HOUSE OF COMMONS

Energy and Climate Change Committee

Oral evidence: Low Carbon Network Infrastructure, HC 613

Tuesday 26 January 2016

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Watch the meeting

Members present: **Mr Angus Brendan MacNeil (Chair), Rushanara Ali, Glyn Davies, James Heappey, Antoinette Sandbach, Julian Sturdy.**

Questions 111 - 165

Witnesses: **Dr Tim Rotheray**, Director, Association for Decentralised Energy, **Dr David Clarke**, CEO, Energy Technologies Institute, and **Chris Clarke**, Director of Asset Management, Wales and West Utilities, gave evidence.

Q111 Chair: Will the witnesses please state their names and organisations for the record?

Chris Clarke: Chris Clarke, chartered engineer, Director of Asset Management at Wales and West Utilities.

Dr David Clarke: David Clarke, Chief Executive Officer of the Energy Technologies Institute, ETI.

Dr Rotheray: Tim Rotheray, I am the Director of the Association for Decentralised Energy.

Q112 Chair: I assume that the Clarkes here are not related in any way, shape or form?

Chris Clarke: Not that we are aware of.

Q113 Chair: We are here to explore the future of the UK's network infrastructure and, today, particularly of the gas and heating infrastructure. Can you briefly begin by giving us an overview of the role that gas and the gas network play in the UK's energy mix?

Chris Clarke: I will start. It is absolutely key to the country's heat and power. I just mentioned to one of my colleagues that we have just completed our mini-review of last week's weather, which, while not particularly exceptional, did see a rise in demand. There was quite a large demand over heat and power—round about 4.2 TWh. That includes electricity generation, 90% of which was supplied through the gas network.

So gas is absolutely fundamental at the moment to the nation's heat, light and power.

Q114 Chair: As we move towards the decarbonisation of heat, what are the main challenges ahead for the gas networks?

Chris Clarke: We may cover this later, but I would certainly say the ability to meet peak demand. When I talk about peak demand, we talk about normal winter peak, one in 20 winter peak, and everything in between. The big challenge is achieving the flexibility that the energy delivery system needs between summer lows and winter highs, and then there are the highest winter highs when we get the real peak demand.

Q115 Chair: And the winter peaks can be as high as how many gigawatts?

Chris Clarke: About 300 GW.

Q116 Chair: Given that that is 300 GW, and given what we know about the electricity network, would the electrification of heat be possible? The peak there that could be carried is not 300 GW but 60 to 100 GW, so there are clear challenges for the electrification of heat.

Chris Clarke: As it stands at the moment, it would be a great challenge. We talk about the electrification of heat, and the most likely—

Q117 Chair: Would it be desirable even to try?

Chris Clarke: I would answer that from the consumer's perspective, and ask whether it would be desirable for the consumer who uses the energy. Clearly, at the moment, it would cost quite a lot more to the consumer to electrify their heat, so something like a heat pump would in effect be a large investment for a consumer without actually saving them any money. Therefore, from their perspective, it would not be desirable as it stands at the moment.

Dr David Clarke: You have to be quite cautious with that kind of question, because the reality is that the UK currently has a system which was built up historically, and essentially there are completely separate systems for electricity and gas. To all intents and purpose, essentially all UK heating—give or take a few per cent.—is based around gas. Those two systems are completely separate, and they operate completely differently. The current question of whether electricity could deliver 300 GW in demand, is one where you would say that it would be illogical to build an electricity system that operated to deliver the same kind of capability as gas.

If I just give you the easy example, we have talked about peak capacity, but the key issue to some extent is less about the peak capacity than the ramp rate that we have all got used to through gas central heating: the ability to turn the thermostat up and get an instantaneous response from a system that is designed to deliver that. On 18 December 2010, the gas demand across the UK on that cold Saturday morning went up by 132 GW to about 300 GW in just an hour, between 7.30 am and 8.30 am. It is inconceivable to deliver that ramp rate from electricity. It is not just the peak number; it is what we have all got used to because we have built ourselves a system that works in a particular way.

If you took the extreme case and started with a clean sheet of paper, you might design a completely different system, and we would all operate houses that ran continuously at 19.5° C with underfloor heating using electricity or hot water from different sources. I stress

caution in thinking that the answer is that we need 300 GW. I am not saying that that is what you were thinking, but that was the implication of the question to some extent. You do not necessarily need to have that capacity or that ramp rate. It depends on how you design the system.

Q118 Antoinette Sandbach: I want to come back to the fact that some people have no choice. In rural areas, people cannot access the gas network, can they?

Chris Clarke: That is the case, and clearly that means that a sort of horses for courses approach is needed to some degree. I point out that we do try to extend the gas network, particularly to fuel poor areas, because it does make economic sense for those folk, but we accept that the gas network is the gas network.

Q119 Antoinette Sandbach: With the greatest respect, you cover south Wales, and you may well do the urban areas, but you are certainly not up in the Brecon Beacons, are you?

Chris Clarke: We are in Brecon and we are in Abergavenny, but, yes, I would absolutely accept that.

Q120 Antoinette Sandbach: So what about that percentage of the population who cannot access your network? What prospect is there for them?

Chris Clarke: From my perspective, I think it depends on what their fuel source is at the moment. We did some work researching previous infills, where we take gas to non-gas areas, to understand the penetration over a long period of time. After 20 years, we found that about 30% of people had not switched, even though they had a gas pipe outside their property. What we found there is that things such as oil heating are still very attractive. Although in the 1970s it was perhaps a concern, if you are on oil heating now you wouldn't necessarily change over to gas just on the price comparison alone.

Chair: James Heappey, a short question.

James Heappey: It is a supplementary to question 2, so you might want to ask that question first.

Q121 Chair: As we have established, the UK is quite heavily dependent on gas for its energy needs. Indeed, the ramp rate has been well explained. Looking forward to biomethane and hydrogen, can you explain what advantages that might have over natural gas, particularly in terms of complementing or, indeed, replacing natural gas on the grid?

Chris Clarke: Clearly, as a renewable energy source, it is considerably advantageous. It is fair to say that it is in its infancy. We have just connected our 50th biomethane plant across the UK, from a start where perhaps two or three years ago we had three. It has accelerated significantly as some of the technological barriers have come down. The other advantage is that research has previously suggested that it is one of the cheapest renewable sources and therefore would appear to be attractive on both counts. Of course, the benefit is that the consumer doesn't notice any difference, so they can continue to use their problematical ramp rate—the storage within the gas network system is sufficient on a daily basis to cope with that. Therefore, yes, it appears to be an attractive proposition.

Dr Rotheray: There is an important question about the type of users. The amazing and very useful thing about gas is that it burns at a very high temperature. If you are an industrial user, you need very high temperature heat to run your industrial processes. When we think about how we transition our energy system into a lower-carbon and more efficient future, we have to think carefully about where we direct those resources. There is a limited amount of biomass, and there is going to be a limited amount of biomethane or biogas. If you try to electrify industry, it would create not only system problems but some very significant economic problems, because electricity is about four times the cost of gas per unit.

One of the things that is worth thinking about is where we want to direct these limited valuable resources, and then how we use it carefully. Your question about whether we could electrify heat raises an interesting thought, which is that almost all our power is generated by heat and that, actually, we waste almost all that heat. The amount of heat that we end up wasting every year is worth £2.3 billion a year if you priced it as gas. We are at probably a third of the potential recovery of that heat. We could recover an awful lot more of it, but we do not. There is an interesting question about whether in future we will still expect to generate power using heat, and I haven't seen many forecasts where you remove heat from power generation, so one of the areas is recovering that heat. That is an important thing to think about for the cost-effectiveness of our systems.

Q122 James Heappey: There are three things that I would like to cover very quickly. The first is how we use gas generated remotely through anaerobic digestion or from landfill. Secondly, the legislation on how that gas can be used and, thirdly, the grid.

On how we use the gas, I visited a number of AD plants and it seems to me that the biomethane that those AD plants produce at the moment, because they can get an electricity connection more easily than they can get a gas grid connection, is being burned in a very inefficient way to generate some electricity that they can put into the electricity grid. It would be so much better if they were able to put that gas into the gas grid for it to be used in a more efficient place elsewhere.

Secondly, those who have contacted me from the landfill industry say that the biomethane that they can produce at the moment can be employed only for transport purposes and that there is a legislative issue over being able to use that biomethane for the wider grid. I am keen to understand whether that is accurate.

Finally, agriculture produces tons of biomethane. If AD plants were employed widely in the agricultural sector, loads of biomethane would be produced. But the areas in which agriculture is most heavily concentrated are perhaps those where the gas grid is the least extensive. How do we square that to take advantage of that resource? What sort of investment might be needed?

Chris Clarke: I will begin with the electricity versus gas use of biomethane. You are absolutely right that it is potentially a waste if you cannot use the heat when you are generating electricity from it. A much better proposition is to put it on the grid. Do people have access? Is it difficult to access the grid? Two to three years ago, we would have said yes because the specification of biomethane had to be so high. That specification is now a much more realistic number—hence why it has gone from three grid connections to 50 in about 18 months. Access to the gas grid is a lot easier than it used to be. We work hard with

developers to help them access the grid and to help them with their production so that is made easy for them.

The second point about landfill is no longer true. Landfill gas can be accepted. We now have a landfill gas connection into our grid in Wales and West Utilities so it is perfectly feasible. Again, the slight relaxation of the oxygen content of the gas made it economical for them to clean it up sufficiently to grid.

Finally, on agriculture, even in Brecon and Abergavenny, the gas grid is quite extensive. Therefore, people are probably closer to the grid than they might think. I accept that that is one of the challenges. We are also looking at whether the grid has sufficient capacity and how we compress the gas back through the grid. An example is Wessex Water in Avonmouth where they want to put a very large quantity of gas in. We are looking at how we can simply reinforce our network so that we can supply most of Bristol from that plant at certain times of the year. To that, they want to add a green bus fleet to get rid of some of the diesel emissions in Bristol. That all comes together very nicely when the network operator and the producers work closely together.

Q123 Chair: Can I move on to hydrogen now? What are the advantages and disadvantages of hydrogen over natural gas?

Chris Clarke: I would not necessarily say advantages. If hydrogen is available, it can be used in two ways. In the first instance, it can be blended up to about 20%. The Health and Safety Executive's laboratory released a report last week that indicated that there are no technical problems with hydrogen blends up to 20%. The challenge is just ensuring that we can bill people correctly because of the different calorific values.

Q124 Chair: In what ways are the calorific values different?

Chris Clarke: The calorific values are different. Also, there is something called the Wobbe index, which is how the gas burns through the burner. That is why 20% is about the maximum that could be put through existing appliances, so a 20% blend would be available now if the hydrogen was available. Excess electricity generation stored as hydrogen would be one source. I think ITM Power is keen that the use of electrolysis could take waste electricity—

Q125 Chair: So would a volume with a 20% hydrogen blend have more or less energy?

Chris Clarke: It would have less energy but, interestingly, it has a lower density and causes less friction through the pipes. Although you need more volume, it does not cost the consumer any more because they just burn more for the same heat, so instead of a boiler taking 10 minutes to warm up, it might take 12 minutes if it was on a hydrogen blend. The conclusion of the research is that the consumer would not notice the difference.

Dr David Clarke: The volume's calorific value is a third, so you get a third as much energy out of the same volume of hydrogen. The challenge is exactly that. If you are trying to match calorific value to give people the service they are used to today—ramp rates and so on—and if you put 75% hydrogen in the network, you would still only save 50% of the carbon as a consequence. If you are going to make a significant carbon saving, you end up saying that you have to go pure hydrogen to make a real difference and get 100% savings.

Very big volumes of hydrogen with residual methane will still leave you with significant carbon in the system.

Q126 Chair: Do you think the Government have a clear strategy for biomethane and hydrogen?

Chris Clarke: I think the strategy that exists at the moment is satisfactory. I think it's working. It has seen the move from infancy to lots of plants out there. I think it still needs some support over some of the technical challenges to be able to widen the gas quality index, for example, to match the European standards, which again, it has been demonstrated up in Oban, would have limited or no impact on consumers' appliances, it would just make it easier for producers to connect to the grid. We would not have to put propane in, for example, to enrich the gas to meet the grid standard. The same legislation or change to the standards would make things like LNG use more easily available, because you would need to ballast it with nitrogen, so there is quite a cost saving there as well.

The Government are heading in that direction—they have been listening—and I think people like DECC are moving in that general direction. But you have to keep emphasising, it is perhaps like solar was 10 or 15 years ago. We are at that stage of development and I think that is where we need to keep the focus on to maximise the use of it.

Q127 Rushanara Ali: Can you say more about the whole system approach to the energy network and what it would mean in the UK context?

Dr David Clarke: Let me just explain that. Probably the best thing is to step back a second from the detail of heat and gas networks and so on and say, "Well, we've got a set of CO_2 targets for emission reductions to try to reduce CO_2 by 80% by 2050". If you look at that the other way round, that says you are emitting 20% of the CO_2 in 2050 that you do today. Logically—no great analysis—where would you keep using fossil fuel? Where would you allocate those CO_2 emissions if you had to, that remaining 20%? It would be in transport—various forms of transport, on-road, off-road, marine, aircraft in particular. By the time you do that, with a bit of industry emissions as well that you have to accept and probably a tiny amount of power sector emissions, your 20% has gone—you've used it.

The important bit is power is essentially zero CO_2 and you have to make some major inroads into heat, in terms of decarbonising heat, to leave the allowance that you can then use in some transport applications. You have also made some big changes in that. That is your starting point.

If you then say, "How will I implement a system to do that?" one of the things we carry out as ETI is a detailed system analysis for the UK looking ahead at 2050 and looking at what is the optimum design to keep costs down and do all the security. If you look at what the optimal way of doing that is, from a cost view point, you would say, "Well, for my power sector I need CCS and bioenergy, and bioenergy being run through systems where I can take the CO_2 that comes out of the biomass and then store it through a CCS storage system."

Why do I need that? Because it gives you these so-called negative emissions, and that gives you more freedom. That is the important bit.

I am painting this picture to start with to say that this is the optimal way, because it gives you more freedom in where you allocate the remaining 20% of CO_2 because you basically increase the number you've got. It goes to more like 30% than 20%. Fine—if you did that and then designed your entire UK energy system on that basis, starting from where we are today and projecting forward, our view is that your heating system across the UK very roughly would be a third, a third and a third—gas, electricity and district heating. Those would be the three solutions. Gas and district heating are broadly cost-comparable, as you got from the evidence submitted today by one of the other speakers. Electricity will be a little bit more expensive, but broadly, a third, a third, a third. So that is the view on the system.

If I then made a different decision—a decision that you were discussing here last week about CCS—let's just for a second take CCS out of the equation and say you can't have it at all. If you go down that route and do all the same analysis, your negative emissions capability has gone, so now you really are confined to this 20% box. At that stage, you go down that list, and gas heating is now gone. You can't do it, certainly not with conventional gas. You end up saying your optimum heating design is now district heating and electricity, and it will cost you more money, because you've taken out the low-cost gas option.

That is a snapshot of the system and why you have to look at it as a system, because you are moving into a world where we no longer have these completely separate views of "Most heating is gas, all power is fossil fuel and electricity," and so on. This is all going to get blurred, and the infrastructures for it are going to start to come together to deliver any kind of operable system.

Q128 Rushanara Ali: So what would the UK Government need to do in terms of a regulatory framework to enable the whole-system approach that you are describing to happen?

Dr David Clarke: From an engineering viewpoint, it would be very nice to say we have some sort of central planning body that worked it out and told you the answer, and then you could go away and build it. In reality, that won't work—no chance—so from our perspective, it is important to recognise two things. The first is that the overall system design needs to be at a national level. It does need to be considered, and we need to consider it as engineering, economics and consumer acceptance. What are people prepared to operate with? Do they want gas heating that ramps up and down fast, or will everyone accept a district heating system, which is probably far more consistent in terms of how they use it?

So you have got that national view, but it is important to recognise that it is absolutely not just about the engineering. I say that as an engineer. The reality is that you then need to recognise that local implementations will be completely different from place to place. I say that simply because of the question earlier about rural locations. I live in a rural location, and I am off the gas grid. I do not anticipate getting gas any time soon, because it is a long way away. The solution that we want in the area where I live will be completely different from what we would put in, for the sake of argument, in the middle of Bridgend, which we were also talking about a little while ago. That is the challenge here: how do we integrate a national view with local implementation tailored to the consumers in those regions?

Q129 Antoinette Sandbach: Can I step in? Are you suggesting that rural communities will be able to be part of district heating networks?

Dr David Clarke: Well—I hesitate, because the answer is yes and no. It will come down to which location we are talking about and what heat and gas sources there are locally, such as biogas. When I say "locally", I mean is this a rural community of 150 houses spread out over a mile and a half radius, like where I live, or is it a rural community of five houses spread out over 10 miles? It will be different. That is my only point.

Q130 Antoinette Sandbach: So could you provide district heating with AD plants treating rural sewage, for example?

Dr David Clarke: Conceptually, the answer is yes.

Dr Rotheray: It is about what is most cost-effective to do. With district heating, it really comes down to the density of the heat in a given area. The lower the density of heat, the more pipe you have to put in. There are losses along that pipe, and it costs money. The question is what the right thing is. One of the largest district heating schemes in the UK is in the Shetland Islands. It is easy to assume that this is only for big cities, but it isn't.

Dr David Clarke: It is very locally specific, that's the thing.

Chair: I think it is in Lerwick, which is fairly—

Dr Rotheray: It is in Lerwick, which is a town.

Q131 Rushanara Ali: Can I bring you back to the barriers to this approach and the cost implications?

Dr David Clarke: Barriers generally?

Rushanara Ali: Yes, to a whole-systems approach. You mentioned storage.

Dr David Clarke: At the moment, the systems we have, in terms of power and gas, are more or less regulated through Ofgem. Does that encompass all aspects of what I talked about—engineering, economics and consumer science? Not really. The level of integration between gas and electricity regulation is pretty thin. They are separate. When you get into the whole issue of how transport gets drawn into it, and vehicles becoming more electric—they are not necessarily all electric, but more electricity is being used to drive transport—clearly you have issues around transportation systems and how that gets built in.

So there is clearly a need for better integration across the various regulators and agencies involved. You then have the question of whether, in the overall package—I hate to say this; I apologise—you need some kind of energy authority to look across power, heat, transport, electricity, gas and all the various subsystems.

Chair: Chris, do you want to come in that?

Chris Clarke: Yes, I have a couple of points. I agree with David that you probably need an optimised approach that is led top-down, and then a more bottom-up approach. I disagree with David a little about the two systems of the electricity and gas networks being separate. We are seeing a great deal more integration between the two. For example, I have about 162 power station inquiries for small plant coming on to my network, which will feed

directly into the electricity network. Our control rooms are just 10 miles apart, and while we have an operational contact, there is no detailed contact to think about strategy, which is worth thinking about with our colleagues.

In terms of some of the barriers, there are good examples: we already have a common regulator in Ofgem for gas and electricity, and there is an association with the Energy Networks Association, which looks across both those sectors. We need to break down some of those barriers and to understand that integration and what a network might look like in the very near future. I think it is going to be a very different looking network than we currently envisage, particularly with things such as combined heat and power, potentially taking a gas energy source and putting it into the electricity grid, and natural gas vehicles, particularly trucks via methane LNG injection. It has become a much more complex picture than we have traditionally had and probably still have, in our minds.

Q132 Rushanara Ali: What would be the cost implications of this approach?

Dr David Clarke: In the analysis we do, I painted you the two pictures earlier—the top-level picture of, in that case, the availability of CCS and bioenergy versus not. That is a black-and-white, extreme view of the world. The difference there is that the second one costs twice as much as the first. It is that simple. What that actually means is meeting CO_2 targets. The analysis we do says that that translates, in numbers, as basically a couple of per cent. of GDP for the UK. It is about £1 billion per annum on customers from 2020, rising to £5 billion to £10 billion per annum by 2040.

Rushanara Ali: Sorry, per—

Dr David Clarke: Those costs are the system cost, so that's power, heat, transport and infrastructure. The numbers I just gave you, the billions, are simply the additional cost compared to the ideal situation.

Rushanara Ali: Of having an integrated system or not having it?

Dr David Clarke: Of the lack of an integrated system and the lack of availability of certain technologies.

Q133 Rushanara Ali: Could you put some numbers on what sort of Government investment would be required to move towards a more integrated system?

Dr David Clarke: That is almost impossible to say. I am not trying to evade the question. The point is what sort of Government investment is needed versus what kind of private sector investment is needed, and how that is funded. If we are assuming that most private sector investment is driven through the regulated structures and continues to be so, is that Government money? It is of the order of today plus multiple billions. That is probably the best answer I can give at this stage.

Q134 Julian Sturdy: I want to pick up on the points about district heating systems for rural communities. In Austria I am led to believe they have established district heating systems to villages and rural communities through farmers forming a co-operative to sell heat by

installing a district heating plant, probably a woodchip plant, in that community. Is there any mileage in the UK looking at similar systems?

Dr Rotheray: Yes, I think that the potential exists for a number of models of developing district heating networks in the UK. These things are infrastructure, and they are cost-intensive at the beginning. In countries like Austria there has been much more support available to enable people to look at those kinds of options. We now have £300 million announced by this Government, and that opportunity to start developing district heating is more clear. On the different models, we need to allow all the options to participate. Co-operatives have been very successful in Austria, but also in a lot of other countries—it is a very good way of getting the consumer involved in it, so, yes, it is definitely worth exploring.

Chris Clarke: The challenge is always going to be why consumers would want to do that given where we are at the moment. As mentioned earlier, when we looked at why people don't take up gas—there is virtually no investment for them now—it is because their alternative fuel is already cheap enough not to need to put perhaps £10,000 of property into a district heating network. I think the blocker at the moment is purely economic from the consumer's perspective.

Chair: Having opened an interesting vein on district heating, do you want to continue, Julian?

Q135 Julian Sturdy: We have touched on the role district heating could play in future low carbon networks. Looking at district heating at the moment, cost is going to be the issue, isn't it? District heating covers 2% of the UK's heat demand, but in Denmark and Sweden it is over 60%. Denmark made a huge investment in the late '70s over the oil crisis, but why is there such a difference at the moment and what does the UK need to do more of on that?

Chris Clarke: I will pick up the facts and figures around this first, but I am sure that Tim will want to jump in. The work we did for our Bridgend research looked at the district heat networks that were proposed in Bridgend as a case study of a typical town in the UK, with very specific housing that is different from some of the examples that you suggest. Again, it came down to the fact that assuming that there was a gas fuel source—as it happened, a very efficient gas-fuelled CHP source—this would save consumers some money, but the payback period was about 35 years. The question was therefore whether the good folk of the UK would be prepared to invest in that. We split the demographics of the sample area, which was about 10,000 people, into a number of areas. We identified that about 80% of the consumers either could not or would not pay. Even what we term the savvy investor was looking for a payback period of about seven years, and therefore I think it would be fair to say that 35 years was simply well outside the scope of most households' imagination.

Dr Rotheray: On your question about why we don't have this, the 1970s oil crisis triggered different countries to react in different ways. Denmark went for efficiency, and that is what they did. They said that they were going to get off oil by being more efficient. France went for nuclear, and the UK found gas in the UK continental shelf. We developed our gas network and we connected all of the town gases together, and that has performed extremely well. The other thing that is important, which relates to Chris's point about the 35-year payback, is that those infrastructure assets, which were publicly owned, were then all transferred into the private sector in a regulated framework. In that environment, where the

Government, through the regulator, effectively ensure the business case for operating a gas or electricity network, it is not surprising that district heating, which does not have that investment framework around it, has not developed in the same way. That is really the reason why.

Of course, the challenge now is that there is a certain level of carbon in gas. We know that we have to reduce our carbon emissions, and also our reserves of gas and oil from the continental shelf are declining. If we are going to move into a low carbon future and do it in a way that is good for the UK economy, we will have to look at alternative sources of heating and a more diverse mix.

I suppose that that is where district heating has its opportunity. Rather like the electricity grid, it is a no-regrets option. If you put in a district heating network, it simply connects sources of waste heat, and there is enough waste heat in London, for example, to heat London. So it connects sources of waste heat to nearby sources of heat use. They are heat-agnostic, and so it doesn't matter—it might be that your heat comes from a tube network in a town, or from a mine, or from a data centre. Rather like the power network, where you can put in different forms of generation, you can put in different forms of heat generation, so it is a kind of no-regrets option. You assume that heat demand remains, as people still need heat and hot water. Heat networks will allow you to move to a future energy system in a way that makes sense.

Q136 Julian Sturdy: Are you saying that we have slightly missed the boat on this, due to decisions made on the back of the 1979 oil crisis when we moved into different things? We will have to make a huge investment in infrastructure. Talking about London, I have the figure that London could produce about 70% of its own heat, but you are saying that now it could be 100%. The issue will be the huge infrastructure that needs to be put in place, which at the moment will not be that desirable because of the cost and because we are not in a '79 crisis, which is what triggered this in Denmark.

Dr Rotheray: That is true, but we are going to have to make a huge infrastructure investment whatever we do. Our electricity grid is ageing, and if we electrify heat, the actual size of the network will have to become larger in order to manage greater physical flows. Whatever you do, we will need major infrastructure investment in our energy system over the next 20 or 30 years. That is inevitable. The question is what is the most cost-effective way to do that.

Q137 Julian Sturdy: What triggered it in Denmark was that the oil crisis meant they had to take drastic measures: there were restrictions on heating, on driving and on power—at factories et cetera. So it was drastic measures that triggered a change, including a cultural change, I suspect, but we are not at that point, are we? People are not at the point where they are saying, "Gosh, we don't have power on Sunday," or, "The factories can't operate at full tilt."

Dr David Clarke: The trigger for change now is low carbon or not, if you see what I mean.

Julian Sturdy: Yes, agreed.

Dr David Clarke: That is your trigger. If you said, for whatever reasons, that all low carbon is forgotten—it simply is—you would carry on with the status quo. You would use

cheap gas, which is widely available and will probably become more widely available in the future. You would have a gas boiler fleet in the UK that rolls over, in round numbers, about every 15 years—boilers get changed every 15 years when they break, and nobody really changes their boilers otherwise, unless they are renovating houses. So nothing would change.

If, on the other hand, you say it has to be a low carbon system for the future, then irrespective of the detail—whether it is, as I said earlier, a third, a third, a third between gas, district heating and electric, or whether it is 50:50 between district heating and electric—then, exactly as Tim said, the infrastructure has to be upgraded. You cannot accommodate those systems with today's electricity infrastructure. The feeds into a street of houses—not necessarily individual houses, but a street of houses—simply are not big enough to do this, so you are instantly, one way or another, almost certainly into digging roads up, whether you put in a pipe, a wire, or both .

Q138 Julian Sturdy: DECC reported in 2013 that district heating could serve up to 20% of the UK's demand by 2030, but as you say, there will have to be huge investment in infrastructure to deliver that. How could DECC bring that about?

Chris Clarke: A more general point, to go back to the 1970s, is that the consumer could actually see the crisis in front of them. It is how you get the consumer to change their behaviour, given that, as far as they are concerned, no one is telling them there is a crisis. When we ask them, "Wouldn't you prefer to be low carbon?" then, yes, everyone would prefer that, but when we ask them, "Well, how much are you prepared to pay?" the answer is "Nothing." You are almost creating a burning platform.

There are other approaches, though. We mentioned hydrogen earlier. A project being done by Northern Gas Networks is looking at creating a hydrogen network for the whole of Leeds, which would potentially be much lower cost. If we are going to have to invest a huge amount in infrastructure, picking the right process and the right system for the local area is the right way. It may not be district heat for everything; some could be hydrogen, and some will continue to use fossil fuels. If they are the most expensive—the peak of how much we are prepared to pay per tonne of carbon abatement—you might say, "Let's carry on using fossil gas," or use your anaerobic digestion and hydrogen mixes.

Q139 Julian Sturdy: So how can DECC incentivise that?

Dr Rotheray: To answer your question, there are two things. Right now, we have the Government's £300 million in place, and that can be used to develop some of the really good-quality projects—they could be at different scales, but we need to concentrate on some really high-quality projects. These are new things for us to build and we need to make sure we build them properly.

What I would then say is that, during this Parliament, while that money is being spent, the Government need to develop a regulatory investment framework, like the one we have for electricity, gas, water and other infrastructure—this is long-term infrastructure—so that if you are an investor like an institutional investor, you will be able to look at different options and evaluate them on a similar playing field. At the moment, the seven-year paybacks we are talking about, that is commercial returns. These projects are for 50 or 80 years—they are long-lived projects—so you need those institutional investors to be able to evaluate them. We

have some details, which I am happy to send through, of a proposal that we think might be able to do that. Fundamentally, you want to get in the lowest cost capital possible, because that is how you will make sure there is the lowest cost for consumers. That will also allow you to choose what network is right in the right place.

Dr David Clarke: I absolutely support that, but I think there is another action. The level playing field for capital is the key challenge. I think the second one, from a Government perspective, is the siting of future of power plants and the ability to use waste heat from those power plants. That does not necessarily mean that they have to be small power plants, which can be in city centres or close to them. As various other countries have shown, you can pipe heat over very long distances—tens of kilometres if you wish to. But there is a key bit around siting of future power stations and making them ready to be able to use the waste heat. Whether you do that on day one or not is a separate question, but it is having that flexibility in the future to be able to go to a power plant—

Q140 Julian Sturdy: And to have that infrastructure in place when it is developed.

Dr David Clarke: Yes.

Q141 Julian Sturdy: That leads on to something. The retrofitting across huge urban areas is going to be very difficult, but then you have got new development, with the Government pushing for new villages, communities and so on across the country, so what can be done in the planning system to deliver that when you are putting in a new development? I have got one in my constituency where we had a new housing development built and a district heating plant was part of that development, which seemed to me a common-sense approach to trying to deliver more of this.

Chris Clarke: I think that is probably where most of the district heat is going in and it seems the most obvious time to put a district heating system in is when you are already effectively putting in development—roads and so on.

Q142 Julian Sturdy: Can the Government do more through the planning system? Are they doing enough?

Dr Rotheray: I think there could be greater clarity. Some changes were made to the Planning and Energy Act by the last Government that removed some of the clarity as to whether local authorities, as part of a plan, could say, "We would like this area to have a heat network installed." It is not whether they have the right to do it or not, but people are unsure. So local authorities—they are probably the right place, because they are doing the planning—could benefit from a clearer system, saying, "If you have a strategic plan that you want to do heat networking in your area and it makes economic sense, then you have the right to require someone to do it, unless they can demonstrate that there is something which will deliver the same outcomes for better value for money." You would always need a value for money test, but I think that clarity would be very helpful.

Chris Clarke: Can I answer the question on what can DECC do? If it does one thing, according to the research we identified at Bridgend on people's willingness to pay and what would get a consumer on board, it would be a subsidy for district heat. We calculated, though, that it would need to be around 75p per kWh to achieve consumer change and effectively change the economic value for a consumer to invest.

Q143 Antoinette Sandbach: A subsidy for whom?

Chris Clarke: For the consumer or the developer, but that is the kind of number you need to shorten the timescale down to a point where people would invest.

Julian Sturdy**:** So that is your seven-year payback.

Dr Rotheray: Our view is, for infrastructure, a 35-year payback—*Interruption.]* I am not sure we would recognise—

Chris Clarke: Solar has taken off because of that subsidy and the ability to make economic sense.

Q144 Chair: Combined heat and power investors have told me that they have got decisions on hold as they are waiting for a CfD allocation and on what conditions will be applied to CfDs in regards to that. How important is that? Is that an anecdote or is that crucial?

Dr Rotheray: I think it is really crucial. If you talk to everyone in the energy industry and the Department of Energy, they say, "Making the most use of a fuel is a sensible thing to do, and combined heat and power is the way you do that, and it is a good idea." What we have is a situation that is more complicated, because it spans heat and electricity, the two silos within energy policy.

We have a situation where you need certainty on the contract for difference feed-in tariff and you also need certainty on the renewable heat incentive, because the Government deliberately decoupled the support so that you would have one from each pot. That was exactly how they did it, and that has created an issue. Just in terms of the CfD, we did analysis a couple of years ago, when this was still an issue, and we estimated that there was about £1.4 billion of potential investment of which we thought £700 million could come forward. We have seen none of that because of the inability to ensure that both the subsidy regime integrates properly and you can bank the CfD and you know that you will continue to have your power generation supported for the lifetime of that plant as you do in other generation.

Q145 Chair: There has been a tendency in this argument to see cost as something that is happening today—what we pay for it at the moment—and not to see an investment. If there is no investment and if no cost is incurred today in investing for the future, what are the likely opportunity costs tomorrow?

Dr Rotheray: Most industrial renewable CHP opportunities are driven not by the subsidy but by something happening on your site. If you are an industrial user and your boiler is coming to the end of its life, or perhaps it won't comply with the industrial emissions directive, you have a window in which you can make that investment decision. If you cannot bank it—we have seen this happen before—someone may say, "This is the most sensible, lowest carbon and most sustainable opportunity we'd like to pursue," and they may then say, "Well, the next opportunity is less good," and the final opportunity normally ends up being a simple gas-fired boiler. There will be two impacts: one is that the opportunity for low carbon technology has been removed; and because the company is now no longer generating its power on site, it is exposed to increased costs of electricity, so its long-term competitiveness, because of not having on-site energy production, is at risk. There is a series of closing doors on a number of industrial sites, so there is genuine time pressure.

Q146 Chair: Previous witnesses have told us that the low carbon networks fund has achieved promising initial results, but failed to bring them forward to the market. The ETI's written evidence contends that the UK is now at a worse later stage of commercialisation than an earlier stage of development of technologies. Why do you think this is? Dr David Clarke may be able to explain.

Dr David Clarke: Let me give an easy example of the costs involved in taking new technology through to commercialisation. We recently supported development of a new wind turbine blade—new materials and technology, new manufacturing approach. The design is for a blade that is the same height as the clock face on Big Ben, so a 78-metre blade, for a 6 MW turbine. The company had spent about £1 million on the basic materials science side of it and the manufacturing concept. It came to us and we spent £10 million taking it through the next stage to what is called a TRL 4 to 6 or demonstration. We built the first blade, which is now on test at the offshore renewables catapult at Blyth. At about the same time as it was put on test, the company was bought by General Electric, which we all thought was a great result because it would take the blade forward to the market. GE will probably have to put £100 million into the next stage to get it into commercialisation. That is the sequence: £1 million research, £10 million development, £100 million.

Q147 Chair: So how can the problem be solved? Is there a problem just with that step in the scale of change that means you must be bold and brave?

Dr David Clarke: Number one is scale, and it is big. Number two is: where is the market? If you going to put in £100 million—you would need to be a big conglomerate to do that—that is the sort of money normally talked about for significant technology demonstration, whether it is productionisation or a roll-out to people's houses of new technology, if you are going to put that money in, you will do that because you can see a market for it. The wind turbine blade in that case clearly had a market and the company could see how it would fit on to its new turbines, and so on.

Step into the heat space. You have heard from all of us that the answer for heat in future will be not quite what it is today and will be different. It is not regulated if it is district heating, so it is looking for a commercial return. Now we are looking for people who are prepared to enter into this market with hundreds of millions potentially to commercialise something when they do not yet see what the market is, certainly not in the UK. The challenge is scale and market visibility. It's that simple.

Q148 Chair: Is it wrong to say that although there is a lot of initial stuff, the commercialisation is not happening as greatly because of a Darwinian or natural fall-off that is happening everywhere? We see that in the UK and notice that we have not taken absolutely everything forward when in fact to take quite a number to one stage and to get a few of those on to the next stage is good enough.

Dr David Clarke: It is definitely a funnel—absolutely. There will be lots of good ideas, they will filter down and you will come out with some good ones at the end. But in the UK context, there is no doubt that it is viewed as being difficult to get that last stage over the line.

Q149 Chair: More difficult than other countries? Is the funnel narrower, if you like?

Dr David Clarke: I think you would say it was perceived that, compared with a lot of countries, the final hurdle—the investment decision around the £100 million or whatever the number turns out to be—is more difficult in the UK.

Q150 Chair: Is that a cultural thing? Is it a Government thing? What is it?

Dr David Clarke: I hate to say it, but I think it's all of the above. It is partly cultural. If you go to the US, it is easier, but risk is probably tolerated more in the US, for instance.

Q151 James Heappey: I want to be clear on what the total cost might be, because one of the concerns raised with me about retrospectively putting in district heat networks is that our housing stock tends to be pretty poorly insulated and the key component of a district heat network is that the heat cannot be degraded by any more than a certain tolerance as it moves from one property to the next. So actually there is a much bigger cost to doing this because of the requirement to insulate existing housing stock to a higher standard.

Dr David Clarke: What you have said is essentially true, and this is why new build is much easier than retrofit—much easier—but in principle I agree with you.

Dr Rotheray: I am not sure that that's correct, actually; I think there might be a little bit of a misunderstanding there. If you put district heating in, you can connect it into a typical gas boiler central heating system with no problem at all; and actually, the hotter the water in and the cooler it comes back, the more efficient the system becomes.

Chris Clarke: Fixed heat pumps are particularly susceptible to poor insulation.

Dr Rotheray: Yes, when you have low-temperature heating systems like a heat pump, you have more of a challenge. If you have high heat losses from inefficient buildings, you do have those challenges. With a district heating scheme, you want to maximise the temperature differential with water in and water out; that is how you make the system most efficient.

Dr David Clarke: That is absolutely right and it goes back to the point I made before. The district heating network, because you have high-temperature water coming in, can operate with existing radiator-type systems. An electric heat pump cannot, because it is low-temperature heat that comes out.

Chair: Do you have a brief supplementary question, James?

James Heappey: I will not detain the Committee further now. I have just been briefed something that I will seek to re-educate myself on offline.

Q152 Chair: Thank you. Sara Bell, the chief executive of Tempus Energy, recently told the Committee that distribution network operators are not innovation companies. Is this fair on the DNOs?

Dr David Clarke: Yes.

Chris Clarke: I disagree with that. We have two allowances that are available, and it is not just for the network operators. We have the network innovation allowance, which is fast, flexible, generally low value and generally aimed at providing, given that the consumer

is paying for this fund, efficiency for the consumer in the future. We have the network innovation competition, which is open, and we have a number of joint bids with other players in the market—a smart energy system for heat, which is run in association with the ETI. That is a good example of where external people can gain access to the network operators, which can then take these things and put them into practical use.

Dr David Clarke: The reason I said yes unequivocally—I apologise for it slightly—is because of the scale of investment that is needed to take some of these technologies forward. I apologise, but I just don't think the DNOs, in a regulated environment, have the capacity to handle that scale of investment. That is the real challenge.

Chris Clarke: In relation to the numbers you were just mentioning, the network innovation competition is only an £18 million pot in the first place, not the hundreds of millions that you are talking about.

Dr David Clarke: Whereas with a low carbon heating demonstrator—we have looked at the scope for how we could transition some of our work into a project of that scale—it is several hundred million for one demonstrator, involving probably 500 to 1,000 houses. It is an enormous cost.

Q153 Chair: In written evidence, the ETI suggested opening the low carbon networks fund to other types of company. Can I ask you why?

Dr David Clarke: It is very focused on the DNOs, which is the way it was set up to be, and projects are fronted by the DNOs. That does not mean it is exclusively delivered by the DNOs.

Chris Clarke: It's all in partnership.

Dr David Clarke: Yes, they are all in partnership. It involves academia and big companies as well. But I think it would be good if that kind of programme was open to being led by other individuals and other companies, provided that the DNOs were engaged in it, so that you would get a broader cross-section and potentially alternative routes to market for the outputs. Crucially, if you could do that, you would want to publicise much more widely the detail of what was coming out of the projects, but again, the budget just is not there in the existing fund to allow that to happen in detail, and to really promulgate some of the results into the market so you get good learnings across the sector with new players as well as the existing groups.

Chris Clarke: It is worth pointing out that we produce an annual report, but every single innovation project is published online.

Dr David Clarke: It really is the nuts and bolts detail—the real lessons learned. We have trouble doing that ourselves from our budgets, which are quite big.

Q154 Antoinette Sandbach: I am going to move on to thermal storage, and where that fits into the whole-system approach. There are a number of different types of thermal storage—sensible, latent and thermochemical. Where are we with these?

Dr Rotheray: The low carbon problem really is a storage problem. If we decarbonise transport and we move to a greater use of electric vehicles, we take out a whole load of fuel tanks. If we reduce our gas use, the gas network has a storage capacity and power stations with big piles of coal next to them. Really, the challenge is a storage problem. The kind of storage that we have at the minute is probably the cheapest, according to research that was done for the commission. Thermal storage costs about 100 times more than storing fuel in tanks and so forth. Electrical storage costs 100 times more again, so 10,000 times more than storing. In terms of what the different technologies are, yes, there are different technologies, and one of the best ones is just hot water. It is really cheap and simple.

Antoinette Sandbach: I am coming on to that.

Dr Rotheray: One of the areas of real interest is if we can have high-temperature thermal storage, because that is an industrial opportunity. Decarbonising industry in a way that keeps industry competitive is really hard, so some of those technologies are key.

Q155 Antoinette Sandbach: In terms of hot water, bearing in mind that people are ripping out their hot water tanks and putting in condensing boilers, or whatever it is, how are we going to link that in and stop that happening?

Chris Clarke: Could I just come in there? One of the issues we have got here, and I have read some of the other submissions to the Committee, is that there is a little bit of a gulf in the understanding of how much storage is required. Clearly, with condensing boilers, we take out our cylinder. But if you want to try to store heat, my estimate is that you would not just need your one cylinder for your daily storage; you would need 21 cylinders in your house. If you wanted to expand that to seasonal storage, my estimate is that you would need 1,351 cylinders in your house. I think the scale and the magnitude of this is a bit of a gulf at the moment, and it is an area that we really need to do some more evaluation on, just to understand the sheer scale of that storage.

I mentioned earlier that we are just doing the review of last week's slightly colder snap, and the daily storage used was about 481 GWh last week. Just to put that into the context of, say, the UK power network's battery storage, we would have needed 48,000 of them to cope with that single day. The challenge of low carbon is actually probably the challenge of storage.

Chair: Covering how many football fields?

Chris Clarke: I can give you Olympic swimming pools, if you like.

Dr Rotheray: Those are very fair points. Storage in homes is quite challenging. We can look at things like heat networks, and there is one just down the road in Pimlico that serves 3,000 homes. There is a 2,500-tonne water store, which was built 50 years ago, and it is still going strong. The larger your thermal store is—the water insulates itself, so they become highly, highly efficient. That thermal store in summer can provide all the residents' hot water needs for three days. I think one of the areas where thermal storage becomes an opportunity is where you build networks. One of the challenges is to make sure that we actually build that storage now in anticipation of the future.

What you see in countries that have started to integrate their systems more is that you use your thermal store as a buffer. In times where there is too much wind on the system, rather

than paying people to stop generating, which is an insanity, you actually pay the users to take excess electricity. They run big electric boilers, and they put that into the thermal store—that happens maybe during the night—and then when everyone gets up in the morning and has a shower, all that hot water is available. They see that on their bill as a reduction in their heating bill, rather than an extra cost on their electricity bill. We have got to involve the consumer in a move to a low carbon economy.

Q156 Antoinette Sandbach: In terms of the statistic you gave about heat storage being 100 times cheaper than electricity storage, what kind of heat storage are you talking about? Are you talking about water-based storage?

Dr Rotheray: Yes. As I say, we will see other things coming through. There is water-based storage, and the other thing—I do not know much about it, but I am told it is becoming more interesting in areas off the gas grid—is resistive heating and stores with Economy 7-type storage heating. They are becoming much better at storing heat and releasing it when you want it, rather than waking up in a boiling house and going home to a cool one. That is another way, and that technology has moved on quite a lot.

Q157 Antoinette Sandbach: You spoke about CfDs. In your written evidence, you said that thermal storage struggles to participate in an electricity market designed for large centralised generators. Can you give us a bit more detail on that?

Dr Rotheray: If you look at what our membership does, they are playing at the smaller scale. We have a system that was fundamentally designed—legitimately so—for large power stations. That was how we used to get economies of scale. We now get economies of scale from modular production, and we are seeing a lot more local energy, but the system has not been designed to cope with that. Just trading small amounts of power in the electricity system and doing things like demand management become difficult. For example, if you could do something like take power from the system and put it into a thermal store, or if you had a small CHP plant and could generate electricity and then put the heat into a thermal store, getting value for that is often much harder than if you are a larger player in the market, because it was never designed for it.

Q158 Antoinette Sandbach: So what do the Government need to do, as a regulator, to prevent those barriers?

Dr Rotheray: In the longer term, there is a real opportunity to move to greater local control. The local distribution networks becoming more actively managed and actually buying the services, or contracting for services at a local level, is something that does not happen. The entire system is traded as if everything happens at a theoretical point in the middle of nowhere, as opposed to what actually is needed in London, Cardiff or wherever. More local action is probably what is needed. It would be one way in which you could remove some of those barriers.

Dr David Clarke: We are developing toolkits that we expect to be used at local authority level, for basically designing a local area energy system. That is exactly where you play that. There is an element in this of trying to find the right balance between central diktat, regulation and control versus local implementation. You have to recognise that there is a key role for local authorities in this in the future, because it is going to be so location-specific.

Dr Rotheray: By way of example, if you have a sunny, windy day, you might be producing a large amount of electricity on the system, which will push down the power price, and that will say to people, "Don't generate electricity because there's a low power price." You might come into the middle of London, which has a cooling problem, and all of the cooling units are going flat out. In London, you want people to be generating electricity. You do not get the signal, so your local guy is sat there going, "Well, I can generate you some electricity," but no signal comes. Those kinds of issue will become increasingly important.

Q159 Antoinette Sandbach: Have you been to talk to the National Infrastructure Commission?

Dr Rotheray: We will, but we have not yet met them.

Chris Clarke: Just one point—unlike the electricity network, we are the system operator as well on a very local level. Some of the points Tim made were about what we do on a day-to-basis, managing the storage between National Grid, ourselves and the very localised plant storage. The model you are describing is not a million miles away from what we already do.

Dr David Clarke: It is not that common elsewhere, though, I don't think, is it?

Chris Clarke: That is how the gas networks operate. It is just different from the electricity network, so it is about understanding that there are different models.

Q160 Chair: We are coming towards the end. Dr Rotheray, you touched on something that is a perennial—in fact, a weekly—question in my mind. You mentioned the reduction in heating bills. You also mentioned a windy day pushing down power pricing. The levy control framework is an element of the bill. We tend to know what this is but we do not tend to know the effect of the levy control framework. You gave an example of the infrastructure that has been built as a result of it. When there is a windy day and a lot of energy is being produced, the wholesale price is depressed. Any idea what saving the consumer benefits from, given what you indicated about a lower price of energy that turns up? We know what the costs are but we do not know what the savings are.

Dr Rotheray: In some ways, the contract for difference is designed to ensure that you have neither savings nor increased costs because you guarantee the generator a certain amount of money.

Q161 Chair: Ministers from DECC are forever telling us about the costs today of one side of that. I am just interested. Sorry, I should let you carry on with your flow.

Dr Rotheray: I was going to say that as the electricity price falls, the greater the top-up from the CfD but, as the electricity price rises, people are paying back. The long-term cost fall should be from the cost fall in those technologies as they come online.

Q162 Chair: But sometimes the cost, as you indicated, has fallen because of the wind that is being dumped on the system. That affects the wholesale price.

Dr Rotheray: Yes, it will have an effect on the wholesale price and on the purchase price of the electricity. At the moment, the way that we meter and invoice customers means

that it probably has no effect on their bill. What we could do in the future and what we would love to see more of is half-hourly metering, where there is lots of electricity and you reward people for using it. Then you could see electricity bills falling. At the moment, you would not actually see a difference.

Q163 Chair: Are you saying that without the levy control framework element in the bill, we would just see a higher price? Does it cancel each other out?

Dr Rotheray: The levy control framework is effectively designed to cancel itself out.

Q164 Chair: So it is a red herring to complain about it.

Dr Rotheray: It is a red herring to complain about?

Q165 Chair: That component of your bill.

Dr Rotheray: One of the discussions that we had with the Government when they designed the CfD was that the nature of low carbon technologies with low-cost operating means that it has a tendency to push down wholesale prices. Therefore, you will see lower wholesale prices. That money effectively moves on to the levy control framework and then on to the customer bill.

Chair: Okay. Thank you very much. I thank you all very much for your time and for sharing your thoughts. It is very much appreciated.