



Energy and Climate Change Committee

Oral evidence: [Oral evidence: Low Carbon Network Infrastructure, HC 613](#)

Tuesday 12 January 2016

Ordered by the House of Commons to be published on 12 January 2016.

[Watch the meeting](#)

Members present: Mr Angus Brendan MacNeil (Chair), Tom Blenkinsop, Glyn Davies, James Heapey, Matthew Pennycook, Dr Daniel Poulter, Antoinette Sandbach, Julian Sturdy

Questions 31-110

Witnesses: **Dr Jill Cainey**, Director, Electricity Storage Network, **Dr Philipp Grünewald**, Research Fellow, Environmental Change Institute, Oxford University, **Dr Gordon Edge**, Director, Policy, RenewableUK, **Stephen Goldspink**, Director, Strategy and Business Development, Siemens Energy Management, and **Sara Bell**, Chief Executive, Tempus Energy, gave evidence.

Q31 Chair: Good morning, would the witnesses state their name and occupation for the record?

Dr Edge: My name is Dr Gordon Edge. I am director of policy at RenewableUK.

Dr Cainey: My name is Dr Jill Cainey. I am director of the Electricity Storage Network.

Dr Grünewald: My name is Phil Grünewald. I am deputy director of energy research at Oxford University. I am an EPSRC fellow and I am here on behalf of the Institution of Civil Engineers.

Sara Bell: Sara Bell, CEO Tempus Energy.

Stephen Goldspink: Steve Goldspink, director of strategy and business development from Siemens.

Q32 Chair: Thank you very much. It is a real pleasure to have somebody here from the Institution of Civil Engineers, given that was the degree I studied once upon a time. It's good

to see you. We are here to consider the future of energy networks in the UK. Today we are looking specifically at intermittent generation and technologies to deal with intermittency. Using as little jargon as possible—always a difficult one—what does it mean to say that a generator is intermittent, so that we establish exactly what that is?

Dr Edge: Perhaps I could answer that. We do not like the use of the word “intermittent”, which I think is an inaccurate term. Renewable generators such as wind and solar are variable: they vary with the availability of the resource, but they are also forecastable, whereas intermittency implies one or zero and a random move between the two.

You can predict when wind is coming. National Grid has a target of forecasting 94% accuracy 24 hours ahead for wind power, and has been achieving that. Similarly, with solar, you know pretty much when it is going to be there; the exact level depends on cloud cover and so forth, and the forecasting of that is improving. It is inaccurate to refer to it as intermittent. We need to think about the exact characteristics of the resources and in the timescales managing the system they are forecastable to a heavy extent.

Q33 Chair: Now that I have learned the lesson on intermittency versus variability, how much more significant do you think variable generation will become in the UK?

Dr Edge: Last year, 11% of our electricity was generated by wind power and a handful percentage from solar, which was larger than the amount from hydro last year. Wind power will seek to double roughly its contribution by 2020. If you look to 2030, the scenarios published by the Committee on Climate Change have 45% to 55% of our entire electricity mix from renewables, of which 35% to 45% will be from the variable renewables of wind and solar, so we can see it is going to be a very large part of our electricity mix going forward.

Dr Grünewald: Variability is nothing new in an energy system. We have got something that is variable and to some degree forecastable, which is demand, and the system has dealt with that extremely well, so we know how to handle something that is variable and reasonably forecastable. What is new is that we are losing flexibility because the variable loads are displacing what has produced all our flexibility up until now, which is thermal power stations. It is that loss of flexibility that brings about the challenges.

Stephen Goldspink: Just to add to that, when you combine wind and solar, those are very large quantities of renewables. We also need to consider sources of decentralised energy, which could play a significant part in low-carbon networks.

Q34 Chair: Do you think that the forecasting of renewable generation can be improved? How will that help to manage that variability that we are aware of?

Dr Edge: As I have said, it is already very good and it can only get better. Certainly, when it comes to what we know, which is wind generation, my members have a very strong interest in knowing exactly how much they are going to be producing as far ahead as they can, in order to trade that power down at the highest cost they can get.

There is a very strong driver for forecasting techniques to improve. That needs to devolve to the National Grid to help them improve further. They are doing quite well but we think we

can always do a bit better. As I said, the error is only a few percentage points in the 24-hour ahead timeframe.

Q35 Chair: Given where I am from in the Outer Hebrides, I tend to keep my eye on the wind a lot because it means a lot for my travel backwards and forwards from the islands. I would like to know what your members make of the accuracy of forecasts. Could you get up to a range of a week? How accurate are they finding forecasting? Is it there any detail on that? Do they have any reports afterwards?

Dr Edge: People tend to focus on the timescales that make the most difference to their economic value, which is 24 hours and under. A week ahead the accuracy falls off because weather is different.

Q36 Chair: How accurate are they finding the 24-hour window?

Dr Edge: As I said, National Grid is targeting 94% accuracy for 24 hours ahead, and we think we can do better.

Q37 Chair: Witnesses to our investor confidence inquiry claimed that solar energy could act as a baseload power if supported by storage. We heard that the whole concept and discussion around baseload is very outdated. What does this panel make of the term “baseload power”—is it outdated and does it need to be updated?

Stephen Goldspink: We have come from a very mature energy structure in the UK and baseload is essentially very predictable, mature technology: it is coal-fired power stations and nuclear power stations. These power stations have planned outages on an annual basis, so you know with a very high degree of predictability that this is going to be available at all times. We are seeing the demise of coal-fired power plants, so what people traditionally refer to as baseload is starting to decrease and be replaced by more variable sources of renewable energy.

Q38 Chair: Do you think the Government is in step with this new understanding?

Stephen Goldspink: I believe so.

Q39 Chair: To what extent will electricity demand in future exhibit greater peaks and troughs due to the electrification of heat and transport? What changes will that make in demand?

Sara Bell: I think that depends very much on how we manage that demand. Both the demands that you have mentioned are highly flexible, so that offers an enormous opportunity to match that demand to generation, and variable generation can be matched very successfully to that flexible demand. Every electric vehicle could be charged when we have excess renewable generation. There is a way, from an economic standpoint, of managing that sensibly.

Stephen Goldspink: I agree to a degree, but I think we have to be really careful when we consider electrification of heat, because statistics from National Grid, the gas transmission operator, indicate that if we were to completely convert to electrified heat it would be the

equivalent of 300 GW. Our current peak load is round about 60 GW for electricity, so we are talking about an electricity infrastructure five times that which we already have. That is not to say that we should not be looking at electrifying heat. We can use surplus energy to convert to heat. We can heat water, for example, in boilers; but I think it has to be tempered in terms of full conversion.

Q40 Chair: And that 300 GW would be at peak demand, so you would have a lot of redundant infrastructure at other times.

Stephen Goldspink: You would have, yes.

Sara Bell: That depends on the thermal capacity of the building you are heating. The more you have thermal storage within the building, the more you can flatten that peak. We should not underestimate the innovation that is coming. We are now starting to commercialise phase change material that is a source of heating and cooling that has absolutely nothing to do with grid infrastructure. What we must not do is assume that we know all the answers for how technology is going to develop in future; because if we go down that route we will have a very expensive system.

Q41 Chair: Thank you. Jill Cainey, did you want to come in as well?

Dr Cainey: I was just going to reiterate that the additional thermal storage—hot water tanks or other thermal stores—help you manage that peak. You do not have to have it all happening. You don't have to have that demand all at once.

Dr Edge: I just want to reiterate that all of this, to my mind—I did not like the word “intermittent” and I do not like the word “baseload” either. It is becoming a really useless term in going from the paradigm where we have been, which is fully dispatchable generation and uncontrollable demand, to a period where you have some uncontrollable generation and a lot of controllable demand at the same time. You can do the electrification of heat transport badly and make your problems worse, or you can do it well and integrate the fact that you have got variable generation with the controllability of the demand, and do it well; but you need to have a whole-system view of this, or you may get it wrong.

Dr Grünewald: I would back that. Depending on how we electrify heating or how we develop heating in future, the estimates we have on additional peak demand are between 40 GW and 60 GW, so depending on how we do it we can reduce the impacts. The worst thing is to do everything with heat pumps, but if you combine different technologies—for example, if you had some heat-led CHP, which produces power at exactly the times when heat is needed—you can mitigate those effects. It is a question of having an intelligent mix of technologies.

Q42 Matthew Pennycook: I want to follow up on that. The decarbonisation of heat and transport is vital to our renewables targets. Dr Edge, you said we could do it badly or we could do it well. What is doing it well, would be my question; and what is your sense of whether the Government have a joined-up strategic approach on this? We have asked the Secretary of State at various points what co-ordination there is between her Department and the DFT and DCLG on this agenda, and we get very vague responses. I think it is probably—

you know, mid-level/senior civil servants have had had a cup of coffee occasionally. Do you get any sense that the Government are thinking about how we do this well in the next couple of decades?

Sara Bell: The challenge with the energy system is always that we have taken a very siloed approach. Even within DECC, generation sits in one department, demand sits in another, transmission networks in another, and so on. There are very few people with the expertise to look across the whole area, so naturally the optimisation between all of them is not done. For example, when we brought in the feed-in tariff for solar we did not ensure that there was the right incentive to use the solar power on the premises, so distribution networks had to start installing voltage regulation technology. If we had had a joined-up policy, the whole policy could have been implemented more cost-effectively.

Only when you look across the whole system do you get the most cost-effective approach, and customers need the most cost-effective approach. It is not just across Government Departments, it is across the energy sector through DECC. There needs to be more expertise developed that can view the whole thing so that you can get this co-ordinated policy making.

Dr Grünewald: I strongly support that. One of the things that brought the ICE and the University of Oxford together on the report that forms the basis of our submission was the need to have system thinkers. If a system is in steady state it is good to have experts on individual technologies and to try to tease the efficiency out of one technology. That will usually help the system, but we are not dealing with a system in steady state. It is undergoing a fundamental transition, and when a system undergoes such a transition what you need are system thinkers who understand how the components fit together.

If I may use storage as an example, in isolation you would want storage to be as efficient as possible. What we found when we looked at it in a whole systems context was that efficiency is a nice thing to have but it is not crucial. Just by putting something into the system that has a finite efficiency does not mean that you reduce the system efficiency. In fact, what we find is that the system becomes more efficient even though you put something in that has a finite efficiency, which is counter-intuitive at first, but if you think of it as a whole system it starts to make a lot of sense.

Electric vehicles could play a very interesting role in helping to balance the system, because they have inbuilt storage, but another debate is ongoing on the extent to which you want to use that type of storage for the grid. We might come back to that.

Dr Cainey: On electric vehicles, it is more that the charging is the critical thing that you need to control, not necessarily using the battery device for the system services. National Grid has a project in which it has looked at that—at providing frequency response.

We should not get hung up on electrification being the same as decarbonisation. They are not the same. You could have solar or thermal heating hot water. That gives you heating. It does not have to all suddenly appear on the electricity system and come off the gas system. There are so many innovative and novel ways that UK business is looking at this. It does not all have to be electricity.

Q43 Matthew Pennycook: That was a very interesting contribution. I am slightly at risk of going off at a tangent, but while you are here I want to ask: where would this system thinker sit? Presumably it is not the expert in Whitehall who is sitting there giving an overview. In layman's terms, where would they sit? Who would they be? From what organisation?

Chair: The Institution of Civil Engineers.

Dr Grünewald: We see our role as training them, and we are happy to train them into any position in Government, in the Department of Energy and Climate Change. We are very happy to support the development of these system thinkers. It is a somewhat new category. The research councils are starting to realise that what we need is not just disciplinary experts but people who appreciate the context.

Chair: I did not mean to prejudice the answer at all, so if anyone else has a contribution—

Sara Bell: A very strong economic basis needs to underpin that system thinking. The energy system still underpins our economic prosperity, so everything we do—all the changes we make to our energy system—needs to be viewed through the lens of the economics of our businesses and our individuals. That is where I would site it.

Stephen Goldspink: Institutions such as the IET have already voiced the opinion that we need this sort of overarching system architect. I tend to agree with fellow panel members that that would really support the development of a better energy system in the UK, but I think it is also important to recognise that we currently have a national system operator. At some point in the not-too-distant future, we probably need to look at decentralising that system operation. Everything that we are talking about today hinges on how we decentralise the energy system and empower consumers to utilise energy in a much more efficient way.

Q44 Julian Sturdy: I want to pick up on something you touched on earlier, Stephen, about baseload and intermittent supply. I understand the point about not liking those terms, but sticking with them at this point, obviously we are moving away from baseload to more intermittent supply, as you correctly said. What is the percentage gap at the moment from baseload to intermittent supply?

Stephen Goldspink: I have to be honest and say I do not actually know that figure.

Q45 Julian Sturdy: Okay. Do you know what the movement is at the moment from baseload to intermittent supply? Do you have an idea?

Stephen Goldspink: No.

Q46 Julian Sturdy: Okay. What I am trying to get at is that you talk about the technologies and how we can bridge that gap, but I want to understand whether the move from baseload to intermittent supply is going more quickly than our advancement in technology.

Stephen Goldspink: We have gone from circa 80 GW of base-load capacity in the not-too-distant past, made up of nuclear, closed-cycle gas turbines and coal-fired power stations, with a small portion of renewables. We have now got to the point where—how much renewable capacity do we have in the UK?

Dr Edge: I don't know in capacity terms, but I know that the percentage last year was 23% electricity from renewables.

Stephen Goldspink: So we are seeing the mix starting to increase. I think we gave a figure earlier of what we expect it to be in 2030.

Dr Edge: Yes, about half of our electricity is from renewables, including some from the likes of biomass and other technologies, which are more dispatchable and have different characteristics. This debate throws up the reason why “baseload” is not a very useful term. Each of the technologies being talked about as baseload has very different characteristics. Nuclear is very large and inflexible, and you do not turn it up and down, because it is highly capital-intensive. CCGT gas plants can be very flexible, and will respond to changes in the generation of variable renewables. What do you want in a system where you have a large amount of variable renewables? You need flexibility. Having big lumpy plant which cannot do very much can give you as much of a problem as if you had a whole load of variability.

Q47 Julian Sturdy: I understand the point about base-load probably not being the right term, but I am trying to understand whether the move to more intermittent technology and energy sources is going faster than our technology to store and reuse. If that is the case, will it cause us problems further down the line with energy usage? That is what I am trying to get to the bottom of.

Dr Grünewald: The Energy Research Partnership produced a graph that probably answers that question quite well. They graphed flexible generation versus variable loads, and they included in that electrified heating and transport as a potential solution for flexibility. The point of that graph was to show that, in the mid-2020s, we would reach a low point of flexibility on the journey toward decarbonisation.

Q48 Julian Sturdy: Right. So that is a danger point—is that what you are saying?

Dr Grünewald: That is potentially when we would be short of flexible sources on the system.

Julian Sturdy: Okay. That is what I was trying to get at.

Sara Bell: At the same time, we have not even started the process of making the demand side flexible. Tempus Energy is the only electricity supplier that unlocks flexibility in customer premises. We go to our customers and we put control and sensor technology into their premises so that we can move their demand. Every time—and I mean every time—we go into customer premises, they are using electricity at times in a very expensive way, completely unnecessarily, because no supplier has ever rewarded them for their flexibility before, so why should they bother?

As soon as we go in and start looking at what a company is doing—we deal mainly with companies, because they have the most flexibility, and it makes sense to go for the most flexible customers first—there is always load that can be shifted. We are one small new supplier. If the whole market operated like this, we would unlock a great deal of flexibility, which would reduce the total system cost.

Q49 Julian Sturdy: I completely understand that. What I am trying to get at is the move from a more flexible energy supply, but also the problem with the technology. There is going to be a danger point where they cross—that is what I am trying to get at. We are saying that danger point is 2020.

Dr Cainey: I think there are some issues with capacity now. That is why we have the capacity market. I guess Electricity Storage Network would argue that that incentivises particular types of technology for security of supply but doesn't necessarily support the new innovative approaches such as demand side and electricity storage because of the way that market has been designed.

We are already in a system where we are having difficulties. We are managing that at the moment, with the capacity market and various reserve tools the National Grid has, but this winter we are likely to see notices of insufficient supply margins—NISMs—in order to bring on some of those reserve services. That will cause much excitement in the media, but that is just how we manage the system; it is a completely normal approach, but we haven't seen them for a while and that is only going to continue.

We are already at the edges of that situation, and it is critical that we find a path to manage effectively going forward. There are technologies and approaches, such as demand side response and aggregation—aggregators are providing demand side response as well. We need to facilitate those approaches to move forward. That is a market approach.

Dr Edge: I would argue that some of the time-limiting steps are not technology but the regulatory market approaches. We need to be thinking about how we make the market so that these things, when they are economic, just happen automatically. At the moment, there are too many barriers.

Chair: Thank you. Stephen Goldspink, before we move on.

Stephen Goldspink: Just to back up what the panel members just said: we have to be careful when we make assumptions that we will hit critical points in the future, because those assumptions are generally made on the fact that the technology that is already available will not be deployed. Technology and solutions are already available, as my colleagues has already said, so it is about how fast we deploy those technologies and the regulatory barriers that need to be removed to deploy them. Energy storage, demand side management, energy efficiency—all these things can support this capacity margin issue and put us on the journey to low-carbon networks much quicker.

Chair: Thank you. I understand what you are saying about regulatory barriers, but we will leave that section there.

Q50 Glyn Davies: I want to ask a few questions about energy storage. We read so often that this is the real game changer that makes renewables so much more part of the future. There is a whole lot of different technologies. I remember going to see Dinorwig once. It was absolutely brilliant—I couldn't believe such a thing had happened—and it was such a long time ago. Can you tell us something about the different technologies and how their impact might differ?

Dr Cainey: I will provide additional written evidence after this session, because it is very technical and very complicated, but I will try to give you a brief overview now.

There are many types of storage for many different types of application. Typically, you have a speed of response, which is how fast your storage device can respond; how much the storage device contains, its capacity; and how long it can provide that capacity—its duration. For instance, already in the UK we have flywheels which are 400 MW at Cullum to support their plasma; that deploys almost instantaneously but only lasts for 30 seconds. You have mentioned Dinorwig: that takes six to 10 seconds to respond; it is 1.7 GW and it can provide that response for five hours. Those are like the two extreme ends—very quick, quite high capacity but short duration to reasonably quick, very big capacity to very long duration—and there are many technologies in between, including batteries. Again, batteries can also be short duration, large capacity, but they tend to be very quick to respond. National Grid have asked for an enhanced frequency response service that would respond in under 500 milliseconds, which is something that batteries and flywheels would be good at delivering.

We have established technologies like pumped hydro and some batteries, and we have much more novel technologies, typically around the chemistry for batteries, where we are trying to explore better energy densities, which is the amount of stuff you can pack into the size. If we could cram a Dinorwig into something the size of a watch battery, we would be there. That would be the perfect electricity storage solution, but we are not there yet—we are a long way from that.

The other thing to think about is that we have hybrid options. You can combine, say, a Dinorwig, which takes a bit longer to respond, with something that responds very quickly, and then you bring Dinorwig on the back of it to give you the duration and capacity. There is compressed air, which is bigger scale storage, like pumped hydro, but not as developed as pumped hydro. There are different types of battery, capacitors, short acting—I could go on.

Q51 Glyn Davies: We could probably allow this question to run on for the rest of the session. Can everyone chip into this part, before I move on to the more specific bits?

Dr Grünewald: In some of the work I did at Imperial College to look at the system value of storage, we took a very technology-agnostic approach and just looked at what types of storage, in the terms that Jill just explained, you would want. One of the trends is that while today some of these short storage durations are very attractive and will be for the next few years, as you go forward into a low-carbon future, it is the longer storage durations that become important. I am pleased to say that there is some real innovation in the UK in developing some of these quite novel approaches that are quite a way away from your traditional lithium-ion battery and have the potential to reach much lower costs than I would foresee us reaching with lithium-ion batteries.

Dr Cainey: There is liquid air energy storage, which is basically where you compress air to make liquid nitrogen, store it as liquid nitrogen and then give it some heat, and it expands through a turbine to make electricity. That is very scalable and is probably more likely to be on industrial sites. DECC have funded a project on waste heat.

Q52 Chair: What is the efficiency of each one of these?

Dr Cainey: They all have different efficiencies, but typically you are looking at around 70% to 90%, depending on the technology.

Q53 Chair: Which is the most efficient and the least efficient?

Dr Grünewald: If I could comment on that, the focus on efficiency tends to come from looking at storage in isolation. What we found through the system modelling is that you can get technologies with modest efficiencies that add real value to the overall system: they make the system operation cheaper and actually improve the efficiency. This might be counter-intuitive, but if you think of having surplus renewables on the system that would have to be curtailed or where you even have to pay to manage them, you are suddenly in a very different system environment where being able to absorb that—even with a somewhat limited efficiency of storage capacity—still helps the overall system.

Sara Bell: You cannot view this in isolation; you have to view it through an economic lens. What is the most economically rational thing to do? Is it throwing away renewable generation that can be stored in a battery at a lower efficiency? No, it's not. It is going to be economically better to put in a lower efficiency battery that can take more generation. It's about looking economically at how we can best manage our system to make it as cost-effective as possible.

Chair: Thank you. I am glad we had that question. It elicited some more pointed answers.

Q54 Glyn Davies: To follow up on pumped hydroelectric storage, is there much of a future for that? We know about the impact that Dinorwig, in particular, has had. It is a very understandable form of storage—we need to engage with the whole population, and that is very understandable. Is there much of a future for that, or are we running out of capacity?

Dr Cainey: There is potential for more pumped hydro storage in the UK. The problem is that it is very expensive up front. It has a very long investment timeframe, so you have to secure your income over a very long period; you have to get your investors to put up a large sum of money up front and then wait for a long time for it to be paid back. That is before you come into the planning risk—there are environmental issues, and securing planning is one of the biggest risks.

We have Quarry Battery, which is a small, innovative company in the UK that is using ex-quarries with a difference in head. They could have a 150 MW facility, but they are sticking to below 100 MW purely on the generation licence criteria, which set an artificial limit on how things operate in our system—we have these different requirements dependent on size. There were or are a number of conversions of existing hydro-generation plants to pumped hydro. I have struggled to find out whether any of these have gone ahead, so potentially there is up to, let's say, 1.5 GW through conversion or new plants, but a recent project has been shelved—it wasn't even recent; it was shelved several years ago. That is the risk. There is potential, but there is investment risk and planning risk to get through.

Stephen Goldspink: I agree. I just feel that in the UK we won't see anything like Dinorwig built again. There are geographical restrictions, and if we did need that sort of grid-scale energy storage, which we may well need in future, more economic technologies are emerging. They are probably at a less mature technology readiness level, but projects are

under way at the moment looking at compressed air energy storage that could give large, grid-scale capacity with existing geographical infrastructure. There are limitations there.

Dr Edge: Water is a good storage medium. It is possible to do some of that through tidal lagoon-type technology, or other barrier technologies, where you can hold some back and use it as a storage medium, which can help to improve the economics of those technologies. There is a general point about storage and the various different types of storage. All the ones that people generally talk about, their applicability is much more as a system benefit for managing the system effectively and more economically. If renewables didn't exist, they would still make sense. The fact that wind and solar are there makes it more urgent to bring forward some of these solutions, but we need to bear in mind that the concept of storage being a big bucket to take surplus wind and solar from when it is sunny and windy for when it is dark and still actually isn't the main point. You will need technologies like power-to-gas where you create artificial hydrogen and, potentially, synthetic methane, which can be stored in very large quantities. That is the kind of technology you would need for that purpose, whereas integrating large amounts of variable renewables into a grid so that you can deal with ramping issues, system inertia and all the rest of it is where these technologies that we are generally talking about come in.

Dr Grünewald: If we look back to the time when Dinorwig was planned, which was a very different environment in the early 1970s, it is very interesting to look at how the business case was made back then. The expectation was that we would be building one nuclear power station every year. That is what Dinorwig was originally built for—it is very good at stepping in when a nuclear power station drops out. That future did not materialise; nevertheless, it shows the versatility of storage and provides a very valuable service to the system. The business case at the time was very much made on the overall system benefit, and today I understand from ScottishPower, who are looking at more pumped hydro, that it is very difficult for them to make the business case. We will come to regulatory barriers and limitations in the market for storage, on which we have some recommendations.

Q55 Glyn Davies: If I could move on to battery storage, I am probably as guilty as anyone: when I think of battery storage, from what I have read, I think of lithium-ion and that's it. Is it fair to say that that is the leader in terms of battery storage, or are new types of battery storage coming through that may eventually have a bigger impact?

Dr Caine: Lithium-ion has received a lot of attention, largely because the costs are coming down because manufacturers are competing with each other to drive the costs down. That is where the focus is at the moment. Many of the large-scale battery projects that are being delivered in the UK and elsewhere are based on lithium-ion, but there are sodium-sulphur and nickel batteries. The humble old lead acid battery is well understood and established and has been used in a number of projects in the UK. There are also flow batteries, which are a completely different type of battery. Having a cell separates the capacity because you keep your electrolyte in big tanks, so you can build bigger and bigger tanks and then you push your electrolyte through the battery and it works the same way as a normal battery. The other potential advantage of a flow battery is that, as well as charging like a normal battery, you can just put in fresh electrolyte. There are companies in the UK working on flow batteries.

Dr Grünewald: The lithium-ion battery is well known and very popular because we all have it in our mobile phones and it is probably the battery of choice for electric vehicles, but if I were to liken storage to a vehicle, the lithium-ion battery is probably like a Porsche, and what we need for grid service is a bit like delivering gravel, and what we are proposing to do with lithium-ion batteries would be like delivering gravel with a Porsche, whereas in fact we need lorries. Porsches are great at delivering gravel very quickly, but maybe not in the quantities that we desire.

Q56 Glyn Davies: You have listed a few different types of battery technology. I hesitate to ask a question that will inevitably lead to a huge answer because it is so varied, but what are the advantages and disadvantages of them? You have covered that a bit, but are there any advantages or disadvantages that might help us?

Dr Caine: One of the advantages is that they can respond very rapidly.

Q57 Glyn Davies: The different ones? Are each of the different types of battery different?

Dr Caine: They all have different properties. Indeed, you can get the same chemistry but have a slightly cheaper version that will degrade faster and will not last that long. I am talking about lifetime.

Q58 Chair: If lithium-ion is the Porsche, which is the lorry?

Dr Grünewald: Pumped hydro acts a bit like a lorry.

Dr Caine: In terms of batteries, you would probably be looking at flow batteries but they are not as well established as standard chemical batteries. For instance, sodium-sulphur is a less responsive and much harder working battery—it has a much bigger capacity and therefore can do a longer duration. As we all know with our mobile phones and tablets, it is the duration that is often the problem with a battery. It is fully charged and then eventually it is not and you have to go and charge it up, and the question is how do you manage that? I can provide further evidence afterwards because there are so many different technologies.

Q59 Glyn Davies: Can you just talk about the Leighton Buzzard development? That is pretty big. How big can storage developments become? Will that have to be repeated on a much larger scale?

Dr Caine: There are much bigger battery installations globally. Leighton Buzzard is a relatively small establishment—I think they say three tennis courts, to go into those kinds of definitions. Two of the tennis courts are occupied by batteries and the other tennis court is the ancillary equipment that you need for cooling the heat in the battery management system—but there are battery systems that are hundreds of megawatts. The problem is the energy density, because they occupy a big footprint so you need a bit of space. That is why energy density is so important. Obviously, if you can make it smaller—battery developers are looking at improving the energy density to have the same capacity in a smaller sized battery.

Q60 Glyn Davies: You have covered quite a lot of the issue and the crossover to the grid. That is probably what we will do for the meeting. What about the environmental impact of the different energy technologies? Is there a distinction? Is there a real difference?

Dr Caine: Obviously batteries contain resources, often rare earth metals that have to be mined. That is an environmental impact, but I don't think we are restricted on any of those resources at the moment. There is end-of-life: certainly with lithium and lead acid, there is a well established recycling process. Then, while you operate your battery—if you have flow batteries, they have big tanks of acidified electrolyte; if you had a leak, that might not be good. Batteries are inherently safe. We hear a lot about phones catching fire, but those cases are the exception. All technologies have some type of risk, but batteries are not especially risky. I do not know whether that helps.

Stephen Goldspink: If I could just add to that, once you consider what we want to use storage for, which is the economic utilisation of renewable energy sources, there is a positive environmental impact from using storage technologies.

Glyn Davies: I was looking at the variation in terms of the different types of storage technology, that's all. Do some have less of an environmental impact than others and do some have more? Anyway, we have covered that.

Q61 Dr Poulter: I have two quick follow-up questions that may or may not be mutually exclusive. If you were to pick a technology or a couple of technologies that could be rolled out with some scale and pace in the storage sector, what would you choose?

Sara Bell: If I was doing it—obviously we are focused on customers—we would be siting those batteries in customer premises, so it would depend very much on the requirements and the economic case for that battery. For example, Tempus Energy is currently involved in a project in Cornwall called the Sunshine Tariff. Basically, the distribution network down there is having more and more problems with more and more solar generation on people's rooftops and the voltage regulation issues. The project is about encouraging customers to use as much of that energy on site as possible. There is a role for batteries. We are putting 10 Powerwalls—the Tesla domestic battery—into customer premises down there. That is an appropriate technology for that project. The economics—

Q62 Dr Poulter: So it is batteries. I want to get plenty of views, because it is a fairly simple question. I like your scheme, but I want to get a few other views in.

Dr Grünewald: I was trying not to answer that question, because I do not think it is for us or the Government to choose which technologies we should install. The challenge is to find the right market environment and to avoid barriers so that the market can decide on the right technology to deploy.

Q63 Dr Poulter: But if you were to say which of the technologies was right at the moment and was in the best place to be taken forward at scale and pace in various sectors, what would you say? That is the question.

Dr Grünewald: To that I would say that lithium-ion is in a very good place at the moment. It is rather impressive how Tesla is managing to sell the Powerwall. At current

prices the fact that it sells is interesting in itself, because it is not necessarily a commercial proposition; people do it for motivations other than just making money. It is attractive to have some independence. There is that relationship that we have with our utilities that is not always very friendly. There are all these things that factor into this, and the fact that the Powerwall is selling so well is quite an interesting sign in itself. In the longer term, however, we need to develop those technologies with longer storage duration.

Q64 Dr Poulter: My second question, which I was going to come to, probes that very issue.

Dr Caaney: It depends on what service you want. For the National Grid enhanced frequency response service, you need a fast-responding device. That is likely to be a battery, and at the moment lithium-ion is king, because warranties are available, manufacturers are supporting it and costs are coming down. If you want longer term storage that is perhaps not so rapid in response, you might be looking at liquid air and other types of batteries. I should say that we are talking a lot about the Tesla Powerwall, but there are UK manufacturers and companies in the same space that just do not have the same marketing budget. I could name UK companies that are working in this space. In the home, it will be a mixture of lithium-ion and potentially lead acid, or lead acid gel, which is slightly safer.

Q65 Dr Poulter: My final question picks up on the earlier point. I did not wish to cut you off abruptly, Sara Bell, but you were answering my second question first. This may be linked to the answer to the first question or it may be different, but if you were looking at the UK energy sector and the UK energy market and the practicalities of delivering solutions there—I come back to you, Sara, because you were giving an example—what are the longer term solutions that it would be appropriate for us to pursue, irrespective of the current market position of lithium batteries?

Sara Bell: I don't believe that any Government should be making those decisions. In the life that we are now leading, none of us, no matter how technology-focused we are, has any insight into the phenomenal technology change that is going to happen in six, 12 or 18 months. The less we start picking winners, the more successful we will be.

I just want to come back to Philipp's comment. Tempus wouldn't put a single technology into a single customer premise unless it were commercial. If you look at the particular environment in Cornwall, an arbitrage is possible between the low cost of using the distribution network and the high cost at peak. You charge your battery during the low cost and make sure the customer uses the electricity during the high cost. You are therefore not using the distribution network and are therefore pushing down the cost of our distribution networks.

If you want to cost-optimize a customer from a supplier's point of view, there is the electricity wholesale cost, the distribution network cost, the transmission network cost and the cost of balancing the system. For all four, the storage unit can be used to ensure that the electricity is acquired for the customer as cost-effectively as possible, and then you can sell it to them at as low a price as possible. That is fundamentally what our business model is. It is possible to make those technologies commercial by optimising the whole value chain.

Dr Grünewald: Maybe I should clarify, just to avoid the impression that there is disagreement, that what Sara said is exactly right. My comment referred to private

individuals buying power walls who haven't got access to the different value streams that Sara's business can bring together. That is the important thing. You need to bring value streams together to make storage work.

Dr Caine: I represent electricity storage, so I am going to digress into heat storage. You are asking about the things we can be doing now. There are 14 million system boilers with hot water tanks in the UK. Those hot water tanks with immersion heaters represent a huge source of flexibility, yet we tend to be ripping those system boilers out and replacing them with a different type of boiler. Additionally, there are electric hot water tanks and households with just electricity heating with immersion heaters. Again, that is another significant source of system flexibility that we could look at now. There could be a tariff, or a smart widget, to put that excess generation into hot water tanks and then store it as hot water. Remember that 80% of domestic households' energy expenditure goes on hot water, either for hot water itself or for heating. Although it is interesting to look at electricity storage, there is a significant resource already out there that we could be accessing.

Chair: Thank you.

Q66 Antoinette Sandbach: So effectively there is existing distributive capacity that isn't being utilised and could be. What is stopping that? Is it just the regulatory barrier?

Dr Caine: No, using things behind the meter is perfectly okay now. It is the structures. It is the willingness of someone to take on the business opportunity. When you are working at the domestic scale, you are looking at very small loads. You have to aggregate a lot of very small loads to make something that the system operator would be interested in, and that is complicated and expensive. But we have Economy 7, so you have tariff structures and innovative suppliers, such as Tempus, offering innovative approaches and securing that flexibility service from behind the meter.

I would say that there is no regulatory barrier to that; it is more a market, commercial barrier. There is the sense that we have moved to a system that functions at the bottom, yet we are still dominated by a centralised transmission system operator, settlement process, etc. We really need to look at empowering distribution network operators to become system operators so we can access all this good stuff that is local, rather than central. If you are doing it locally, you are avoiding those transmission line losses, which are 10%. We essentially have five large-scale power stations chugging away so we can waste it on our wires as it goes down to the bottom. Working at the bottom does create that sustainable, efficient, low-cost system, but we don't yet have the structures to do that.

Chair: Thank you. We're going to have to move on.

Q67 Tom Blenkinsop: Many of the questions that I was going to start off with have actually been asked. One suggestion relating to the points that you have been making might be to look at the homes of individual customers. The assumption now is about home ownership, but I grew up in rented accommodation and that needs to be taken into account.

How do you think that the costs of storage compare with building more generation?

Dr Grünewald: I can refer to some of the modelling that we did at Imperial College, where the approach was to take a low-carbon energy system and then add storage for free and see how the costs compare and then take that saving as the potential value of storage. What we found across a range of scenarios, whether with high CCS, high nuclear or high renewables, was that storage reduced the cost of the overall system across the board, so it had value. It is important to recognise that that was across the board. Our challenge now is to ensure that we tap into that value and allow that to happen by making sure that we have the right market signals and that we avoid regulatory barriers.

Q68 Tom Blenkinsop: What would it take to get a price at which storage becomes financially viable and would persuade mainstream opinion?

Dr Caine: I guess it depends at what scale and what may be viable for behind the meter. There has been a lot of work on behind the meter. If you have solar on your roof and you're getting a feed-in tariff and a little bit for export, then if you can maximise your self-consumption, you can probably pay for that battery in three to five years. If there was a time-of-use tariff, under which it was more expensive for you to buy electricity in the evening, the pay-back period would shorten. That is kind of like the domestic position and is probably viable now, particularly if you have solar.

When you look at the larger scale devices that we would expect to be providing system support, the incredible interest in the national grid frequency response call has suggested that that is viable now. The complications are around connections and regulation: who can own and operate a storage device. There is sufficient value in providing system services, even just that one system service at the moment, to get a project to fly. If the markets and the commercial arrangements were set up in a more supportive manner so that you could provide services to the distribution network and the transmission network and provide multiple services, instead of just putting all your eggs in one service basket, it would be much easier commercially to secure a project.

Dr Grünewald: You asked about the cost. The situation is shifting in such a way that the peaking plants that you are comparing them with will have a tougher and tougher environment in which to operate, because renewables are frighteningly cheap on a dispatch basis. They can always feed into the system, so they undercut other plants, which then have lower load factors and fewer hours in the year in which to operate and their business model becomes tougher and tougher. That is why, even if the cost of storage did not go down, storage would become more and more viable and a better and better alternative to building peaking capacity.

Maybe at this point I should raise the recommendations that the ICE has put together to help storage in this environment. It has identified three things. One is a straightforward regulatory barrier in that we're charging every larger load or generator for the balancing services that the national grid has to provide, which is a billion pounds a year. Storage has to pay that twice, because storage charges and discharges. It is double-penalised by the balancing charges, so we are suggesting that that should be addressed as a simple way of sending a signal that storage is seen as a solution for the future.

The second one, which has already come up, is one of simple classification. There is a historical hangover with classifying storage as generation. If you take a systems perspective,

that is just plain wrong, because it does so many other things. In a sense, it acts as demand when it is charging and generation when it discharges. In between, it actually fulfils a network function. What the networks do in space—they are delivering electricity from where we have plenty to where it is needed—storage does exactly that function in time. It takes the electricity from when we have plenty to when we need it. We are suggesting that the classification of storage needs to be addressed so that the licences can be held by people like DNOs, who currently are not able to own storage because it is classified as generation, and you are not supposed to be a DNO and a generator.

Chair: We will cover more on regulation later.

Dr Grünewald: The last point is on markets. We talked about giving a market signal, and the ICE is suggesting a percentage premium feed-in tariff, which would be a very simple signal that, basically, rather than feeding your renewables into the system as and when, whether they are needed or not, it is more valuable to feed renewables into the system at certain times. So if you collocate storage with renewables, you suddenly gain the ability to earn a higher premium. Obviously, overall in the system, that should not be an additional cost, because we are shifting the electricity to when it is valuable. That would be a small percentage premium on times when the wholesale price is high to encourage people, through storage, to make sure that renewables get into the system when it is valuable.

Q69 Tom Blenkinsop: The one advantage that large generators potentially have over renewables is peak generation. Some of the written submissions to the inquiry have claimed that thermal storage is significantly cheaper than power storage. What is your view?

Dr Grünewald: Electricity is a lot more valuable than heat, is my short answer to that. But I would not dismiss that point at all. I think heat storage is very important. We have talked about the peak increase of heating, potentially, on the electricity system. Thermal storage can help with that tremendously, and I completely agree that it is much cheaper, so it should be looked at in the context of the different solutions. You should not say that we need electricity storage or heat storage; you definitely need both heat storage where heat is needed and electricity where you need electricity, which is such a valuable vector.

Stephen Goldspink: Heat is a valuable source of energy, and there is a lot of waste heat around the UK. Siemens are currently conducting a trial project in the city of Manchester where we are hooking up three CHP plants, which would typically run individually and may be sub-optimised. Rather than run them individually, we run them in a joined-up, connected way and ensure that you get maximum efficiency out of them, but also use the heat to drive a very small—at the moment, it is very small—district heating scheme. This is real, feasible technology that can be deployed today.

Q70 Tom Blenkinsop: It has been noted that storage systems have different potential value streams, such as selling balancing services to the system operator or smoothing renewable generation. Which of these is most promising, and what scope is there for storage systems to benefit from multiple streams?

Dr Caine: That is a tricky question. It depends who is going to buy the service and who is going to pay the money. At the moment, the value sits in providing system services to National Grid, in particular their new enhanced frequency response service, where they value

the speed of response. There have been various projects looking at—indeed, the Leighton Buzzard project looks at this—constraint management. That battery’s primary purpose is to manage evening winter peak load, and the battery is used outside that to provide system services, so it has multiple income streams. There is unlikely to be a single income stream at the moment that would fully finance a storage project, so you have to access multiple income streams.

The problem with partnering with renewable energy, which we see as a good approach, is that there are barriers to that. You cannot, for instance, secure a CFD as a site; you can only secure it as renewable generation, and storage is not eligible for a CFD. In trying to create that efficient system, there are difficulties in the market. There are many services that electricity storage can provide, and they can be provided at the same time. It can provide more than one service at any one time, such as reactive power. There are services it can provide to suppliers. In the UK, we have put up our imbalance costs to help with balancing the system, but the only tool that a supplier currently has, or that the normal supplier has, is market-based. You have got demand response, but you could also use storage, and there are regulatory issues in using storage unless it is behind the meter. There are many services; no one single income stream will make it fly. You have to have multiple income streams and, at the moment, there is only one potential income stream—and that has not even happened yet—that will make a project work.

Sara Bell: We have not put up our imbalance cost. We have made our imbalance costs more cost reflective, so sometimes they are lower and sometimes they are higher. That is a very important point to specify. We have done that because a more cost-reflective imbalance cost gives the right incentives for generators and the demand side to act in a way that reduces total system cost.

A supplier like Tempus, to answer your question, uses all the value streams, so the more you can layer together the ability to trade on the wholesale market and the ability to reduce the costs of the distribution network and the transmission network as well as the balancing services, the more you create a commercial proposition that makes storage fly.

Q71 Matthew Pennycook: May I dig a bit deeper into the governance and regulatory framework around storage? You have all touched on the regulatory barriers and, having looked at the evidence, given the help that storage is bringing to balancing the system, it is odd that there are barriers and penalties in place. Rather than ask you what they are, can you give us an idea of why they existed in the first place, what the rationale was and why that has moved on? Why are there charges? Why is—or was—it classed as generation?

Dr Caine: It was just an accident of history. When we split our system up, we classified generation, supply, transmission and distribution as distinct activities under the 1989 Act. We did not classify storage as a distinct activity and the legacy storage that we had at that time, which was our pumped hydro systems, were classified as generation and not as storage. Therefore, as an accident of history, storage tends to be classified as generation. If you are another regulated entity in a highly regulated industry, for instance, a distribution licence holder, you cannot operate generation as a supplier. That makes it very difficult. You have to get over that issue—this is just an accident of history.

We have since had interconnectors. They were initially unlicensed and an unspecified activity. Subsequently, they have been licensed and added to the suite of things that we do in our electricity network. We would see electricity storage as being one of those things. I would also say that Ofgem is looking at the position of aggregators who also operate in our market and do so unlicensed. One could argue that they are successful because they are unregulated—they have that room to move and be innovative—but, again, Ofgem is exploring whether that needs to be regulated. It is just an accident, and it is not a very helpful accident.

Q72 Matthew Pennycook: Given that it is an accident and we know that storage has a huge part to play, why are we only talking about removing barriers to regulation now? Has it been looked at before and stuff has been dismissed?

Dr Caine: I have been sitting on DECC and Ofgem's Smart Grid Forum for the last three years. They reported in October.

I guess that there has been a lot of movement in the last 12 months. We did not have anyone in DECC or Ofgem responsible for storage. We had an office for nuclear and an office for solar, but nothing for storage. We now have two individuals at DECC and two individuals at Ofgem specifically looking at electricity storage.

Q73 Matthew Pennycook: So there was no DECC official responsible for storage in the whole of the last Parliament.

Dr Caine: No, apart from the innovation team. The DECC innovation team had someone who looked at storage in terms of providing innovation support, but there was no other person as part of the innovation suite. I would like to say that that team has done a good job of looking after storage, but it was not really ever its remit to do so. There is a great deal of interest now and it is a very active and fast moving area.

Dr Grünewald: I agree with that. We probably have been a bit late to the game, but the take-up over recent years has been quite impressive. Ofgem has just published its report on flexibility, which covers storage. I am very pleased to say that the National Infrastructure Commission is looking at storage as part of its call for evidence, and DECC will consult on storage in spring. The direction of travel is very promising. As Jill said, large technical systems such as the energy system evolve over time, and we are left with regulation, infrastructures and capital from the system that served us through the past.

Q74 Matthew Pennycook: You have teed up my next question perfectly. You have touched on the three recommendations that the ICE had given. This consultation has begun, and we heard a couple of weeks ago from Andrea Leadsom that they want to remove barriers. From each of you, what would be your key asks? If they are the same as the three we have heard already then there is no need to go over them, but is there anything we have missed?

Dr Edge: I would follow up on what Jill said about the ability to bid for a contract. The difference, on the basis of a hybrid technology, is that at the moment we can only say that an operation is a wind farm or a solar farm, and solar is completely left off, whereas we should have an interest in supplying the least cost, low-carbon electricity, and if that is a

single connection with a wind farm and a solar farm and some storage, that is great. At the moment that is excluded. That is one thing that you could quite easily do in order to promote the use of storage behind the generation meter, and promote the system benefits.

Dr Cairney: One very quick win is that the way we fund our low-carbon incentives at the moment is based on an end user. As another accident, storage was not defined as not being an end user. If you try to operate storage at the moment, you get charged for the climate change levy as it goes into the device, and then when it reaches the final end user, because storage is determined as an end user when it should not be. HMRC has ruled in the case of the UK Power Networks project. It has taken a pragmatic approach and said that it should not be treated as an end user. However, for the other two incentive schemes, Ofgem has not yet agreed that storage should be an end user. That has a very material impact on the economic benefits of running the UK Power Networks battery for the supplier involved. They are quick wins: just a notice that needs to be written. We need storage to be an activity classed with a licence to clarify that position.

Q75 Matthew Pennycook: May I turn briefly to distribution network operators? What would be the advantages and disadvantages, if any, of licencing the DNOs to own and operate storage?

Dr Grünewald: The distribution network is one of the most costly parts of the network. When we looked at the potential value that the system gains from storage, the distribution network was a large share—operational savings and peaking plants—so it would make a lot of sense if distribution network operators could help themselves by avoiding ripping up the roads and putting the infrastructure in by intelligent use of storage. I have to say that the Low Carbon Networks Fund has gone a long way in that direction, to encourage them to try these novel approaches. With a bit of sympathy for distribution network operators, it is quite a step from installing passive networks to investing in something like storage that then needs to be operated in the right way. I think that they need to be helped in that process.

Stephen Goldspink: Our distribution network operators are still going to play an extremely vital role in the UK. I know we may see a shift—and we will see a shift—towards more behind the meter storage, but that will be a transition, so distribution networks are really, really important. What storage allows us to do is really optimise the utilisation of that existing infrastructure. Storage plays a key role in that, and at the moment there is no incentivisation for a DNO to install storage to use that for constraint management and other grid support functions, so we need to change that. Allowing DNOs to install, operate and utilise storage would be a really positive step.

Sara Bell: We need to make some quite large changes to the regulations to ensure that they fully optimise that unit. They would very quickly only use that unit for their own purposes. Distribution networks are not known for their innovative approach. In the UK, most of them have been bought by infrastructure investors. That is really about parking cash that is earning a higher rate of return than it would at a bank. They are not in it because they want to innovate or want to drive a smarter energy system, and it is incredibly important to understand that. If you site the unit with an organisation that wants to optimise the whole value chain, you will get the most economic response—and unfortunately that is not the distribution network.

Dr Cainey: UK PNs own and operate the largest battery on the system at the moment. They have done a lot of work on the regulatory approach. They would say that they would always try to seek a third party, which is exactly what Western Power Distribution has done in Somerset with the solar farm. If they did not receive any tenders or received only one expensive tender they would always like the option of doing it themselves. That is the most cost-effective way to support the system at the moment and it is very difficult for them to do.

There is a lot of discussion around the best location for storage. Yes, you can put it behind the meter, but you can also have community-scale electricity storage. A community is going to want security of supply, just like the distribution network operator, which has a very strict security of supply requirement. That partnership is not one we have explored yet. Community energy has gone very quiet in DECC, so I do not know where that has gone. Storage was not part of its remit, although it was interested in it. That partnership would still allow households in the community to park their energy in the storage, then use it later. There are so many business models that I cannot go into them here. The DNO could operate it on behalf of the community because it has the skills. It has the knowledge, and when you have larger-scale storage, it is easier to secure services with it, rather than lots of little aggregated pieces.

Stephen Goldspink: One final point is on the support of DNO utilisation of storage as the networks become more complex. We have already talked about system operation and the need for things like ancillary services such as frequency response. That will decentralise. Our distribution networks will have to provide system operation functionality as well. Storage has a role to play in that; at some point distribution networks will need to have that functionality.

Q76 Matthew Pennycook: On something you said earlier, Dr Cainey, we understand that the capacity market is under review or will be reviewed. Is there something in it, as it has been constructed, that mitigates against the case for bringing storage forward?

Dr Cainey: Storage was not originally included. DSR and storage were placed in the transitional arrangements, which allows them to secure a one-year contract, whereas in the enduring arrangements you can secure up to 15 years as a new asset. If you are trying to build a new asset, a one-year contract is not going to help you very much. Storage could bid into the enduring mechanism, so it could go in for a 15-year contract, but it is competing against diesel gensets. There is not much that can beat a diesel genset at the moment, not even a new CCGT, so we are struggling to find the new plants that we need—or which the Secretary of State says we need—on the system.

The key problem is that the capacity market is designed for something that can clatter away indefinitely, so it is a duration issue. At some point storage is going to run out of capacity. It is a design thing: the way that the stress event is called is that you have to start delivering at T-zero and the stress event is subsequently determined. With the best will in the world, you could start to deliver, you could run out of capacity, then the stress event is in the next half-hour settlement period and you will have caused yourself a penalty. You could arrange it so that certain assets would be called on when the demand control instruction is issued, and they would then be able to release their capacity at the time it was actually needed, not just be sitting there providing capacity when it was not needed. However, that was not the approach that was taken, and as I understand it that duration and framing of a stress event is not up for discussion in the consultation.

Sara Bell: That impacts on the demand side in exactly the same way. There was some very successful lobbying around the design of the capacity market. The role, we believe, of Government is to get security of supply at the lowest cost to customers. The way we achieve that is to create a level playing field where we don't pick the winners, and where we give everyone the same contract length and let them come forward with their prices. That is not the way the capacity market was designed.

Dr Grünewald: I do not want to belittle the challenge of creating a level playing field between something like generation or a diesel genset and something that fulfils so many other functions, like storage. The trap we might fall into is that we reclassify storage as some form of generation and try to deal with it in the market that is designed for generation per se. It is a genuine challenge to create that level playing field.

Q77 Chair: Before I move on to Antoinette Sandbach, your earlier response to Glyn Davies, Doctor Cainey, made me think about the regulatory atmosphere surrounding storage in wind generation—a hangover of the desire of Government and regulators to provide generation nearer to population centres. We ended up with a situation where, where the wind resource was, people were penalised. Ofgem has changed that to show that this was not an actual cost, but a regulatory cost to stimulate and to drive generation nearer to centres of population, which meant that wind in peripheral areas was not exploited as well as it could be. However, you said something about battery storage needing to be a certain size because of the difficulties in obtaining space. There are places in the UK where there is a lot more space and where land might not be as expensive. Is battery storage similar to wind? Is it subject to locational challenges in terms of connections with the grid if it is located, let's say, in rural Wales or the highlands of Scotland, as opposed to, say, the centre of London?

Dr Cainey: Is that to do with transmission—

Chair: Yes, transmission costs.

Dr Cainey: I guess that the advantage of storage is that you want it to help support the network. I would not want it to be subject to the same sort of costs.

Dr Edge: There is an interesting regulatory question about how you class storage. Yes, the transmission costs are high for generation in Scotland. If you wanted to connect to large demand, you would be paid. If you class storage as a demand, these things are very complementary, and the economics can work really well—you reduce the specific cost of the transmission to the south because you are using it more effectively. If it is generation, you use the same capacity, and you are charged the same costs. What is storage in this situation? You want it to be a demand which then generates when this other generation isn't working.

Dr Cainey: This is the complication that we have at the moment. If you try to connect a storage device to a distribution network, your demand side—your charging side—sits under the demand connection methodology and the demand charging methodology. However, a few metres away, you have to connect your device as a generator, and that is subject to the generation connection methodology and the generation charging methodology, so for one single asset, you have to have two approaches. That is just as hard for the DNO, who has to take two approaches when assessing that connection. That ties into the whole piece about whether storage is demand and generation, or is it storage, and I would argue that it is

storage. Yes, it looks like demand sometimes and it looks like generation sometimes, but it is a specific activity.

Chair: That is a useful distinction to make. My question was whether land price would determine the type of storage that you might have, but you have come up with an even better distinction than I could have imagined I would get as an answer.

Q78 Antoinette Sandbach: I am going to move on to the demand-side response, but before I do, I have a question. Dr Cainey, you spoke about the complexity of addressing storage at household level. How can the Government and the regulator deal with that, because we have a real problem in rural areas? Rural poverty exists in about 21% of the households there. Gas is not an option, and they cannot access cheaper pricing, for lots of reasons. Connection costs for small-scale renewables are very high. How can the Government and the regulator incentivise that household level?

Dr Cainey: Of energy storage?

Antoinette Sandbach: Yes.

Dr Cainey: Communities have a big role to play in that. In terms of accessing behind-the-meter storage, if you have hot water tanks, that should always be your first port of call. If you are able to access excess electricity as a service to heat your water, you get paid for providing that flexibility, because you are then not using other energy sources to heat it. You are being paid to support the system. It seems to me that that is a very easy thing to do. In terms of electricity storage, it only really works at the moment if you have generation. If you haven't got generation, then it is probably not something that you want to do, but with hot water storage, yes.

Q79 Antoinette Sandbach: Moving on to demand-side response, clearly there are a number of demand-side response technologies available, but how effectively are they currently being managed on the network? I appreciate that your evidence to the Bill addresses that to a large extent, but the others may have views as well.

Sara Bell: In terms of the technology that goes into customer premises for real demand response—in other words, turning down and turning up the load—it does not vary massively. Some of it is slightly cheaper because parts have come from countries where manufacturing costs are lower, but in terms of the sensor and control technology, it is very similar.

It really comes down to the commercial opportunity. Where best should demand flexibility be used? Distribution networks have been quite reluctant to use demand response, despite the low-carbon network fund innovation projects. Very few of those projects have become business as usual, and we have to judge their success by their uptake as business as usual. That comes to an industry led by engineers who are very reluctant to take price risks, because an infrastructure investment business model is not about taking price risks. Ofgem has perhaps been a little slow to understand that investors' reasons for going into asset ownership will drive how they behave.

We now have an incentive framework where if you have a fast-track business plan, you can potentially get 70% back on everything you save. Let us say that UK Power Networks says, “We think we’re going to need to spend £10 million in London,” but only spends £2 million. If its business plan is fast-tracked, it gets to keep £7 million as pure profit. If you gave that incentive framework to an innovation company, it would be extracting every last penny out of it, but the distribution networks are not taking that full opportunity, because that is ultimately not the kind of company they are. They are about delivering electricity safely and ensuring that there is enough capacity—lots of things that have enabled us to run a very safe system—and it is quite challenging to ask them to be innovators. When we ask them to use a lot of demand response, we are asking them to be innovators.

Stephen Goldspink: It is fair to say that the distribution networks are quite mature in their thinking, and that has resulted in extremely secure distribution networks, but it is also fair to say that they have been making real efforts to innovate. There have been lots of low-carbon network funding projects—Siemens has been looking after and been involved in a good number of those—looking at things like time of use tariffs, demand response and better utilisation of the networks.

However, we should not underestimate the behavioural challenge around demand response. You are asking a domestic consumer basically to allow somebody to control their infrastructure.

Q80 Antoinette Sandbach: I will come back to that.

Stephen Goldspink: You also have to have a pull on the distribution networks to really get some momentum. I believe that the low-carbon network funding process has driven some really good learning, but at the moment it is like case studies sitting on a shelf waiting to be deployed. Some of it could be deployed now and commercialised quite successfully, and I believe that some of it will be, but other parts of that learning need the pull from the demand side to make it happen.

Dr Caine: I would say that DNOs are doing the best job they can, given their licence conditions. If there is ever a security of supply issue, they are brought before the House to be questioned, so security of supply is key to them. That is their main focus, because that is what they have to deliver, so they are more interested in engaging in demand response with industrial and commercial customers because the loads are bigger and it is easier to secure. Trying to engage 20,000 customers on a low-voltage feeder to secure 1 MW of response is a much harder ask than going to two or three industrial and commercial customers and securing the same service. It is not just distribution network operators that struggle to engage demand response providers; the National Grid does too.

The other thing I want to say is that DNOs do not have an energy function. They are a network operator, not a system operator. Until you empower them to have an energy function—in other words, to manage their system, just like National Grid manages the national grid—it is hard for them to go out and secure services. It is that transition from just looking after wires and transformers and making sure they all connect up to actually managing their network and the energy flows around that network.

Dr Edge: I would back all that up. The challenge is turning all that great learning from the low-carbon network funding and all the rest into business as usual. It requires a leap from the DNO to the DSO, and it will be very interesting to see how Ofgem gets on with that and prioritises it as part of its flexibility project and how it actually plays out. It put off the whole thing in the first RIIO regulation period, until 2023, and suddenly it is having to accelerate it when it only implemented RIIO-ED1 last year. In my view, that was a massive missed opportunity to get ahead of the game with this. Ofgem completely squandered that opportunity, in my view.

Q81 Antoinette Sandbach: You are quite critical of Ofgem, then?

Dr Grünewald: Of the four options that we are evaluating for flexibilities—flexible generation, building interconnects; and we have discussed storage—demand response is probably the least well understood. We are hoping that there is huge potential, but we do not actually know. Jill referred to the difficulty of engaging 20 million households to participate in this market. At the moment, we do not even know what these households are actually doing with the electricity during peak demand events. This is why I am leading this five-year EPSRC study to actually find out.

Q82 Antoinette Sandbach: But won't the information from smart meters help with that?

Dr Grünewald: To a point. Smart meters help us to get some resolution as to who is using how much, but, as Stephen said, we are also talking about a behavioural challenge here, and for that it is not enough just to know how many kilowatts somebody is using; it would actually matter what they are doing with those kilowatts. Is it essential that this be done at this point in time, or is it a shiftable load? We are working at the moment to understand what households do at different times in the day and what signals they respond to in order to become flexible. There is the neo-classical approach—that we just set a price signal and they will respond—but there is also a school that says these behaviours are more complicated and deserve more scrutiny to understand what triggers flexibility on the demand side.

Q83 Antoinette Sandbach: In October, DECC decided to incorporate demand-side response into its modelling. Given the lack of understanding that you say is there, how effective will it be and how satisfied are you with that approach? Do you think it is a good thing, is it concerning, or what do you think may be missed with the DECC approach?

Dr Grünewald: I think it is important that it is there; it is an important component of the system for flexibility. What is likely to happen—without the knowledge of what actually happens—is that we tend to work with technical potential. We say that there is a washing machine and therefore it is shiftable. That is not necessarily the case from a household's perspective. It is that gap between what it is technically possible and what actually happens. That is probably one of the areas that we need to understand much better.

Q84 Antoinette Sandbach: Perhaps as a supplier that has that engagement at household level, you might be able to—

Sara Bell: Yes. We have domestic and commercial customers across both levels. We have yet to come across a single customer who has an issue with us managing their load. There are two aspects to that: whether you trust the party that is going to manage your load

and whether you are getting a fair share of the value that comes from managing that load. On both points our customers can say yes about Tempus. That is why they do not have an issue with being managed.

Q85 Antoinette Sandbach: What about the data protection issues and the vulnerable customer issues? Have you seen the evidence from Citizens Advice?

Sara Bell: Yes, definitely. There is one area where we are dealing with a fuel poverty population—eight buildings in Glasgow that have electric storage heating. We are putting in technology to manage that. We will not manage the rest of their load, only the flexible load. We are obviously complying with all the legislation. The fear of data protection is vastly overstated. Where an entity is ensuring that you get a lower electricity bill by managing your load, and that entity acts honourably and explains what it is doing, there seems to be no issue with customers agreeing.

Q86 Antoinette Sandbach: The key to that, though, is the word “honourably” and the fear that there may be entities in the market that may act dishonourably.

Sara Bell: But you cannot legislate for behaviours. You cannot legislate to make people stop acting dishonourably. You can legislate in a way that ensures that the right commercial incentives exist for being honourable. The better you treat your customers, the more they will stay with you, the more your business grows and the more they will recommend you. There is a direct commercial reason to behave honourably as a business.

Q87 Antoinette Sandbach: I understand the commercial reasons, but I am thinking about the rights of the individuals. If those protections are not in place in terms of demand-side response, how do you deal with those who are abused, potentially, by misuse of information or misuse of demand-side response, if you are saying that you cannot legislate against that behaviour?

Sara Bell: Ultimately this comes down to whether you are sharing the value with the customer from the actions you are taking. The more you have transparency of pricing and information, the more you can compare and ask, “Is the tariff I’m paying a reasonable tariff based on what the supplier has asked me to perform?”

Q88 Antoinette Sandbach: Roughly 70% of households have not switched their electricity supplier because of trust issues, mainly around the big six. How do you overcome that?

Dr Caine: You are talking about the big six—another big, centralised, distant set of organisations. If you are really looking at the future system, it will be de-centralised. It will be local. You will have local, trusted partners. You could have been involved in siting that generation and how that generation is managed. The way it is at the moment is centralised and distant. The customer is this tiny little speck at the very bottom. We want the system to be focused around that tiny speck at the bottom. That is where local and small is a much better approach.

Q89 Antoinette Sandbach: I understand that, and I know that people regularly talk about the future in terms of distributed energy systems, but it is about the journey that Julian Sturdy

was talking about between householders taking responsibility for energy use with the assistance of demand-side—

Stephen Goldspink: The starting point has to be the smart meter roll-out. When you start to educate people about their energy consumption and once you understand your energy consumption, then you are more likely to want to do something about it if you feel that it is high and that cost savings can be made. I think that kick-starts this whole behavioural change within the UK.

Dr Grünewald: And storage potentially as well. The combination of market and storage probably will give people a greater sense of ownership of their electricity and therefore may be more engagement and agency in managing electricity affairs.

Q90 Antoinette Sandbach: Coming back to my original question which is that, given that DECC is going to incorporate demand-side response into its modelling, how do you best suggest it does that to help the kind of journey we have just been talking about?

Sara Bell: The more they engage with industry players who are doing demand response, the better. A lot of the reasons why the capacity market ended up in the position it did was because DECC fundamentally did not understand what would be involved in using demand response—the unended events that Dr Jill has discussed. If you imagine a factory making widgets, if you ask them as a demand response aggregator wanting to sell the capacity market to them, “How would you feel about being flexible in order to help the total system in the UK to keep the lights on? You will be getting a payment for doing this because you are providing a service, but I can’t tell you how long it is going to go on for. It could be half an hour; it could be three days. If you don’t deliver for the period of time that the capacity market has asked you to, you will be penalised, so the revenue I have just offered you will all be taken away,” what sort of business would sign up for that? It is not a sellable proposition. If we had understood that the industry needs to produce their widgets and sell to their customers, but within certain boundaries of flexibility, it is perfectly possible to provide a service. We would end up with a much better scheme that would enable customers to come forward.

When we go to customer premises, we look at what they are doing and we use only their flexible load. In air-conditioning units, it can be turned off and on within certain parameters and still deliver the comfort that the building requires. The customer has no issue with that being managed. If suddenly we had a very hot day, they would be able to override our management of their system to deliver the comfort that they need. So the customer when doing demand flexibility is more in control because they are managing the cost of something.

Stephen Goldspink: One quick point: in Siemens we talk not just about demand response; we talk about demand-side management, which has two fundamental elements to it. One is demand response—how can you flex your demand? We also have to consider energy efficiency. Reducing your peak load in the first place is a very valuable potential within the UK as well.

Q91 Antoinette Sandbach: I think we are looking at that in a separate context, so you may want to feed in evidence to that inquiry. On the specific regulatory changes for demand-side

response, I know that Ms Bell has called for an ability to trade directly into the wholesale market. What other changes do you see?

Sara Bell: Number one, settlement of consumption against the actual customer consumption. We are the first electricity supplier to half-hourly settle all our customers. Ofgem has been desperate to bring in half-hourly settlement for many years, but it is politically very difficult to do so because the big six are not keen on the change. We are proposing as a country to bring in smart meters, create all this data, and then not use it. That is a fundamentally crazy position to be in. In order to take the value out of the system and give it to the customers, you have to settle them against their actual consumption.

My No. 1 ask would be half-hourly settlement of all customers as quickly as possible. The wholesale market is not a transparent and competitive market. As a new supplier coming in, there are limitations to growth. Because we disrupt the market we move customers' load out of expensive periods into cheaper periods. At scale, that obviously reduces the profitability of generators. Therefore the ability to buy electricity at scale becomes much more challenging because it is not traded in a transparent market. If you look at some markets in the US such as New York state, anything above 1 MW is traded or settled on an exchange, so you have complete price transparency. That would fundamentally change our electricity sector if we brought those changes in.

Q92 Antoinette Sandbach: In your evidence, you raised concerns about an inherent conflict of interests when a system operator owns the physical network infrastructure. Can you explain the advantages and disadvantages of having an independent system operator?

Sara Bell: When you are a system operator you obviously have to balance the system. You can balance the system by increasing generation or by reducing demand. If you reduce demand, you need to build out less infrastructure than if you increase generation. There is an inherent conflict in there. In the US, as soon as there was a decoupling between network ownership and system operator functions, immediately demand response started to grow. There is some very clear evidence in that.

I am not suggesting for a moment that the National Grid is not doing the right thing, but in our experience, both from a distribution network and a transmission network point of view, there is a fundamental difference between an infrastructure investor who wants to grow and grow the asset and the role of cost-effectively managing a system that should be run in a most cost-effective manner. Every time we go into customer premises, they are using demand at peak that they have absolutely no reason to. I am seeing a fraction of customers, so clearly there is a great deal of load that is being used at peak that there is no reason for.

Q93 Antoinette Sandbach: Do the other witnesses have a view on that?

Dr Grünewald: In general terms, I would agree that when an entity owns the electricity transmission network, large parts of the gas network, is responsible for capacity mechanism, whose subsidiary owns interconnectors and is the system operator, it stands to reason that there are some conflicts that ought to be addressed, because they just get bigger as we go forward.

Stephen Goldspink: I think National Grid has taken considerable steps to silo its network operation and system operation. It is a very intricate system operation and there is a lot of mature experience in there, but I would urge caution and give some real consideration to what needs to be done. That is not to say that it should not be done, but really consider it. In terms of systems operation, the clear step we have to take is decentralisation of system operation.

Chair: Thank you. I will stop the panel there and we will move to James Heappey. Time is pressing.

Q94 James Heappey: In relation to smart grids and nothing else, is it size that matters or what you do with it?

Stephen Goldspink: Do you mind if I start? Everything we have talked about today—decentralised energy systems, empowering consumers, smart-meter roll-outs—is absolutely dependent on moving our distribution networks from being very passive to being very active, and being able to operate in real time.

We have to understand that our distribution networks in its truest sense are largely blind to the distribution network operators. We do not have automation right through the networks, we do not have sensors that can detect faults and give very rapid indication of where those faults are. We do not have the communications infrastructure right the way through the network, which enables things like demand response right across the distribution networks. So that automation, that monitoring, that real-time communications across the networks are just the fundamentals of smart grids.

Dr Grünewald: Scale matters. It was very interesting that we picked up on things that could be done at the community scale. If you look at the spikiness of profiles, if you like, just aggregating them across a few households already gives you some diversification of those profiles. Doing things at a slightly larger scale in that sense makes a lot of sense. Obviously, and this is the second point, what you do with it greatly matters. I completely agree with Stephen that, at the moment, what we do on the distribution networks is not smart yet. There is a lot that we can do to use the resources effectively.

Q95 James Heappey: Dr Edge, in your evidence you have been a bit greedy and gone for both. You said that, in the short to medium term, it is all about growing size, and in the longer term it is all about going smart. Can you expand on what those timescales mean to you?

Dr Edge: What I was getting at is the distinction. There are really good renewable resources far away, but there are some renewable resources that are close, too. The ones that are further away tend to be commercially more viable. There is very large wind resource in Scotland that is far away, for instance. You just need to get wires to the resource in order to exploit it. That is the near term. We are doing it, to a large extent. For instance, the “western bootstrap” is under construction right now, and it is going to help bring that power down from Scotland. We have technology that is still developing and the regulatory issues that I referred to as being a more time-limiting step, which is why the smartness will end up coming a bit later simply because it is going to take that time to translate all the knowledge that we have into its being business as usual. It is definitely not an either/or, and the delivery of it is simply because we recognised earlier that we need more wires and started delivering

them. The realisation that we need more smartness has come later, and we are delivering it later.

Q96 James Heappey: When the Committee went to National Grid's control centre in Wokingham, it was very interesting to hear from them how they didn't know how much was being generated by solar and how much was being consumed by solar. One presumes that, when storage comes to be available, they won't know, given the current system set-up, how much is in storage and how much is being used for storage at any one time. Should our priority be getting to a place where National Grid has a clear and immediate understanding of what energy is being produced, held or consumed at any one time?

Dr Cainey: The choice is whether we give National Grid total control down to behind the meter, that is control of the system from the top to the very bottom—National Grid would be quite keen on that approach—or whether we have the grid supply point, which is where the national grid links in to the distribution network. If you empower the distribution network and distribution service operators to balance their system up to that point, it should make it much easier for National Grid to balance down to that point. It is not necessary for National Grid to know exactly where everything is on the network at all times, particularly if you give that function to the people who operate the bottom end of the system.

Q97 James Heappey: Would you have that same reservation if the network operation part of National Grid was separated off and was entirely independent?

Dr Cainey: No. We have 14 distribution network operators in the UK, which supplies system diversity. Each area is subtly different and operated in a subtly different way. That provides resilience. I am old enough to remember the 1987 storm and what that did to the south-east of England, how it impacted on the CEGB and how they had to bring the network back. That is not something we have explored. We talk about security of supply, but we don't talk about resilience to significant weather events—we have seen some significant weather in the last few months. Having diversity gives you that resilience, and by having various distribution systems you have that resilience built in. If you give all the control to a central entity, it is likely to create a more homogenous network, and perhaps you will have less resilience.

Q98 James Heappey: Before I come to Dr Edge, I want to be clear about what you are advocating. I am interested to get the panel's view. As long as, regionally, the network operators have that granularity—they know exactly what is being produced, stored and consumed at any one time—National Grid just needs to be able to balance between those regions. Is that what you are saying?

Dr Cainey: What I am saying is that there is a boundary between National Grid and the distribution system. At the moment the DNO has no requirement to balance; it just has to look after the wires, and stuff flows across those wires. It is up to National Grid to make it all work. If it was system-operated and had a requirement to look after its system—even if it could not do all of it, but could do the large majority of balancing its bit of the system—the work that National Grid needed to do would not be as hard.

Dr Edge: The point I would make is that, although Dr Cainey said that National Grid would love to be able to manage right down to the lowest level, I am not so sure. The data management challenge of that would be overwhelming—[*Interruption.*] Moore’s law notwithstanding, I think it would require massive investment in data management. What we are getting to is millions of active participants in the system, and being able to communicate with and manage those on a direct basis—“You do this” and “You do that”—is not feasible. There has to be a market signal and then what you have to do. National Grid is able to predict demand now very accurately. That is not because it is in every home and seeing that you are doing this or that; it is because it has observed over time how people react and over time it starts to know that people will turn on their batteries or do this or that—that is what the system is now doing, because the market signal is telling them and so people are responding in a way that we understand. It is about a certain amount of letting go and trusting that if you send the right economic signals, people act in the right economic way and therefore you can predict what they do.

Sara Bell: But that requires the data in the first place, so it is just stepping back and looking a little deeper into your question—perhaps it is not the entity that matters, but actually the availability of the data in the first place. If we handed this over to a DNO now, below the substation it would have no idea what is going on, because that metering does not exist. We need to get on with the smart meter roll-out and get that data, because there are multiple potential roles for entities that can cost-optimize. Lots of new business models can come out of that, so that we have the most efficient—from a cost point of view—service delivery to the customer. But the foundation step is to get the smart meter roll-out done and to use the data. The data collection company currently cannot half-hourly settle profile classes 1 to 4. We need to solve that very urgently, so that we can actually deliver the value to customers from the meter roll-out that they are paying for.

Q99 James Heappey: I agree very much when you say that there is no point having a smart meter system so that we can feel chuffed about databases filling up with data if we do not then grab some value from them—it is a point very well made. Is this all going to be very expensive though? The DNOs have cost quite a lot of money already, and to take them to a point at which they have the same sort of understanding and are able to deal with that dynamic network will be pretty expensive. Does anyone have any thoughts on what it might cost?

Dr Grünewald: The balancing cost?

James Heappey: Simply getting the DNOs to a place where they can do that, where they can operate in that way.

Dr Grünewald: What I have heard is also a desire to pass that further. At the moment we are working on a project called Energy Local, where we try to use the balancing at the local level—if you own PV and are generating, but not using, at least theoretically electricity is being passed all the way up the network and then back to your neighbour’s house who is currently using it. In practice, of course—

Dr Cainey: The electrons.

Dr Grünewald: Yes, the electrons probably take a shorter route. It would be nice to have the market mechanism to allow that as well, so that you can actually pass the challenge of balancing right down to the DNOs, at a sensible level, where communities can try to balance themselves and therefore reduce their cost, so passing the need to balance the system upwards less and less, therefore reducing the cost at the national level. Then there is neither a desire nor a need for National Grid to know what happens beyond every node.

Stephen Goldspink: It is difficult to quantify what it would cost, but there is real potential for cost savings. Look at distribution network operators and the moment they start to make their grids smarter, they have the opportunity to avoid network reinforcement. There is inherent redundancy in our distribution networks that we can tap into and utilise much more effectively with a smarter grid system. We have looked at self-healing grids; we have actually conducted trials with utility companies on self-healing grids. You only have a self-healing grid if it is well automated and well understood, and has real-time communications. There are also savings to be made on operational expenditure. At the moment we are quite inefficient. When we do have a fault we have to send people out—on foot, in vans—to try to isolate and find the fault. We could do that far more intelligently, and save maintenance costs and operational expenditure.

Q100 James Heappey: On smart meters, some of the written evidence we have received has suggested not that the Government's plan is not universally supported but that there is scepticism over whether it is going to be achieved, and if it is achieved what value it is going to bring. Does anyone want to comment on the smart meter roll-out, on whether it is going to be achieved on time and do all the things it should do?

Dr Cainey: I did a lot of work on workstream six of the DECC and Ofgem smart grid forum on smart meters, and there is no doubt that they are potentially a very powerful tool to help people understand and better manage their energy use. But that means that the smart meter has to be out there. It means that the data have to be sensibly accessible to them and to whoever is helping them manage their energy. It is certain that the big suppliers find the concept of having to manage 48 data points per household exceptionally challenging, but the telecoms industry seems to have managed that adequately.

We are still settling customers on outdated profiles, which may or may not bear any particular resemblance to the electricity they have used. Absolutely, if we can have settlement that is based on the electricity that you use, that is what should happen. I am not even sure that the specifications of the smart meter are locked down and ready to roll out yet.

Q101 Matthew Pennycook: May I come back to something that James said? Since this new Committee in this Parliament has been up and running, we have seen a slight shift, or some indications of a shift, in thinking away from, "You must have an IHD" to, "There might be other ways of interacting."

I just wanted to press you on the fact that you said that this is one of the country's biggest infrastructure roll-outs and costs a huge amount of money, and you are potentially saying that because we cannot get to half-hourly accounting, because the big six do not want to go there, it is all going to be useless. So why is DECC not just saying, "Get out of the way. This is a huge infrastructure project and you have to change your behaviour as an energy supplier"?

Sara Bell: Because this increases the price risk to electricity suppliers and, therefore, there is a commercial implication for them. They sit, and I have sat, on the half-hourly settlement expert group, and I have obviously advocated, “Let’s get on with it as quickly as possible.” Without exception, they all say the same thing: “In principle we support half-hourly settlement, but, we are going to have to put these systems in, it’s going to increase our risk in this way, from a price point of view, it will be more costly for us to run the system, therefore it will cost more, therefore we will be putting prices up for electricity customers, and when they ask us why, we will tell them it’s because you, Ofgem, and therefore by default, you, Government, have made us do it.” It requires a great deal of courage from Ofgem and the Government to say, “Actually, we’re still going to do this, notwithstanding what you’ve said.” We have seen that very clearly in the cash-out reform. The cash-out reform is, if you manage for it, delivering enormous value to customers. Two suppliers on their websites have actually said that this is increasing the cost to customers and is the reason why they are putting their bills up.

Q102 Chair: So you reckon it is the lobbying and the muscle of the big six?

Sara Bell: Yes, I do.

Q103 James Heappey: I am intrigued by that. How does one undermine the position of the big six? They can be competed out of the market—that is too much. They can be challenged in that view by competitors demonstrating that they can achieve better value for their customers by showing how half-hourly switching can work, but is there a challenge because of the big six’s role in generation that perhaps undermines that?

Sara Bell: Only at a very large scale, and we have certainly not hit that because we can still buy the energy that our customers need on the part of the market that is genuinely traded. As we start to grow, we will come to more of those issues, but it is now possible for us to demonstrate the business case for half-hourly settlements. We are having lots of conversations with Ofgem, who are very excited to see that data, but in order to get there, we have had to deal with many regulatory barriers.

We are the only supplier that is voluntarily moving from non-half-hourly to half-hourly for all customers. Until 5 November, it cost £150 more per customer because of how distribution network and collateral charging worked. If you imagine a domestic customer thinking about the size of their bill, if a supplier has to pay another £150, it is not commercial to half-hourly settle them, so we have been working through a number of regulatory barriers with Ofgem and Elexon, and both parties have been very helpful because they genuinely want to move to half-hourly settlement. The more we demonstrate the business case, the more this will grow.

Dr Grünewald: I had a conversation with Juliet Davenport from Good Energy, and she showed how she has to balance her generation portfolio against what is basically a deemed low profile. She has to buy electricity in at times when her resources are not running just because it is assumed that her customers will be using electricity at that time. All incentive to get her customers to be well behaved and use electricity at certain times is completely impossible. I think that, if we want to go down that low-carbon pathway, it is essential that we allow for that balancing to happen.

Q104 James Heappey: A final question. Antoinette was asking you about the demand-side response and you were casting doubt over people's enthusiasm for internet things: the washing machine will run at 3.16 in the morning because that is when it can get the cheapest energy. Regardless of how much people might want to use it, how far away are we from having that technology available in the UK?

Sara Bell: It is in my home now—it is possible to do this now. My dishwasher runs like that. I agree that the washing machine is not as desirable a load to do that, because I have children and sometimes they create a lot of washing that needs to be done there and then. The dishwashing load is different—this is about how you sensibly change the system: take the load that is easiest. Most people are only interested in having clean dishes first thing in the morning. Washing is a little bit more of a subjective load.

My dishwasher runs at night-time, controlled by our electricity trader. Sometimes it is possible to get negative pricing. In December one morning we bought electricity at minus £60 a megawatt hour—that means that someone is paying Tempus £60 a megawatt hour for running my dishwasher load. Obviously we have other load that we are managing too. The economic incentives are there already and the technology is there. It is a simple plug: turn on, turn off.

James Heappey: I wish that time wasn't tight.

Chair: That is an awful lot of dishes that can be done in one load.

Sara Bell: A messy household!

Q105 Dr Poulter: This is the last vital area to cover, but I will be brief. Thank you for the time you have given us so far today. Innovation and research and development are clearly a key issue, and I want to touch on the Government's track record of supporting and stimulating R and D and innovation and future plans. How successful would you say the low-carbon network and other network innovation initiatives have been?

Dr Caine: I would say that they have allowed DNOs to explore various options. Without seeing those alternative approaches, it is hard to see how they could ever move forward. I guess that DECC has supported electricity storage projects through its innovation funding and low-carbon network funding and the new NIA and NIC funding opportunities under the current business plans allow utilities to explore various new approaches, and I think that the low carbon network fund has been very successful.

Stephen Goldspink: I would concur. They have been really successful and they have encouraged the distribution network operators to move outside their normal space. They have started to look at system-wide challenges. They have been engaged in trialling things such as time of use tariffs and how to deploy energy storage and optimise utilisation of the network.

It has actually encouraged them to engage with customers, which historically they have never done, so I think it has been a really positive round of funding.

Dr Grünewald: I support that. The important thing is that this innovation does not happen just in the labs. The fundamental research is important and there is a lot that we can do in that area, especially on storage. The UK has the potential to be a real world leader, but

it is important that we feed that through into demonstration and application. It is not just about making better widgets but, as the other panellists said, learning how to use them and developing them—sometimes getting it wrong, but making sure that we learn how to set up the right contracts and learn in the field what the pitfalls are. That is just as important as the fundamental research.

Dr Edge: But you are still challenged with the next step of moving it into business as usual. That is something that, across the board with innovation, the UK has never been very good at. We are good at developing technology and demonstrating it, but getting to mass deployment is the step where we often trip up and where our companies often end up being the losers, while other countries say, “Okay, we need to make a market for this and make it happen.” The ideology seems to be that if it is economic, then it will happen, rather than that it needs to be co-created with Government and the industry.

Q106 Dr Poulter: Absolutely. This is a point in the evidence that Siemens submitted. Stephen Goldspink, you called this the commercialisation of the lessons learned from the knowledge—we have got the knowledge, the data and the information, but how do we take that out to the consumer and to business? How do we do that? The challenge is to benefit the consumer.

Stephen Goldspink: If you look at the RIIO plans for the DNOs—I think Gordon referred to it earlier—they do not really show any ambition to move towards real low-carbon networks. What we have to do is not wait. We need to push for more decentralised energy and get the smart meter roll-out. As I said earlier, that pull on the distribution networks will absolutely force them, or encourage them further, to implement some of their learning. It could also be argued that rather than trying to find new solutions through the next round of the network innovation competition or the network innovation allowance, we should encourage them to take what they have learned and use that funding to commercialise it, driving it even further than they have done so far.

Dr Grünewald: If I can illustrate the cultural challenge that we face in some of the industry, we had a meeting with a network that was absolutely at the limit—the DNO would not allow any more renewables on the system. One large user tried to come up with a solution for managing it, and at the end of a very long discussion, they suggested, “Couldn’t we build some storage?” The DNO’s response was, “Potentially, that could make matters worse.” They still have an attitude of assuming the worst. That is a natural part of the culture, because they have to provide great reliability, so there is a lot of learning that has to happen.

Sara Bell: All that innovation has been done by separate departments. Every distribution network set up a future networks department that was completely separate from the rest of the operation. It becomes very hard to institutionalise innovation if you are doing it in a separate entity. There needed to be a direct incentive and disincentive that ensured that anything that was researched, developed and proved to be commercial was actually implemented, and if it was not, that there was a real disincentive through the price control for that measure.

Q107 Dr Poulter: This is the thing. Looking at other business and scientific models, you gather the evidence, you look at the evidence and you then use that to make sure that what

you do is better and improved. What you seem to be saying is that we are not using the research and development effectively at the moment.

Sara Bell: Because those companies are not innovation companies. An innovation company naturally goes through that process; a utility does not.

Q108 Dr Poulter: No, but in terms of the green innovation initiatives that have been put into place, Siemens seemed to believe that there was a world-leading body of knowledge; I think that that is the quote that you put in your evidence. Why are we not using that? Any other sector, such as medicine or science, or any other business would use that to engage better and to make things better for the consumer or to improve their business model. I am trying to get at why we're not doing that.

Stephen Goldspink: Can I use a real example? For its largest low carbon networks fund project, called the grand unified scheme, Northern Powergrid looked at various technologies. It took three different parts of the network—rural, urban and semi-urban—and looked at deploying energy storage using a time-of-use tariff and consumer engagement. The whole purpose was to learn about the impact on its network and what a distribution network operator needs to do when these future technologies are deployed. Everything we have talked about today indicates that until regulatory barriers are removed to allow distribution network operators to deploy storage, the smart meter roll-out, and the implementation of time-of-use tariffs, there is no incentivisation for the DNO to deploy that technology. It is not incentivised to do that without the demand for it. It is incentivised to deliver outputs, which are very much around customer satisfaction, network interruptions and how many minutes are lost. We need to create that pull on the distribution networks.

Dr Caine: The point is that we are kind of locked in to RIIO-ED1, which is the business plan that started in 2015. I am a stakeholder representative on a DNO and its plan estimated that domestic demand-side response was going to be less than 1% of its energy out to 2023. That has to change, but we are locked into that business plan until 2023, because it framed its business plan in a different environment and we are stuck in that unless we do something radically different. We need to, because we urgently need flexibility now. If we wait until 2023, it will be too late. The way business plans are operated mean that you can't just say, "I'm going to do this over the next eight years and I don't need to think outside of that eight-year box." Yes, they must innovate and do it at lower cost, but they have already set it out. If you want to change that, it's difficult.

Dr Grünewald: If you look at how attractive the business proposition of the Powerwall is and if you think about consumers suddenly taking that on, the DNOs might actually be overtaken by reality in an area that they should really be owning and controlling. It might slip out of their hands. There is a danger for network asset values if consumers suddenly do their own balancing and don't use networks any more.

Dr Edge: DNOs have been overtaken previously. I heard of one DNO whose projection for distributed solar connections was beaten by the time ED1 started. That was meant to happen in 2023. They are very slow moving, and the flexibility to respond to events and technological changes is low, which is a barrier.

Q109 Dr Poulter: Finally, in the spending review in the autumn, the Government announced that they would double investment in the innovation programme. What should the priorities be for that programme? Are there any good examples of R and D programmes elsewhere in the EU or somewhere else that we could follow?

Dr Grünewald: A general point that I would like to make on that topic is to take that systems approach that we talked about at the very start so that we don't just look at these technologies in isolation and so that we understand how we can make them work together. We have talked about demand response and storage, which are technologies that are almost meant to work together. The Oxford Martin School, for example, has just started an integrating renewables project, and it is looking in the round at what is needed to integrate renewables effectively. That involves a broad range of disciplines, such as economics, technology and legislation. All that needs to be brought together if we want to come up with effective solutions for the future.

Dr Edge: While innovation funding is welcome, the issue we now have is that the future is already here, but it is just not well distributed yet. We need to focus much more on rolling out the solutions that we already have in a cost-effective manner, which would make a huge difference. If we get some better ones coming down the line, that is fantastic, but we don't need to depend on that.

Dr Grünewald: If I can come back to Mr Heappey's earlier point about whether we have the technology, we do have a lot of the technology and it is really a matter of avoiding the barriers that still stop people having the investor confidence to make it happen on the ground. That should not be underestimated.

Dr Cainey: Quite often with these innovation projects it is specified that it has to be completely new learning. Say that another DNO wants to connect a battery to the network, it cannot do that because UKPN has already done it. Quite often, such projects have to be packed up, disconnected and terminated at the end. I understand that that will not be the case with the UKPN project and that the battery will stay on the system, but they had to argue long and hard for that. There are some issues around the structure of the innovation funding and how it is deployed in that, yes, there are new learnings, but can we deliver it? It shouldn't just be completely new learnings. Can we develop something that we have and take it further and roll it out wider?

Q110 Dr Poulter: So some flexibility around existing technology or innovation—you would further develop that.

Dr Cainey: Yes.

Sara Bell: We need a much clearer plan around what technologies could be exportable. This country has not been strong enough in thinking about the transition that we are undergoing in our energy system. Every country will need to do that. The faster and more cost-effective we make that transition, the more we will build businesses that can export their goods and services overseas. We can get jobs creation off the back of that. There is enormous export potential in every aspect of this: sensor and control technology, data security, storage. By thinking much more strategically at a system level that also involves



HOUSE OF COMMONS

economic development, we can really leverage this opportunity. We are not doing that and time is running out, because other countries are.

Chair: Thank you for giving up your time and expertise so freely. We heard a call for the balancing of costs and for a system thinker. Perhaps the biggest system thinker we need is somebody for the dishes in the Bell household, and they might not have enough megawatts—perhaps we need an army of civil engineers. Anyway, I thank you all for coming along. It was appreciated and we will use your knowledge when we come to our report.