: Chairman, may I just follow on from that? Having said that, do you feel, therefore, that the 4% margin is insufficient?

Dr Roberts: I think Lord Hennessey was posing a slightly different question.

Lord Willis of Knaresborough: Under his doomsday scenario, every nuclear power station goes out, it is the coldest day of winter that has ever been, and it follows on from floods. We have an awful lot of things, and Nigel Farage is Prime Minister.

Dr Roberts: And Liverpool has been relegated. To try to put that point into context, I go back to the report of last year and the point that at 4% you are really skating on thin ice.

Lord Willis of Knaresborough: Right.

Dr Roberts: There is not the resilience in the system. Terms like “you could get away with it” are a bit emotive, but I think we are at a point where there is not that much resilience in the network, in the system, to shock events—the kind of thing we have talked about. They would be one-off events, but the longer 4% persists the greater the likelihood that something would happen that cause severe disruption. Therefore, we need to invest and move away from 4%, but it will be at a cost. That, again, to go over ground that we have already covered, is a question of the political will to do it and the acceptance by the public at large that it is worth paying that price. I am not sure that we are there at the moment.

Lord Willis of Knaresborough: We have only had one witness, Dieter Helm, who has argued of a greater margin. Somewhere between 15% and 20% were the figures he gave. Is he in the right ballpark?

Dr Roberts: I know Dieter very well and I respect his opinions. I think 15% to 20% is probably on the high side, and it very much depends on how that is expressed. In the past, we have talked about a 20% margin, but it very much turns on how much reliability of supply you attribute to renewables. Take wind, for example. You can take an average value of how much the existing renewable wind power would contribute over the course of a year and factor that into your calculation, but if you take the stress scenario that we were talking about before—zero—you need a bigger margin. So certainly something more towards 10% would, in my view—and I am not an expert on these things—be closer to the mark.

Lord Willis of Knaresborough: Right.

Lord Broers: He argued that in the end that would cost less than the 4%, so there would not be the penalty to pay for it.

Dr Roberts: I respect his view. I have not heard his arguments in detail, so I am afraid I cannot comment.

Lord O'Neill of Clackmannan: He also made a point about what 10% or 20% really meant, because we have had other evidence that showed that two was actually six under the old reckoning. We really need to get a clearer expression of the numbers for this.

Dr Roberts: In time. This is where, as I say, I would need to know precisely what Dieter is attributing to wind power and so forth, and to intermittency, when he talks about 15% to 20%,.

The Chairman: I think we have to be careful not to misquote him. I think I remember him saying, "Something north of 10%"—something like that.

Dr Roberts: I would go along with that.

Q164 Lord Rees of Ludlow: Going back to the distribution system, you used to be concerned about the substations around London and things like that. Are you confident that those vulnerabilities have been reduced?

Dr Roberts: Vulnerabilities of the substations around London in what sense?

Lord Rees of Ludlow: In that if they failed we would be slow to replace them. This was, I understand, one of the big concerns that people had in the past. I am just concerned generally about whether the distribution network is sufficiently robust and could be repaired sufficiently quickly.

Dr Roberts: In general terms, London has a very robust electricity network because it is all underground. I think there are some potential problems in that a number of substations are in the basement of buildings, which can cause logistical difficulties as well as economic difficulties. But, to be honest, I do not know enough in detail about the London electricity distribution business to be able to comment. You would have to ask them the question.

Q165 Baroness Sharp of Guildford: There are two issues that I would like to raise with you. In terms of mitigating the potential social and economic impacts of interruption for electricity supplies—you have talked about the potential domino effects of breakdown and so forth in the scenarios that we have just been talking about—are the public sufficiently aware of the dangers? We learnt last week about Denmark and its Energinet, which runs the system in Denmark. We do not have anything like that now; we are relying on the market to do it for us and Ofgem says that it does not have any directional capacity on this. Is sufficient attention being paid both to the supply and to the demand side measures to mitigate this? Secondly, when picking up again this distribution issue, do you think that Ofgem and the distribution companies are sufficiently aware of the dangers of a possible breakdown here?

Dr Roberts: To answer your first question, I do not think that the public at large have the faintest idea of the importance and potential vulnerability of the electricity system. They certainly have no sense of the amount of money that needs to be invested in it. I will go back to what I have said before: that most people believe that they pay too much for electricity anyway, but then everybody always believes that about electricity everywhere in the world; there is nothing new about that. They also believe that they are paying for 100% availability and that they should not pay any more.

On the second point, from the distribution companies' point of view they are very well aware of the importance of maintaining the integrity of supplies. In fact, they are incentivised by Ofgem to do that both in terms of the frequency of interruptions and the

duration, and there is a symmetrical system of penalty and incentive. Certainly from my experience, both Ofgem and National Grid, in their relative responsibilities at looking at the overall integrity of the system, are very aware of the importance of what they are doing and how it needs to be addressed. Certainly, the consequence of a reduction in the supply margin is something that everybody is very alert to, and they are taking the measures that they need to take to maintain security of supply without investing excessive amounts of money.

It is a balance that has to be measured, and NGC in my experience is very professional at doing that. However, it is not widely recognised in society as a whole. Again, to repeat myself, that is one of the big challenges, both for the industry and for the political control of it: how we educate the public at large that we do have to invest significant amounts of money. Forget decarbonisation, which we all want; we just have to make sure that we still have a resilient network from now to the end of, say, this century.

Baroness Sharp of Guildford: Yes, and yet then there is also a fundamental irony in the fact that if we want the public at large to save electricity we need to have a high price for it.

Dr Roberts: Indeed, and they do not like that.

Q166 Baroness Hilton of Eggardon: On a rather different issue, you were talking about the need for better management of the systems. The Institution of Engineering and Technology has suggested that there should be a systems architect to increase integration in the system. I wondered what your feeling was about that.

Dr Roberts: I can see the point. I would say that at the moment we already have Ofgem, we have National Grid, which have nationwide responsibilities. To me it is more an institutional thing. Who would this body be? To whom would they be responsible? Do they override Ofgem? Do they override National Grid? Are they purely advisory? I can see the point perhaps in principle, but the practicalities would be very difficult to work through.

Lord Dixon-Smith: If we are looking forward and being pessimistic and we get a major national outage in, for example, 20 years' time, by which time we are all on smart meters, it seems to me that theoretically it would be possible to manage everybody's individual supply externally. I doubt whether it would be socially acceptable, but it could be done to spread the load. If that were to happen, do you think it would be acceptable, because increasingly we shall move that way?

Dr Roberts: We shall certainly move that way. If everybody had a smart meter, technically it would be possible to switch their supply off remotely from a central point. Whether or not that would be socially acceptable would be difficult to say, as so much would depend on the circumstances. It might be socially acceptable if you could demonstrate to people that maybe—as we had in 1974, although it was not done in anything like the same way—being offered three hours a day was better than having nothing at all and that was how you managed the system. If you could achieve that acceptance, then technically it would be possible. But—and it is a huge but—given that in 1974 people were not that reliant on electricity anyway, whereas 20 years from now we will be absolutely and totally reliant on electricity, the likelihood of it being socially acceptable is very remote, frankly.

The Chairman: Dr Roberts, we have detained you for rather longer than we had intended or probably you had intended. Thank you very much indeed for a very helpful session. You have given us a lot to think about, and, indeed, one or two very concrete suggestions, which I am

sure that we will follow up. Indeed, we have an opportunity for further questions with Ofgem and the Secretary of State, and some of your evidence will help to inform some of their discussion, I am sure. When we started I said that we would be concentrating on your second report. In practice we have covered both reports and very fully. Thank you very much for a very full session.

Dr Roberts: Thank you, it was my pleasure.