HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: The role of Hydrogen in achieving net zero, HC 1066

Wednesday 7 July 2021

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Watch the meeting

Members present: Greg Clark (Chair); Aaron Bell; Dawn Butler; Chris Clarkson; Katherine Fletcher; Mark Logan; Rebecca Long Bailey; Carol Monaghan; Graham Stringer; Zarah Sultana.

Questions 333 - 421

Witnesses

I: Professor Katsuhiko Hirose, CEO and Chief Consultant, HyWealth Co., and Visiting Professor, 12CER, Kyushu University; and Professor Takeo Kikkawa, distinguished fellow at the Graduate School of International Management, International University of Japan.

II: Eric Heymann, Senior Economist, Deutsche Bank Research; and Franz Lehner, Head of International Cooperation, NOW GmbH (The National Organization for Hydrogen and Fuel Cell Technology).

III: Dr Jane Dennett-Thorpe, Deputy Director of Decarbonisation and Energy Transition, Ofgem; and Dr Martin Hanton, Technical Director, TUV SUD National Engineering Laboratory.

Examination of witnesses

Witnesses: Professor Hirose and Professor Kikkawa.

Q333 **Chair:** The Science and Technology Committee continues our inquiry into the role of hydrogen in achieving net zero. This morning we are taking evidence from experts from Japan and Germany. Then we will hear about some of the challenges for domestic metering and regulation more generally.

Without further ado, I am very pleased to welcome and introduce our first panel of witnesses, both joining us from Japan. They are Professor Katsuhiko Hirose, who is the visiting professor at Kyushu University and, for 38 years, led the Toyota Motor Company's research into hydrogen-powered cars. We are also pleased to have Professor Takeo Kikkawa, who is a distinguished fellow at the International University of Japan and has published extensively on Japan's energy policy. I thank both professors for joining us today.

Perhaps I can start with Professor Hirose and then I will ask Professor Kikkawa the same question. Would you summarise the proposed role of hydrogen in Japan in reducing greenhouse gas emissions?

Professor Hirose: Thank you very much. Good morning, everybody. It is a great honour to talk here.

Japan initiated its hydrogen strategy a few years ago. It has a long history for Japan. We started with hydrogen as a form of energy security because we import a huge amount of our energy from outside. Especially after the Fukushima case, we import more than 90% of our energy from outside. Hydrogen is very important to replace our sources of energy and reduce the energy amount, because when you convert from fossil to hydrogen energy, especially for fuel cells, you can reduce the total energy amount. That reduces the amount of energy we have to import. Of course, by becoming carbon neutral, that is the only way to import energy from outside, and also using more internal energy like renewables. But renewable energy is far away from the centre of Japan. Japan still has the world's third largest GDP based on manufacturing. Also, the size of this power is three times bigger than that of the UK and 1.5 times bigger than Germany. Hydrogen will be very important both for the future energy of Japan for international trade in energy and also using more domestic energy. That is why Japan bet on hydrogen.

Q334 **Chair:** Thank you very much indeed, Professor. I will put the same question to Professor Kikkawa. How do you see the role of hydrogen in Japan in the years ahead?

Professor Kikkawa: I am very honoured to speak here. Last October, Japanese Prime Minister Suga announced the realisation of a carbon-neutral society by 2050. Hydrogen technology is the most important key technology to achieve a carbon-neutral Japan. That is not only for power generation on the industrial side, but in public life hydrogen energy is

very important. On the industrial side, for example, our iron and steel industry must change its manufacturing processes totally. We normally use coke and must change to using hydrogen. Steel and gas companies changed from using methane gas to synthesised methane. That was made by CO_2 and hydrogen. At least in Japan methanation is one of the carbon-free methods. So, not only in power generation but also on the industrial side and the life side, we have the realisation of carbon neutral. Hydrogen technology is crucial. That is my point.

Chair: Thank you very much indeed. I am going to take some questions from my colleagues, starting with Zarah Sultana and then Aaron Bell.

Q335 **Zarah Sultana:** Thank you, Chair. I will start with Professor Kikkawa. Are there particular sectors of the economy where Japan is focusing on using hydrogen and what is the reason for this?

Professor Kikkawa: The most important reason is carbon regulation, which should be stronger in the future. Right now, Japan's carbon price is very low at 300 yen. Many industrial persons are expecting that it should be 10 times bigger than the present standard. Therefore, to decrease the carbon regulation burden they must make a change, especially in the iron and steel and petrochemical industry. The iron and steel industry is the biggest producer of CO_2, and the second biggest is the chemical industry. Therefore, it is very important for both of them to use hydrogen.

Q336 **Zarah Sultana:** Thank you, Professor Kikkawa. Professor Hirose, would you like to add anything to that?

Professor Hirose: That is correct. Japan emits one gigaton of carbon dioxide every year currently. One third is from power generation and one third from industry, and, within that one third, half is emitted from steelmaking. Japan still produces 10 million tonnes of steel. That is the biggest obstacle to reach carbon neutrality. Using hydrogen will be a key technology to decarbonise those huge industries.

Q337 **Zarah Sultana:** Professor Hirose, Japan, according to CEDIGAZ, the international natural gas association, has "the world's most ambitious vision" for hydrogen. What do you think are the strengths and weaknesses of this national strategy that Japan has for hydrogen?

Professor Hirose: Japan has a long history of developing hydrogen technology. Japan is proud of its history of innovation. It is proud to have initiated the solar panel semiconductor and the lithium-ion battery. We are proud to have contributed to changing the world. We lost most of our industry as it has gone out of the country. So we must not lose this opportunity or challenge. Hydrogen is a challenge for technologies, but it may have huge potential for our industrial business or other business. That is why we are going to have a very ambitious target.

Q338 **Zarah Sultana:** Professor Kikkawa, what do you think are some of the strengths and weaknesses of this strategy?

Professor Kikkawa: There are two points in Japan concerning hydrogen. One is the technology of fuel cells. Japanese companies have the biggest patents all over the world in the fuel cell field.

The second point is that we Japanese think that to import hydrogen from abroad is very important. Therefore, we focus on shipments of hydrogen. In that field, we have some unique technology. Most of them are at a *[Inaudible.]* point in Japan. On hydrogen infrastructure, Japan is not so strong in comparison with Europe and America. For example, with regard to the hydrogen pipeline, perhaps in Europe and the USA they have 3,000 km pipelines for hydrogen. In Japan, there is almost none. That is a weak point.

Q339 **Aaron Bell:** Thank you to both of our distinguished professors who are our witnesses today. Following on from my colleague Zarah Sultana, what would you say is unique about Japan's hydrogen strategy? What things that are specific to Japan are not being done anywhere else in the world?

Professor Hirose: As I said, Japan is importing a huge amount of energy from outside. Previously, we needed best efforts to secure our energy from certain countries because oil is produced from limited areas, and also the path is a very fragile path. If you convert from these to hydrogen, there will be huge potential partners to import energy, like Australia or Chile. That diversification reduces risk of those kinds of uncertainties. At the same time, we have buying power for the energy. Currently, we are the biggest importer of energy. When, in future, we choose low-carbon energy from outside, we have buying power to choose the proper partner. This is one of the strengths.

Unfortunately, we do not have an oil industry or gas industry, unlike the UK. That means switching from fossil to hydrogen *[Inaudible.]* point.

Q340 **Aaron Bell:** Professor Hirose, obviously Japan is putting a great deal of emphasis on becoming this hydrogen society. Is that debate now largely concluded? Is that a settled strategy? Prime Minister Suga has said that you want to be carbon neutral by 2050. Have you considered other technologies? Is that debate still going on?

Professor Hirose: The debate is not so strong. In the past there has been some debate about how we should bid for battery or not. Most of the people realised that we need both. To use more renewables, we need hydrogen to store the electricity and also we need the hydrogen to import, because we cannot import electricity from outside. Currently, our renewables are relatively expensive because of our weather. We have typhoons. Our solar panels and wind turbines need to be able to stand the strain against very strong typhoons and earthquakes. We cannot just rely on our own renewables. That is why we recognise that a portfolio strategy is necessary for Japan. Hydrogen and electricity need to be developed in parallel. That recognition is ongoing in Japan.

Q341 **Aaron Bell:** Professor Kikkawa, I am interested in your perspective on

the same questions because you have been sceptical about hydrogen, and particularly the costs, in the past. Do you think that the debate is largely over in Japan—that a hydrogen society is the goal that you are working towards?

Professor Kikkawa: Yes. Of course, hydrogen is important, but hydrogen alone cannot realise a carbon-neutral economy. By 2050, Japan wants to realise a zero carbon economy. Concerning electricity generation, about 50% to 60% will be by renewable energy; right now it is about 20%. So it will be three times bigger. Ten per cent. will be hydrogen and ammonia for electricity generation. This figure will rise to 30% to 40% of electricity generation and nuclear. It is a very tricky point. It is my opinion that the nuclear percentage in 2050 will be about 10%. That means that 30% to 40% will comprise of hydrogen and ammonia and 50% to 60% will come from renewable energy. That is the Japanese Government's plan right now.

Q342 **Aaron Bell:** In terms of costs, you have said yourself that the big bottleneck is carbon capture and storage, and it is the economics of hydrogen. Do you think that Japan can make hydrogen economically viable as its energy source, how will it achieve it, and by what date do you expect Japan to make hydrogen economically viable?

Professor Kikkawa: Cost is the biggest problem. The target for hydrogen cost in 2030 is 30 yen per normal cubic metre of hydrogen, and for 2050, it is 20 yen. That means the same cost right now of our energy generation—that is the target. But I think that will not be so easy. We need some innovation. Not only do we need technical innovation, but institutional innovation is needed—for example, an international offset system.

Q343 **Aaron Bell:** Those are the target prices by 2030 and even 2050.

Professor Kikkawa: Yes; 30 yen by 2030.

Q344 **Aaron Bell:** I have them here in dollars, but, obviously, they are the same number. How confident are you of reaching those targets and how much Government investment will be needed to get to that level?

Professor Kikkawa: In my opinion, the biggest global enemy is on the demand side. The bigger the demand, the cheaper the cost—the benefits of scale. The biggest demand expectation is hydrogen power generation, but there is no plan for hydrogen generation in Japan. That is the biggest problem.

Q345 **Aaron Bell:** Professor Hirose, can I turn to you about the economics? How confident are you that Japan can make hydrogen economically viable?

Professor Hirose: When you talk about energy costs, there are two parts to them. One part is what people pay for this, but also the energy costs to society can be slightly different, because when you pay at a gas stand for one litre of gasoline, you pay almost 40% or 50%, and that is

money just going out of Japan. Only 10% to 15% remains in Japan and the rest is tax. So this is the total cost for the customer. When you produce energy for yourself in your domestic setting, the money you spend is circulating within the internal economy. The cost to the customer is identical. The customer doesn't care whether you pay the same amount for gas at the stand or for electricity, but it has a completely different meaning for the economy of the country.

As Professor Kikkawa has said, 30 yen per normal cubic metre is equivalent to around $3 per kg, or £2.30 to £2.40 per kg, of hydrogen. That is achievable, but that cannot be completed in the foreseeable future without carbon pricing for the customer. If you can produce energy by yourself, the overall cost for the economy is much less than what you pay at the gas stand compared with money spent outside Japan.

Many people have said that hydrogen will be expensive, but whether that is just expensive for the customer or for the economy, we need to differentiate these calculations.

Sooner or later, electricity will be much cheaper because the investment costs decrease. Then you need a 50 kWh of electricity to produce 1 kg of hydrogen. If the 2 cents per kWh is achieved, the hydrogen will be less than $1 per kg, as an energy source. We need to think much more deeply about the cost.

Aaron Bell: Thank you very much, Professor Hirose. My colleagues have a few more questions on the economy.

Q346 **Rebecca Long Bailey:** Thank you both for speaking to us today. I note that between 2012 and 2018 Japan spent £1.2 billion in hydrogen technology development for the production of both green and blue hydrogen. What is Japan's hydrogen strategy in relation to the production of blue hydrogen over the long term? Is it to be used temporarily as an interim measure in the shift to green hydrogen or is it planned to be rolled out as part of the mix in the long term?

Professor Hirose: I think that is the most difficult question to answer. The question is also: how serious are we in reducing carbon dioxide emissions? If we want a very quick reduction of carbon dioxide, blue hydrogen is good to improve the efficiency of vehicle or trucks. In the long term, of course, green hydrogen is necessary. This is a question of how quickly and how seriously we reduce the carbon dioxide. Both are very important.

Q347 **Rebecca Long Bailey:** I put the same question to Professor Kikkawa.

Professor Kikkawa: There is a very big difference between your country and Japan. In your country, in the UK, I think only green hydrogen is acceptable. In Japan, many industrial persons think that up to 2030 blue hydrogen is more important than green hydrogen. After that we will shift from blue to green, step by step, until 2050. Therefore, the Japanese Government and Japanese industry also think that both blue and green

hydrogen and both blue and green ammonia is almost the same. That is the very big difference between the two countries.

Q348 **Rebecca Long Bailey:** Thank you. That is very helpful. More generally, what incentives and support, both in research and development and also market subsidisation, are the Japanese Government providing to meet these very ambitious targets? I put that first to Professor Hirose.

Professor Hirose: The history of incentives in Japan for innovation is more R&D than commercialisation. Because of the *[Inaudible.]* issue of lithium-ion battery and so on, the discussion is ongoing as to how to implement more in commercialisation, how to connect the current and develop the technology into the commercialisation.

I think the Japanese Government have allocated $20 billion for stimulation. Of the $20 billion, I think $3 billion is to accommodate international trade to support the hydrogen trade and so on, and $700 million for the development of the technology. That is the temporary target for Government spend. But the discussion is ongoing as to implementation, as Professor Kikkawa said, because demand is very important to reduce the cost of implementation. How to stimulate the demand and how to incentivise those people to accelerate the use of low-carbon technology is under discussion. It has not yet been decided.

Q349 **Rebecca Long Bailey:** Thank you. I put the same question to Professor Kikkawa.

Professor Kikkawa: The Japanese Government gave subsidies, help and support to industry. Some parts are good but some parts are not good. The good part is fuel cell. Right now in Japan, there are about 4,000 fuel cell vehicles and 140 hydrogen refuelling stations, about 100 fuel cell buses, and about 200 to 250 fuel cell forklifts and so on.

On the other hand, the number of people using hydrogen in a fuel cell is not so big. It is only 1% or 2% of total electricity use. Therefore, the main target is for hydrogen generation, but, in that field, the Japanese Government help is not so valid. Therefore, field by field, the situation is very different. That is my impression.

Rebecca Long Bailey: Thank you both. Those were very helpful answers.

Q350 **Mark Logan:** It is almost good evening to both Professors Hirose and Kikkawa. I have a few questions around how Japan's hydrogen strategy may affect or have an impact on the UK. What can the UK learn from Japan's hydrogen strategy?

Professor Hirose: As I said, Japan is good at planning the future, but sometimes it fails to implement those technologies. UK and Japan share some islanders' feelings as we are both surrounded by the sea. Energy is limited by those barriers. We need to import a lot of energy. The

difference is that you have a huge amount of offshore wind and very shallow waters, but Japan has a very deep sea, just off the coast.

The good thing about the hydrogen strategy is that you can make your own strategy by yourselves. For the oil or fossil fuel, geographical and geopolitical issues are the main issues to decide the strategy, but for hydrogen Japan can decide its own strategy and the UK can decide its own strategy. There are some collaboration points, such as how we define blue and green hydrogen, how we deal with those kinds of emissions in total, how we achieve the total emissions and also how we increase the business together. There is a lot of potential to collaborate, but strategy can be independently developed. That is the unique point of hydrogen.

Q351 **Mark Logan:** Thank you. Professor Kikkawa.

Professor Kikkawa: Of course, there are many points that we Japanese should learn from your country. Your question is in the opposite direction. As far as hydrogen is concerned, there are two points. One is fuel cell technology. Of course, you prefer EV—electric vehicles—but, for example, for the commercial car or long-distance car, especially commercial trucks and buses, maybe fuel cells are more excellent. Therefore, in that field, maybe our technologies are useful for your country.

The second point, as Professor Hirose said, is that both countries are island countries. Maybe we must import some hydrogen. We are now developing two big technologies. One is related to hydrogen, and the second one is hydrolysis. From these technologies, maybe you should learn from Japan, I think.

Q352 **Chris Clarkson:** Konbanwa sensei. I want to take my colleague's question and turn it around. Are there any elements of Japan's hydrogen strategy that the UK should not be following? How do you think our approach to hydrogen should differ from Japan's?

Professor Hirose: You have a huge potential for wind power already. You should use that the most and hydrogen to enhance its use. I understand that you have a lot of arguments about the efficiency of hydrogen: efficiency is very important in deciding the future, but economics is more important. I always said that this is something like milk and cheese. You have a lot of production of milk in summer. If you convert it to cheese, you can eat it in winter and you can trade. The efficiency is less but the economics can be better.

We need to create more ideas to develop towards carbon neutrality. Japan is thinking that the portfolio of the future is not just deciding one technology. Japan is also working with some combustion engines with hydrogen. Carbon neutrality is not a goal. A sustainable society and life is the goal. Towards this, we need to use a wider diversity profile of the future. That is probably Japan's thinking. In the UK, you also have to think much about that. That is my opinion.

Professor Kikkawa: The most important point is a cost cut, especially a cost cut for green hydrogen. Green hydrogen is made by electrolysis of water using surplus renewable power. That means that, if a country has enough surplus renewable power, that is very advantageous. Therefore, I think the new technology or more efficient technology of electrolysis of water will be born in European countries, including, of course, the UK. Therefore, after that, Japan will run that technology. Efficiency of electrolysis is essential to make hydrogen economic. That is why the origin should be in Europe, I think.

Chris Clarkson: Arigatou gozaimasu. That is it from me.

Q353 **Chair:** Thank you very much, Chris. There are a couple of final questions from me, if I may. Starting with Professor Hirose, you have great experience in the motor industry with the Toyota Motor Corporation, and you have been very closely involved with the development of fuel cell technology, I know. What we see around the world are different technologies that have the potential to be clean and green but to an extent are alternatives. The question is whether one is going to predominate or whether the two are going to co-exist.

Clearly, in passenger cars we have battery electric vehicles and we have fuel cell vehicles. What is your assessment and prediction of what will happen in the long term? Will one predominate or will both exist?

Professor Hirose: The biggest argument, as I say to my friend Michael Liebreich, is that we agree on the importance of hydrogen, but we are struggling with whether that can be applicable for the passenger car or not. Usage and mobility are freedom in your life. The customer decides not only energy efficiency but the cost of the fuel, because a car or mobility is always a reflection of your lifestyle. A bicycle is definitely the most efficient form of mobility with the least emissions, but you cannot force my 80-year-old parents to ride a bicycle on a rainy day. We need mobility.

Mobility can be chosen by the customer. We need to provide options for people. If you have several people together, that is not the case in the UK or Japan any more, but for south-east Asia and the rest of the world the families are still much bigger. Also, you need to carry a huge amount of luggage. We need both technologies. As long as it is economic and environmentally feasible, this will remain an option. Of course, for small passenger cars, the battery vehicle will be much easier to build. Also, there is the issue of the economics value chain. With decarbonisation, we are trying not to import a lot of energy from outside, but we need to import a huge amount of battery material or battery cells. So economics-wise it compensates, instead of sending cash to another part of a continent. That is not very feasible.

We need to think about the long term. As we discussed here, hydrogen will be available widely because of the decarbonisation industry and so on. In that case, the customer can choose the fuel, both battery and

hydrogen. That is a reasonable option. So we do not need to decide our children's mobility now.

Q354 **Chair:** Thank you for that. My final question is to Professor Kikkawa. Thinking about the costs of this, we know that there are going to be transition costs. There is a very long-standing debate in this country as to whether these transitional costs should be paid for by consumers through levies on their bills or whether they should be met by the Government from general taxation. You have pointed out some of the costs and you have said that, principally, it has been research and development where subsidies have been made. Is there such a debate taking place in Japan as to whether it should be paid for by consumers or by taxpayers in general? What is your view as to what should be done?

Professor Kikkawa: We have the same debate in Japan. The Ministry of the Environment favours a tax-style payment. On the other hand, METI—the Ministry of Economy, Trade and Industry—is separate and different. That means not a tax style but some kind of offset system—to pay an emission-light system. They are worried about two industries. One is the energy-consuming industry. The second one is SMEs—small and medium-sized enterprises. This is a very big debate between two Ministries in Japan.

Chair: Thank you very much indeed. I am very grateful to both Professor Hirose and Professor Kikkawa for giving us a very current perspective on this debate and practice in Japan. We are very grateful for your evidence today. We look forward to drawing on it when we write our report. Thank you very much indeed to both professors.

Examination of witnesses

Witnesses: Franz Lehner and Eric Heymann.

Q355 **Chair:** We will now move straight on to our second panel of witnesses. I am very pleased to welcome two witnesses who are going to talk about what is going on in Germany: Franz Lehner of Germany's National Organisation for Hydrogen and Fuel Cell Technology, which supports Germany's National Hydrogen Strategy; and Eric Heymann, who is the senior economist at Deutsche Bank Research in Frankfurt. Thank you for joining us today.

Perhaps I could start with Mr Lehner. Could you summarise the key elements of Germany's National Hydrogen Strategy?

Franz Lehner: Thank you. It is an honour to be here on this panel. Let me start with a quick summary. The German Government have brought together five Ministries—the lead was the Ministry for Economic Affairs and Energy—to bring together the strategy across the different branches of Government. It took a bit longer than was initially anticipated, but about a year ago the strategy was launched. It combines existing programmes of Government with future needs to make hydrogen an integral element of the energy transition.

There is a broad acknowledgment in the Government that hydrogen will be a key enabler to get to net zero, and that additional time was needed to get an agreement about the specifics of that, which is not always easy.

The strategy also includes 38 very specific measures across different sectors, starting from hydrogen production through hydrogen use, hydrogen use in mobility, in industry, as well as in heat, infrastructure and supply, and also research, education and innovation. I would like to highlight at this point that an emphasis of this strategy is also an international topic. Germany is aware that we will also continue in the future importing energy as we do today, so it is important to start looking now at potential future energy partnerships from the energy source hydrogen.

Why is hydrogen an integral part of the energy system in Germany? First and foremost, from the German perspective, it is an all-renewable future in the long term, and that means we will mainly use solar and wind energy, and then the next step to turn that into molecules is hydrogen. Hydrogen is then the counterpart to direct electricity use. Wherever we cannot use hydrogen, we would then use synthetic fuels and other derivatives of hydrogen. Because we are not a country with fossil resources to a large extent, it is quite clear that it is renewables in the first place.

Q356 **Chair:** Thank you very much indeed. That is very helpful. Mr Heymann, you have written that you think that "hydrogen will probably only make a small contribution to the national global energy transition in the next one or two decades." Just thinking of Germany and the national contribution, could you explain a bit about what was behind your thinking in making that assessment?

Eric Heymann: Good morning also from my side. It is also a pleasure to be here. Thank you for the invitation. When you look at pure green hydrogen, this source will be scarce in the next few years and also expensive, and therefore the absolute contribution to energy supply will remain small. You have to build up the infrastructure, the production sites, to produce hydrogen. You have to have enough renewable energies to produce pure green hydrogen. You have to build up the infrastructure for transportation and distribution, and this will all take time. Therefore, for at least the next 10 years, the absolute contribution will be limited. But, of course, we have to start at some point in time. Therefore, this strategy is a good starting point, and, as Franz Lehner said, it contains all major issues that are related to the inclusion of green hydrogen into the energy transformation.

Q357 **Chair:** So your caution about the contribution is based on the constraints that the capacity imposes.

Eric Heymann: Yes.

Q358 **Chair:** I see. Thank you very much.

Eric Heymann: Yes, exactly. You have economic constraints, but also time constraints because building up such plants takes some time in terms of the process that you need to be allowed to build up those plants and so on. As Franz Lehner said, the Government are aware that we need a large share of imports of green hydrogen, and most of these sites are not yet there in these countries where we want to import from.

Q359 **Dawn Butler:** Thank you to the witnesses for coming in today. Can I pick up on something that the Chair asked Mr Heymann in regard to the importing of green hydrogen? If you have to import green hydrogen, would that then contribute to Germany hitting its net targets?

Eric Heymann: Yes, of course it would contribute, but you have to fulfil some conditions, and this is also mentioned in the National Hydrogen Strategy. This hydrogen also has to be produced by renewable energies abroad, and also transportation from there to here has to be in a way that is as climate friendly and carbon neutral as possible.

I listened to the last 15 minutes of the former session. Ammonia might be a solution to transport from countries with better and more constant weather conditions to produce green hydrogen. This is, of course, also work in progress. We are at the beginning of a learning curve and we hope to make positive experiences in this process in order to reduce costs and to give those countries that are supposed to produce green hydrogen the reliability that there is demand at the very beginning.

Q360 **Dawn Butler:** You think there will be a net benefit even though you are going to have to import the green hydrogen.

Eric Heymann: A net benefit for both sides. You have to find ways to transport this green hydrogen in a climate-friendly way. I always try to avoid "climate neutral" because this is very high level. Climate-friendly ways to transport hydrogen and ammonia from countries where you have good conditions to produce this hydrogen to Germany or to Europe are, of course, a precondition for a climate-friendly inclusion of hydrogen. We are not able to produce all the amount in Germany, especially if we want to keep a high level of energy-intensive industries in Germany, which will probably be the main users in the first years of green hydrogen.

Q361 **Dawn Butler:** Thank you very much. Mr Lehner, why the focus on green hydrogen and not include grey, blue and pink hydrogen?

Franz Lehner: The position of the German Government, which is reflected in the National Hydrogen Strategy, is that only green hydrogen is a sustainable pathway in the long term. The German Government acknowledges that blue hydrogen might be available in the short term and then it would not be excluded. However, funding and the regulatory framework in Germany will likely be designed to support only green hydrogen. At least, that is the position in the hydrogen strategy.

With other ways of producing hydrogen there are several types of limitations. With blue hydrogen from, for example, natural gas, there are

residual emissions. It helps in the short term to get down from grey hydrogen to reduce by 80% or 90% compared to grey hydrogen.

In the long term, when we really want to get to net zero, any residual emissions will have to be abated in an additional way, and that has to be taken into account. We have to make this decision now whether to do only green or several options. Because we know in the end it should be green, there is no reason now for investing in blue for just a short period of time, because both technologies will need investments and ramp-up, and both are not instantaneously available. Very often, the discussion is that green hydrogen takes longer and that is why we use blue hydrogen, but I have not seen strong evidence why blue hydrogen would be instantaneously available. Both take time.

Q362 **Dawn Butler:** Great; thank you. What incentives and support are the German Government providing to help meet the necessary targets?

Franz Lehner: The strategy sets targets for the deployment of water electrolysis capacity—5 GW electric input capacity by 2030 and another 5 GW between 2035 and 2040.

Ways to realise the specific incentives are, I would say, still in the making, but what is currently being launched is a programme that would support the import of green hydrogen from elsewhere in the world to Europe or Germany. That is the so-called programme "H2 Global", which works with a contract for difference scheme where the Government would cover the difference between the production costs somewhere in the world, which is auctioned, and the highest bidder price in Germany, which is auctioned. That is intended to kickstart the first, larger-scale deployments, exactly as Mr Heymann said, by doing an auction system to identify the best locations on the globe where low-cost renewables are available and where low-cost hydrogen can be produced, and, in the first instance, probably in the form of a derivative like ammonia, it can be delivered to Germany.

Q363 **Dawn Butler:** I see. Great. Thank you very much. Germany wants to be the leader in hydrogen technology. Why?

Eric Heymann: If we do not lead in football, maybe it is good to lead in hydrogen. Maybe it is a kind of typical political approach. We want to be the leader in e-mobility. We want to be a lead market. It is the German attitude with its focus on innovating and developing capital goods for international clients. It belongs to the German business model to be good in such technologies. Since we need alternatives, and we cannot rely only on weather-dependent renewables, we need some other technologies, and hydrogen is one of these. Also, we have the sectors that are the initial users, such as steel, chemical industries and building materials. We have experience in terms of transportation and distribution, and therefore maybe the political attitude is, "If we want to do it, we want to be the best." Of course, this is also a political statement.

If I am allowed, I would add one comment on this question of the different colours of hydrogen. I said at the beginning that pure green hydrogen will be scarce at the beginning. At the same time, you want the industry, especially the industry-intensive energy, to transform their production sites from the traditional forms of production to integrating any forms of hydrogen. You also need a guaranteed demand. If there is not a guaranteed demand in production sites, there are little incentives for those countries that are supposed to produce, so you need both. Therefore, at the beginning, at least for the first five, I would say, or, rather, 10 years, you should, in my eyes, not be too strict on this question of colour of the hydrogen, because you need both. You have to ramp up those sites where you can use hydrogen.

If you allow only green hydrogen, there will not be enough at the beginning, and therefore there is no incentive to invest for the energy-intensive industries. At the same time, there will be some time where you have mixed hydrogen types, and this allows also for the producer countries to ramp up capacity. This is probably an issue that, at least from a climate perspective, you can discuss. From an economic perspective to create economies of scale to ramp up all the infrastructure, I would not be too strict in terms of the colour. As Mr Lehner said, the National Hydrogen Strategy addresses that there will be blue hydrogen at the beginning.

Q364 **Dawn Butler:** So, Mr Lehner, you should not reduce your capacity to just green hydrogen; you should try to expand it to include blue. Do you agree?

Franz Lehner: The position of the strategy is that Germany only sees green hydrogen in the long term, and it is acknowledged that in other countries there may be blue hydrogen in the short or mid-term, and therefore it is not excluded. I think there is a clear vision that, at least for Germany, without fossil sources in our own country, green hydrogen is the way to go.

We want to lead in that field because it is an industry that has to be scaled up in that area with water electrolysis using hydrogen, for example, fuel cell technology, but also the production of renewable electricity. That all offers opportunities for the German industry to take a lead in that development. That is the other reason why the political statement is to be a leader here.

Dawn Butler: Thank you both very much. I hope that you might be cheering on England tonight. Thank you very much.

Q365 **Chair:** Thank you, Dawn. Mr Lehner, obviously, with blue hydrogen, you need to mitigate and contain the CO_2. Does that require a contemporaneous programme of subsidy to contain the CO_2? Is that provided for in the plan?

Franz Lehner: Blue hydrogen is not part of the strategy. There are no specific plans to support it. If you wanted to incentivise blue hydrogen,

the capture of emissions, it would probably work through a certificate system that low-carbon hydrogen has a higher value than grey, regular hydrogen. That would then finance the additional investments for capturing and storing the CO_2. But there are no plans in Germany at the moment to come up with an incentive to do that.

Q366 **Chair:** Indeed. To turn the question round the other way, is it the fact that the plan relies on green hydrogen because of a reluctance to engage in the costs of mitigation of the blue hydrogen?

Franz Lehner: There is no incentive for Germany to support blue hydrogen per se, but there is an incentive for Germany to support green hydrogen because it offers an industrial opportunity. That is probably the reasoning behind that. As I said, with the residual emissions that you still have with blue hydrogen, it is a question that sooner or later comes up, because for a few years now we are not discussing 95% reduction any more but net zero. Any residual emissions are a concern, and green hydrogen is a route where you have essentially zero emissions as soon as you also enable the production of the equipment with zero emissions.

That is why the German Government focuses on green hydrogen. Storing CO_2 that is captured is also a finite resource. The storage capacity is also not limitless. You run into a similar problem as with fossil fuels, just in a slightly different perspective. I think that is why the focus is on green.

Chair: Very good. Thank you very much indeed. I will go to Rebecca Long Bailey and then Zarah Sultana.

Q367 **Rebecca Long Bailey:** Thank you both for speaking to us today. We have just been speaking about green hydrogen and the preferential support of green hydrogen. Is there any strategy for businesses that might want to adopt blue in the first instance and transition to green, or is it very clear that there will be no direct Government support for blue-hydrogen operations and only green?

Franz Lehner: I could see that users of grey hydrogen today—for example, refineries that have steam-methane reforming with natural gas in place already—could be quicker and easier to transition back to blue hydrogen. Those may be cases where you already produce grey hydrogen and it is then easier to get to lower-carbon emissions by using blue hydrogen without having a specific programme to support blue hydrogen, but just by using the pressure from the ETS trading scheme to get your industrial emissions down you might switch to blue hydrogen.

When you are talking about greenfield deployments, starting with new hydrogen production sites, I would not see a strong reason why we would build from scratch blue hydrogen instead of green. Both sites have lead times and need to be constructed.

Q368 **Rebecca Long Bailey:** Thank you. Mr Heymann, is there anything you would like to add to that?

Eric Heymann: As far as I understand, the discussion is that it is not excluded; on the imports side blue hydrogen is integrated. I have no idea how we could exclude that, at least in the beginning. When I joined several discussions on the integration of hydrogen into the industrial value chain during the last few months, especially the potential users in the energy-intensive industries said that at the beginning they probably will need enough amount to ramp up.

Looking at, for example, the steel industry, the shift from coal to natural gas to hydrogen is an improvement in terms of CO_2 emissions. If the shift is a transitory process at the beginning with a mixture of green and blue hydrogen, or even at the beginning with natural gas instead of coal, that would be an improvement. As far as I understand, there is no exclusion of the usage, and you have to put a price on it. Green hydrogen is more valuable in terms of CO_2 pricing. At the same time, if you pay a higher price for blue or even grey hydrogen, and it is still worse for you to ramp up capacities, then why should we do that at the beginning? In terms of improvement from coal to gas, it would already be a huge improvement in the steel industry, for example.

Q369 **Rebecca Long Bailey:** Thank you. More broadly, what have you seen recently in response to the Government's strategy from industries in terms of market response and investment by particular businesses? Has it had a positive effect? Have you seen growth in the industry overall? Very generally, what are your thoughts on the current market?

Eric Heymann: I am an economist, but I work for a bank; therefore, this is a relevant question. I talk to my colleagues who work in the operational business looking at hydrogen projects. I hear more or less always the same thing at this stage at least, which is that, since the technology is currently not competitive with traditional technologies, we need some kind of support mechanism: carbon contracts of difference, as Mr Lehner mentioned; maybe price guarantees or guarantees that you can sell the amount of green hydrogen that you produce; or some power-purchasing or hydrogen-purchasing agreements on international projects, so a kind of guarantee. As soon as this is there, I would argue that financial resources will not be the limiting factor.

In the German Renewable Energy Act, without this kind of support, we would not have seen this increase in wind power and solar PV. If there is a similar programme or subsidy regime—you can name it as you want—financial resources will not be the limiting factor. This is something the Government are currently working on. We have now, more or less, more than 60 concrete projects where there is discussion about direct subsidies, which of course create competition issues with the European Union. As soon as there is a kind of regulatory framework that reduces the risk for the investor and for us as the bank, I would say that financial resources are not limiting.

As with many climate technologies at the beginning, this point is true. Usually, we should be used to taking risks as a bank, but, given the

difference in competitiveness and the uncertainties about the regulatory framework for such climate technologies, you can argue in favour of that from a regulatory law perspective and also that a kind of support regime is necessary at the beginning.

Q370 **Rebecca Long Bailey:** Thank you. That is really helpful. Mr Lehner, the same question to you.

Franz Lehner: I think Mr Heymann raised a very important point already, which is that the regulatory framework needs to be in place to take those investment decisions so that there is some certainty about the project lifetime. The strategy itself sent a strong signal that this is the Government's intention, but the measures that are included in the strategy are, for example, exactly shaping this regulatory framework that enables and attracts those investments. That is probably something for the next Government—we have elections coming up in September—to tackle the regulatory framework that currently is adjusted in a way that fossil energy is kept relatively low cost compared to electricity, but, on the other hand, in our longer-term perspective, electricity is the energy vector by which we can get to zero emissions in the easiest way. We need to rearrange this regulatory framework not to make electricity artificially expensive and put the burden on fossil fuels or carbon-emitting fuels.

Rebecca Long Bailey: Thank you both. That is really helpful.

Q371 **Zarah Sultana:** We asked our Japanese witnesses in the previous panel what some of the challenges and opportunities are for Japan in implementing its National Hydrogen Strategy. I would like to pose the same question to you about the German strategy.

Franz Lehner: Thank you very much for the question. On challenges, the deployment of renewables is the first challenge. Since we only look at green hydrogen, we first need to have an abundance of green electricity to make green hydrogen. That has been a barrier in recent years to accelerating the deployment of renewables and therefore we have turned to look at imports more strongly.

On the opportunities side, of course, we believe that German industries can be part of this global industry that is shaping up with hydrogen production. The emphasis on net zero by 2050, and in Germany by 2045 with the decision of the Constitutional Court recently in Germany, put pressure on the Government to be more specific about how we want to reach net zero. This puts pressure on the global energy system with the Paris Agreement now being taken seriously. We can electrify a lot of sectors, but there will always be a need for a molecule-based energy carrier in the same way as we use fossil fuels today. The hydrogen industry in 50 years from now will probably be at the same scale as the oil and gas industry today. That will not be a resource-driven industry so much but an equipment-driven industry. In making that equipment, there

are obviously huge opportunities for industries, including the German manufacturing industry.

Q372 **Zarah Sultana:** Mr Heymann, is there anything you would like to add to that?

Eric Heymann: It is probably not only enough capacity or supply of renewable energies in Germany but also on a global scale in these countries where we want to import green hydrogen. If they build up the renewable energy capacity to produce green hydrogen for us but at the same time use fossil fuels or whatever for their own energy supply, it does not really help. If green hydrogen stems from countries with scarce energy at the moment, when you do not look at the oil countries today but maybe at poorer countries but with good weather conditions for green hydrogen production, they currently do not have enough energy for themselves. This is also a challenge.

Another challenge, of course, is for industrial users. We are not living on an island. You have more or less the same regulatory framework in the European Union. There is supposed to be a kind of border adjustment mechanism for carbon emissions. When you produce steel or chemicals based on green hydrogen, it is more expensive than when you produce it in a traditional way, at least for the time being. Some of these products are tradeable goods, and therefore this is a competitive issue.

Chances, yes: if we, with our integrated industrial value chain, manage to include green hydrogen into this chain, we can benefit from demand on the employment side, and also from electrolysers and other technologies. Our strength in R&D and capital goods is something from which we can benefit if we ramp up this technology.

Q373 **Zarah Sultana:** On that point around job creation, has there been the research to estimate what that would look like for the German economy if the hydrogen strategy achieves its goals?

Eric Heymann: I have no concrete numbers in terms of absolute jobs. Of course, when you put money into certain technologies as politics, you always create jobs. The question is, is it an efficient job, or could you spend your money somewhere else in a better way? Therefore, for me as an economist, the job creation is not the relevant question to put. I ask more in terms of efficiency. Do we reduce carbon at the lowest price? Probably not at the beginning with green hydrogen, but we have to ramp up; I understand that. We need some stimulus at the beginning. I have not seen any job numbers.

I can imagine that this is a kind of transformation. You transform those plants or production sites where you currently produce fossil-fuel refineries step by step into plants where you produce green hydrogen. Maybe the job effects are limited. As I said before, for me, in every case it is not good news if you produce the same amount of energy or

electricity with a much higher number of jobs because this is not a good sign for productivity.

Q374 **Zarah Sultana:** Thank you, Mr Heymann. My final question is looking at the EU's hydrogen strategies as well as the German hydrogen strategy. What would you say is particularly unique about it?

Franz Lehner: Unique about German strategy in comparison to the European?

Q375 **Zarah Sultana:** Or elsewhere in the world as well. Do you think there is anything particularly unique about the EU's hydrogen strategy and the German hydrogen strategy compared to elsewhere?

Franz Lehner: For the German hydrogen strategy, I guess the uniqueness is in focusing on green hydrogen but also maybe in making quite large funds available as part of the stimulus package last year. The strategy itself is equipped with €9 billion. On the European level, the European strategy acknowledges that it is a topic for the continent overall and not just for an individual country. We are travelling across borders. We trade energy across borders. I would say that the uniqueness is to put an umbrella over those individual approaches and then also be more open to different routes to hydrogen because each country has different views on that.

Q376 **Zarah Sultana:** Thank you. Mr Heymann?

Eric Heymann: I would maybe add something that is only related to the question because Mr Lehner mentioned the relevant points. This is also based on the question where the hydrogen comes from. I can imagine looking at the next 20 or 30-plus years—this is a kind of optimistic view, although some would say a rather pessimistic view—that the United States may develop next-generation nuclear and produce enough hydrogen 24/7. You would then have another dynamic in this market. It is something that will not happen in the next decade, but I can imagine that the United States is more open to this technology. This is an issue also in the European Union. When you read the Green Deal, nuclear power is not mentioned. That is because of the conflict between France and Germany, so you just ignore it.

I can imagine that other countries in the world, at least the richer ones, may include nuclear energy in the production of hydrogen. For you as the UK—I got that in the latest minutes of the former session—with your high share of offshore wind energy, you have a very good, quite reliable source of renewable energy, and at the same time, if you want to say it, it is a kind of advantage that the energy-intensive industry is not that important any more in the UK because then you have a lower demand for hydrogen at least at the beginning. Maybe in the UK it is a topic in the medium term for aviation and other things, but not to the same extent as in Germany for the energy-intensive industries where you do not have real alternatives to hydrogen.

Zarah Sultana: Thank you. That was really insightful. Thank you, Chair.

Q377 **Chris Clarkson:** I would like to start by asking a question to both of you about what the UK can learn from Germany's hydrogen strategy. In particular, should the UK increase its commitment to green hydrogen and rule out or decrease blue hydrogen from the mix?

Franz Lehner: I guess you have good reasons for not excluding blue hydrogen given the resources that you want to keep using, so that is not up to me to recommend. I think it is a political decision for Germany to focus on that.

Sending a signal to investors by having a very concise and all-encompassing strategy across different branches of Government is something that has helped push the topic in Germany a lot. Equipping the strategy with specific measures and a monitoring plan to be accountable for progress of putting the strategy in place with concrete measures—it is only one year old—at least from the experience so far, looks like a good approach for Germany.

As far as the colours are concerned, I guess that is a question the UK has to solve.

Q378 **Chris Clarkson:** Mr Heymann?

Eric Heymann: On the question of colour, at the beginning I would not be too strict from an economic point of view in terms of creating economies of scale. We need economies of scale at the beginning, and then you should not be too strict. This is somehow acknowledged in the German strategy as well. I would argue that the UK with its potential of offshore wind power has a good chance to rely to a large extent also on green hydrogen or to produce it on site. It is also clear for rich industrialised countries that, also for the UK, some import share will probably be there. It is also a political question in the UK whether you include nuclear energy. As far as I know, this is an ongoing discussion in how to use newer plants and whether there will be a cost reduction in production. It would be an advantage to run the electrolysers at full capacity 24/7. It is again a cost issue. This is a political question. There may be a difference between the UK and Germany in terms of the sources and how to produce hydrogen.

Chris Clarkson: Excellent.

Franz Lehner: Mr Clarkson, may I add something?

Chris Clarkson: Yes.

Franz Lehner: One approach that has turned out to be very useful is a regional approach to create clusters, not in the sense of a small demonstration but to try to build regional ecosystems at a relevant scale that maybe later can connect when hydrogen is rolled out on a broader scale.

I would also like to add that research and development are still important in the hydrogen area, and they are included in the German strategy, but I am happy that they are not the emphasis of the overall strategy or the focus of the overall strategy because these technologies are essentially ready to be deployed. The overall challenge is that time is running out to get to net zero. Focusing on the things that we can deploy quickly at large scale is very important and not using R&D as a distraction.

Q379 **Chris Clarkson:** On that basis, would you say that the UK should be scaling up its investment in hydrogen to compete with countries like Germany?

Franz Lehner: Using the regulatory framework may be even more effective than just pouring more money into it. I remember the UK phasing out coal with the carbon price floor within a few years, which has been a much more painful process in Germany. Using those levers may be more effective than just having a competition on the price tag that is on the strategy.

Q380 **Chris Clarkson:** Mr Heymann?

Eric Heymann: I am not sure if it is a question of competition between the UK and other countries, because if there are technologies that can be used at reasonable cost in the relevant industries they will be deployed everywhere. I do not see at the moment that it is them against us. Maybe in terms of sources abroad where the hydrogen comes from, you try to find partners wherever in the world there are good conditions to produce green hydrogen in order to secure the supply. There may be a competition, but not in terms of deployment of competition. I would rather say that there might be a win-win situation as soon as we see that new technologies are more or less competitive.

Q381 **Chris Clarkson:** In that sense in terms of the translatability of the technology and the certification, is there an opportunity for countries to set standards or work together collaboratively regardless of what mix of hydrogen or colour they go for? I am thinking of things like technical standards, green certification and safety requirements. Should there be some sort of international co-operational standard set?

Eric Heymann: The short answer is yes. It is complicated. You see it in the European Union. Creating such standards not only in hydrogen but the question of colour and other regulatory issues, how to price, the difference and so on, is not easy to fulfil, but in terms of technological standards it is always helpful to create economies of scale. It should be supported, in my eyes.

Q382 **Chris Clarkson:** Mr Lehner?

Franz Lehner: Absolutely. There are international initiatives that work together on these topics—for example, the IPHE, International Partnership for Hydrogen and Fuel Cells in the Economy. That is a working group at Government level. They are all active to work together

on finding agreement on standards and methodologies for certification. At the European Union level, there are various processes like the renewable energy directive, how to count hydrogen here and which requirements for the production of hydrogen should be used. On the global picture, standards for refuelling and refuelling protocols is something that is happening in the relevant bodies like the ISO. That is very important to enable products to be able to be used around the globe.

Q383 **Chris Clarkson:** Thank you. To turn around my original question, is there anything from Germany's strategy that the UK should not be doing? Is there anything that we can learn from it that you do not think the UK should follow—anything we should do differently?

Eric Heymann: I said at the beginning that this is also a learning by doing and work in progress in Germany. Therefore, you may look at Germany, where we are maybe one or two years in advance, at which paths are not successful and where we change our strategy and, therefore, do not repeat the same mistakes that maybe we will do. At the moment, I would not say that there is one concrete thing where you should not follow the strategy. The source issue is something that is a political question that I mentioned before. Addressing the whole value chain is something where you could watch what not only Germany but other countries are doing, and when you see that some things are not working do not repeat them.

Q384 **Chris Clarkson:** Mr Lehner?

Franz Lehner: Indeed. It is a learning strategy that will definitely go through adjustments over time as we find out what works and what does not work so well. A market-based approach probably helps a lot—focusing on the regulatory environment—but that is something that the UK tends to do anyway. Rather than putting a lot of funding into buying equipment, you rather tackle the regulatory environment to set a stimulus for change.

Q385 **Chair:** Mr Heymann, the German Federal Transport Minister, Andreas Scheuer, said, "We are making Germany a hydrogen country," which is quite a bold statement, a bold claim. I mentioned earlier that you had said that hydrogen will probably make only a small contribution to the national transition in the next one or two decades, and you explained why that might be the case.

Would you go further? Is that statement that "we are making Germany a hydrogen country" likely to be achieved in your view, or will it be more mixed?

Eric Heymann: It is, first, a political statement, of course, and it is a question of time horizon. I think that Germany will go to electric. He is a Minister of transportation. I do not see hydrogen being used in the passenger car segment because all the technological trends go towards electric battery. We have heavy-duty traffic, aviation and shipping where the question is still open; what kind of fuel we will use, be it next-

generation biofuels, overhead electrification for the trucks at motorways or hydrogen or fuel cells. This is maybe something that Minister Scheuer had in mind when he said this sentence.

In the passenger car segment, I do not see Germany as a hydrogen country. Maybe there are some reasons to have liquid fuels in parts of the transportation sector but not in the passenger car segment for the majority. Therefore, it is rather a political statement.

In the long run, we are a more electrified country even if there is a huge challenge to go there in terms of absolute capacity. Mr Lehner mentioned resistance to expanding renewables on sites. There is no easy way. Hydrogen will not be the main source of energy because it is not a primary energy source. You have transmission losses. The efficiency grade is decreasing with every step and every transformation. It will play an important role in the long run, especially in those sectors where you do not have reasonable alternatives, but we will probably electrify more things that are now run by fossil fuels instead of shifting them to hydrogen.

Q386 **Chair:** This was behind my question, really. This inquiry has heard from different sectors, and it is clear that there are some sectors that at least now will find it difficult to be totally electrified, shipping being a case in point, and there are others. To step back from that, do you think that, overall, the use of hydrogen is likely to be for those uses where electricity is not feasible or not economically practical?

Eric Heymann: Yes.

Q387 **Chair:** So would it be fair to say that Germany and perhaps other countries are going to be an electricity nation rather than a hydrogen nation, or will it be—and this is the crucial point, I guess—a mixture of both, or in 30 years' time will we be able to say, actually, the heavy lifting and most of the uses are electricity?

Eric Heymann: It is rather an electricity world, but at the current point I do not believe in an all-electric world because some areas are really difficult to electrify. Therefore, there will still be some need for fossil fuels or at least fuels with a higher energy density compared to electricity or battery storage.

In economics, the 100% solution is often expensive. Electrifying the first 70% of the economy is probably something that we can do at reasonable cost. The next 30%, the next 20%, or the last 20% or 30%, will get more expensive, and therefore we need other technologies there or we do not have the technologies at all. I cannot imagine aviation with electrification.

Chair: Absolutely.

Eric Heymann: Maybe after me—the next generation or two generations after me. But, at the moment, there is no technology in sight that makes aviation happen without energy sources with high energy density.

Therefore, a mixture, probably also from an economic point of view, is something that we should achieve, and the residual energy sources that do not stem from renewable power should be produced in another way—next generation bio-energies; hydropower is very limited; synthetic fuels; imports from countries. We should be open-minded to new technologies. A mixture is probably cheaper than an all-electric world, which is also difficult to implement from a technological point of view.

Q388 **Chair:** Absolutely. It is that way round. It is not that we are going to have a hydrogen economy and electricity being the residual power use. It is the other way round. You think electricity will be dominant and then hydrogen and others such as biofuels will pick up the strain.

Eric Heymann: Yes. The big question for me is the heating market. For transportation, I would argue that a passenger car is something that will run by electric battery, and heavy-duty aviation and shipping on some kind of fossil fuels or other technologies, or maybe fuel cell. I am not sure about that. The heating market currently relies on natural gas in buildings and stock; 50% is natural gas. Heat pumps are running up. Of course, then you need a higher share of renewable electricity for producing enough renewable energy in the winter months when you need to heat and when solar PV does not deliver.

This is, for me, the open question. I do not see hydrogen in the building market because it is probably too expensive in terms of losses at every step of the hydrogen value chain. I am not sure if heat pumps are the right solution. You have to convince house owners to invest in this technology. It is a question of money. Is it available to invest? For me, the major open question is the heating market.

Q389 **Chair:** Thank you. That is very helpful. Finally, Mr Lehner, do you agree with Mr Heymann's characterisation? I think I heard you saying earlier that you thought there would always be a molecule-based energy vector in use. Is it your view that it will be residual uses?

Franz Lehner: I agree that we will have limited availability for green molecules in the next 10 to 20 years maybe. This is exactly the challenge to not talk it down now but to create an environment so that these technologies can grow as quickly as they have to grow to reach net zero by 2045 or 2050. The global electrolysis industry today is maybe at around 100 MW production. The IEA in its net-zero report this year said that we need to be at 850 GW installed by 2030 to be on a net-zero path. The next few years are really decisive. By 2050, if we cannot agree that green molecules will be abundant by 2050, we cannot reach net zero.

I can fully agree with the near-term discussion. There will be limitations, but I think there will be no limitation on green energy, be it molecule or electron-based, in 2050, so the market then will decide and, obviously, direct electric use will have an advantage in the techno-economics because you do not have to turn that electricity into molecules. I do not

think there is a need for a Government mandate to limit the use of hydrogen to specific sectors because the economics will decide anyway.

Chair: Very good. I am very grateful to both of you, Mr Lehner and Mr Heymann, for your evidence today. It has been a fascinating insight into what is going on in Germany. We are keen in the way that you advised us to learn the lessons both ways—to avoid the mistakes but to learn from the successes. We are very grateful for your help in allowing us to do that today. Thank you very much indeed.

Examination of witnesses

Witnesses: Dr Hanton and Dr Dennett-Thorpe.

Chair: I will now turn to our third panel of witness. They are from the UK. Welcome to Dr Martin Hanton, who is the technical director of the UK's National Engineering Laboratory, and Dr Jane Dennett-Thorpe, who is the decarbonisation lead for the UK's energy regulator, Ofgem. I will go straight to my colleague, Carol Monaghan, for the first questions.

Carol Monaghan: Thanks very much, Chair. If I can turn to—

Chair: We have a bit of an echo. I do not know whether we can do anything about that. Perhaps if any colleagues who are not asking questions at the moment could mute themselves, that might help. Carol, go ahead again.

Carol Monaghan: Thank you, Chair. Dr Hanton, if I can come to you first of all, we have heard a lot—

Q390 **Chair:** We have a bad echo still. Let us see whether we can do anything about that. Perhaps while we are doing it, I can ask Dr Hanton this, first of all. In an earlier session of the Committee, we heard about some of the challenges for metering future hydrogen supply through the gas infrastructure domestically and for commercial users. Dr Hanton, can you give us a primer on the challenges and the prospective solutions to that? Then, hopefully, we will have solved the sound problem we have with Carol.

Dr Hanton: The primary challenge at the moment is to determine the suitability of the existing metering solutions in place for hydrogen. The UK gas grid is looking at two different potential solutions: 20% blended by volume initially, through to 100% conversion clearly as the end point. There is sufficient metering in place at the moment that works today. There is fundamentally no major reason to think that there will be any insurmountable barriers in terms of metering in the future in relation to hydrogen, but the work needs to be done to make sure that an understanding exists of whether the existing metering will be suitable, whether corrections will need to be applied, or whether new meter technologies will need to be used.

The slight complication, I guess, comes if we start talking about a blended grid, where you would need some additional metering to manage the complexity that you may have different compositions of hydrogen and methane within that grid.

Q391 **Chair:** Thank you. Just on that, before we try Carol again, the Committee heard evidence from Angus McIntosh of SGN, which, as you know, is a gas distribution company. His assertion was that the smart meters that are very substantially rolled out and are being rolled out are not compatible with hydrogen. He said, "There are quite a number of lessons to learn from the smart metering roll-out, but current installations will not be hydrogen compatible in their current form." Is that your view?

Dr Hanton: My view at the moment would be that we need to collect more evidence on that. We certainly do not have evidence that says they will be compatible. We have been doing some work with the gas networks through their various demonstrator projects. In fact, we are currently doing some work for the HyDeploy project to assess the performance of existing gas meter stock for hydrogen. In this particular case, it is the blended scenario; we are looking at 20% hydrogen and 80% methane.

The simple fact is that at the moment there is not a sufficient body of evidence to say that the current smart meters will be compatible, but at the same time, unless Mr McIntosh is aware of evidence that I am not, I do not believe there is any evidence that says definitively the current smart meters are not suitable for hydrogen. I would say that at the moment we do not have the evidence required.

Chair: Let us try to see if we can get Carol again without an echo this time.

Carol Monaghan: Thanks, Chair. I do not know if that is any better.

Chair: Yes.

Q392 **Carol Monaghan:** Good. Thanks very much. Unfortunately, I missed a little bit of Dr Hanton's answer. Could I follow on from the Chair's question on smart metering and ask Dr Dennett-Thorpe whether Ofgem is currently looking at domestic metering for hydrogen?

Dr Dennett-Thorpe: Thank you for the opportunity to talk to the panel. If I may, it will perhaps be useful just to take a little step back and say something about Ofgem's role because I think this may come back in various forms in the conversation.

Ofgem's role is to regulate energy suppliers and network companies. We do that to ensure a fair deal to consumers and to deliver net zero at lowest cost. The Government and, in particular, BEIS are responsible for setting the overall policy framework of the energy sector, and we operate within this. We often work with Government to inform their policy decisions to ensure that they are deliverable and delivering for consumers.

We will come to this again, and it relates to previous conversations about what decisions still need to be taken, where there is certainty, where there is not, and how Ofgem fits into that.

To answer your question about domestic metering, the first point is that there needs to be a policy framework and Government are the lead on domestic metering. There is some funding that we have been making available through our network price controls. One of the things that we do is to ensure that there is still innovation in the regulated sector through making funding specifically available for innovation, and, in fact, Dr Hanton has just referenced one of those projects as HyDeploy. Some of those projects in particular are looking at metering, and BEIS has also part-funded the development of a prototype smart meter in a Hy4Heat programme.

When, in particular, we are looking at the domestic metering question, there is a prior, which is, "Do we ever need it?", and there are some decisions that Government are committed to take in the mid-2020s on the role of hydrogen, particularly in domestic heating. It is quite clear, as I am sure you have heard from other witnesses, that there is almost certainly a role for hydrogen in certain sectors of the economy. Its role in the domestic heating sector is unclear, and Government are set to take decisions on that. That actually has quite a big impact on Ofgem's roles and responsibilities because 85% or 80% of our current housing stock is heated by natural gas, and that is where critical change may come, and it depends on that decision.

In addressing the question, why we are not looking at it, given the final uncertainty and the timing of those decisions, we feel that the current development work is what is needed to both help inform those decisions and to ensure that we are ready for when those decisions are made.

Q393 **Carol Monaghan:** Some of the evidence we have heard has been talking about the possibility of using the existing gas infrastructure for hydrogen. In your opinion, is this feasible? Is this something that should be considered?

Dr Dennett-Thorpe: The question as to whether we can use the existing gas infrastructure, and how ready it is, is a question that we and Government are looking at. There are a couple of things to say about that. The first is that much of the gas infrastructure at the moment is made up of a variety of materials and a variety of ages. But there is a programme of work that is being undertaken for safety reasons to address safety issues with methane in our iron mains, which is a programme known as the iron mains risk reduction programme, and it is run and sponsored by the Health and Safety Executive.

One of the things that happens is that there is a replacement of iron mains by plastic pipes, in effect, which may be more suitable for transporting hydrogen. That is not to say that, simply because you can put hydrogen down a length of pipe, our full network infrastructure is

therefore immediately enabled to take hydrogen. There are still some steps to make sure that the full system is safe and secure. The technical feasibility and the safety cases are what those innovation programmes are trying to address, and in particular, feeding into the Government decisions on what is needed to enable the hydrogen to flow through those networks if that was to be chosen.

Q394 **Carol Monaghan:** From what you are saying, if we are replacing pipes that could be more suitable for hydrogen, we would not be talking about an entirely new infrastructure requirement. There may be parts of it but not necessarily a full system.

Dr Dennett-Thorpe: Not necessarily, but those are exactly the kinds of things that are being explored.

Q395 **Carol Monaghan:** Thank you. Dr Hanton, I will come back to you. Apologies, I lost you at the start there. I know the Chair has already mentioned smart meters. I would like to ask a couple more questions about them. One of the things we have been talking about is the use of blended fuels—the possibility of potentially 20% hydrogen and eventually 100% hydrogen. Would smart meters be able to cope with this change both in terms of blended and moving to 100% hydrogen?

Dr Hanton: Yes. This is quite an important distinction between the blended scenario and the 100%. This is probably what Mr McIntosh of SGN is referring to when he talks about the lack of suitability of smart meters. He is thinking about the 100% conversion to hydrogen. We do not have experimental data and evidence at the moment, but if we look at diaphragm meters, for example, with hydrogen, if you were in the pure hydrogen scenario of 100% hydrogen, you would have roughly three times the volume of hydrogen going through that mechanical meter, and therefore you would expect that it would be significantly over-ranged. Diaphragm meters are currently the predominant type in the UK.

If you look at USM, or ultrasonic meters, of which there are some in the UK, and thermal mass flow meters, which people are increasingly thinking about, the fluid properties become important. Effectively, if you go to pure hydrogen, you would be outside the current limits, and it then becomes a question of whether they could achieve the accuracy. Our expectation is that existing meters or the smart meters being rolled out at the moment would not perform suitably well with the 100% hydrogen scenario, but I would be very clear with people that there still needs to be a programme of experimental work to definitively examine this.

If we look at the blended scenario, which is what we are currently working on for the HyDeploy project—and I believe those results will become available either late this year or early next year; I cannot prejudge the work that is in progress at the moment—the expectation is that the meters could, in theory, cope with the blended scenario. What we will see as a result of this piece of work is whether they cope with that

and still meet the accuracy limits, because, of course, under the Gas Act there is a nominal accuracy that gas meters must achieve.

Q396 **Carol Monaghan:** There is a part of that I am unsure about. You said that hydrogen is about three times less dense than natural gas and methane gas, and you talked about the meter not coping with the flow rate because it would need, I would imagine, a flow rate of three times greater. Why would it not cope?

Dr Hanton: Hydrogen is, by mass, gravimetrically more energy dense than methane, but as a gas it is less dense. Volumetrically, it has a third the energy density, hence why you would need three times the flow rate. Existing domestic gas meters have an upper range of 6m^3/hr. Due to the lower energy density of hydrogen, to get the same energy through you would need a maximum flow rate of 18m^3/hr. If you think about a diaphragm meter, simply, it is a diaphragm that is filled and emptied repeatedly. Obviously, it has been designed to cope with doing a sufficient number of repetitions to achieve 6m^3/hr. If you push it to 18m^3/hr, you are effectively pushing it outside its design limits.

The questions then become things like how long it can cope with that. Maybe it can do that for a short period of time, but, of course, we expect gas meters to last in houses for a number of decades. You would expect that the lifetime of the meter may be reduced by three times in a simple linear fashion, but it may not go that way because, through the over-ranging, it may fail even quicker than that. This is my point about collecting data to understand the answer to that question.

Q397 **Carol Monaghan:** Thank you. That is a bit clearer to me. Dr Hanton, I know in NEL you are involved in the metrology of different fluids. What are the challenges with measuring and regulating hydrogen, and what should the Government be doing to address these challenges?

Dr Hanton: It is worth saying to begin with that there is a significant difference between the blended scenario and the pure hydrogen scenario. If we think about a future gas grid that was composed of essentially 100% hydrogen, in practice it would not obviously be 100%; there would be small levels of impurity there, but that would not fundamentally be any different from the natural gas grid that we have today. In fact, arguably, it may be even simpler because natural gas, of course, itself is not pure methane; it has a number of other components in there. As it stands today, there is a certain amount of work that happens within the gas grid to control the calorific value to within a certain range. Arguably, with pure hydrogen, that may even be slightly easier. Certainly, you would not expect it to be any more difficult.

Where it would become very challenging is when we think about the blended scenario because the calorific value of hydrogen and methane is very different. You would need to know reasonably precisely the composition of the gas passing through any meter at any point in time to understand what the calorific value being received by the customer was. I

would suggest that in a blended scenario this is one of the complexities that you can certainly envisage. There could be ways in which within a certain region you attempted to control that composition very carefully, but that in itself would bring operational complexity.

Q398 **Carol Monaghan:** Has enough work been done just now, Dr Hanton, on the measuring of hydrogen and developing ways in which it can be measured in different scenarios?

Dr Hanton: There is a lot of innovation work, as the witness from Ofgem has said, currently going on within the gas sector. A lot of that early innovation work has focused quite rightly upon the safety aspects, but I would suggest that, at this point in time and with the current trajectory, there probably needs to be a bit more of a shift towards looking at some of the metrology aspects, particularly if we are thinking about blended scenarios in the interim period, because there are certainly some metrology challenges there at the moment that not only are not understood but I would say quite a large number of people are not even aware of.

Q399 **Carol Monaghan:** Dr Dennett-Thorpe, we are hearing about some of the challenges in terms of the metrology and the blended scenario. What is Ofgem doing or what plans does Ofgem have to tackle some of these challenges?

Dr Dennett-Thorpe: As you have just heard from Dr Hanton and almost certainly from many of your other witnesses, there are multiple potential uses and multiple potential scenarios and decisions particularly around its use in hydrogen for heating. If we look at the regulatory changes that will be needed under each of those scenarios, we have to consider them separately, and that is what we are doing. We are working in particular with Government, thinking about industrial clusters and what might be needed in enabling hydrogen in industrial clusters, which is certainly where we might expect the hydrogen to start. For that, the regulatory challenges in particular are less than as we think about either blending or, certainly in 100% of hydrogen, in homes. We are preparing on all of those fronts working with Government but also mindful of the trajectory at what point the decisions are being taken and need to be taken.

For example, the Government are committed to ensuring a hydrogen supply and have made industrial clusters a centrepiece. Working with that is pretty important. As Dr Hanton has also said, there is a trajectory between the safety case, the feasibility, and then the cost and the desirability. Thinking about the overall innovation programme and the overall evidence programme together with Government in that trajectory is perhaps a way to think about it. The innovation programmes have in the past, in the last five years or in the last price control, the last eight years, funded 60 smaller hydrogen projects from the gas networks, but we have also funded some of these really big demonstrator projects to ask some of these bigger questions. For example, we have heard about HyDeploy. There is also H21, which has plans to try to run hydrogen

through the existing gas network, and H100, which is a first-of-a-kind green hydrogen project into homes. There is a range of different questions, and we are trying to address them at the appropriate time.

Q400 **Graham Stringer:** Dr Hanton, you were talking about not knowing whether the meters would work for different percentages of hydrogen and natural gas or 100% hydrogen. Would it be simple to design an experiment to find out whether the meters would work or at what levels they would work? How long would it take to do such an experiment, and is it important to do that?

Dr Hanton: Thank you for those questions. I will take the last one first. Yes, I think it is very important to do this because we need to make decisions based on evidence. As the UK's designated institute for flow measurement, which is part of the national measurement system funded by BEIS, we built a facility last year specifically to allow us to do the necessary metrological research with regards to domestic gas meters. That facility opened in February of this year, and, as I have said, we are currently doing some work for the HyDeploy project to look at their particular gas meters. That is a project that is taking us about six to eight months.

We are testing a range of different meters. We are looking at diaphragm, ultrasonic, and thermal mass meters. We are looking at those under a range of conditions. We are looking at those very specifically with the 20% hydrogen/80% methane blend.

There is the facility that we built. We built it in such a way that it would be able to cover all gas grid scenarios being envisaged, so we can, in fact, look at any ratio of hydrogen and natural gas or methane right through to pure hydrogen. We have the physical capability to look at a range of different blending ratios up to about 20% limit or 100% hydrogen. The test programmes needed to do that would be in that period of six to 12 months depending on the detail of the test programme, how many meters were being looked at and so on.

Q401 **Graham Stringer:** Just to be clear, you have the capability to do these experiments over 12 months. Are they going to be done over that period, or does that yet have to be commissioned?

Dr Hanton: Largely, that still has to be commissioned. The current programme of work we have for HyDeploy, which will probably finish in the next few months, is very specifically looking at some meters in relation to their particular project at Keele University. Most of the meters that we are looking at are brand-new ones, but there are four meters that have been in service within that project that we are looking at to see how the performance of those has changed after they have been in service.

We are involved in a European project funded through EURAMET, the European metrology organisation, which probably in early 2023 will look

at domestic gas meters for pure hydrogen, but it is quite a small project so it will just look at two meters. In principle, that is the only thing at the moment that we have in progress or commissioned. I would suggest that there certainly is a need to commission probably a more wide-ranging study to examine this particular point.

Q402 **Graham Stringer:** Dr Hanton, I understand that this country was unusual when it rolled out smart meters inasmuch as it combined both gas and electricity in the same meter. Would it be easier if we had to transform if we had initially installed separate meters?

Dr Hanton: I am not 100% sure I am terribly well placed to answer that question. Certainly, my understanding at the moment is that electricity and gas meters are separate. Perhaps my colleague from Ofgem may be better placed to address that question.

Q403 **Graham Stringer:** Dr Dennett-Thorpe is shaking her head. We will leave that.

Dr Dennett-Thorpe, we have just heard that we will not know, as Angus McIntosh contends, that these matters will not work at 100%. Nobody seems to be sure at what percentage they will work. There is a huge cost implication if these meters have to be replaced, is there not?

Dr Dennett-Thorpe: Indeed. Replacing any part of the energy system comes with costs. The overall system cost is one of the things that will certainly be a key part of Government taking their decisions about whether or not we will be using hydrogen and to what extent we will be using it in people's homes. That is one of the key elements of the question, but it is not the only one. There are many other aspects.

Part of the complication of this is that we need to see the whole energy system. It is not just thinking about the cost of hydrogen; it is also about what the counterfactuals are and how indeed there is a potential role for hydrogen in a new and zero-carbon electricity system. Without wanting to make the question more complicated, yes, there will be costs, but the question is what we are comparing it to, and that is a question for Government. It is why we are trying to do this work; to inform those decisions is the key point of the work that we are undertaking.

Q404 **Graham Stringer:** I understand that. I am just trying to think what the costs may be of moving to a 100%-hydrogen system. Rolling out the smart meters at the present time is not only taking much longer than anybody expected; the costs have been higher than expected—over £11 billion at the present time. It would be interesting to this Committee and for our report, if all those meters had to be replaced, what their cost would be, because, even though the Government now spends tens of billions of pounds regularly, it is still a lot of money. I am just trying to get at, first, whether the meters would have to be replaced and, secondly, what the cost of that would be.

Dr Dennett-Thorpe: I am unable to give you a cost on that. That is partly because we do not know what would be required, as Dr Hanton has set out. There are two things I should say. One is that the overall policy framework is one for Government and not for Ofgem. The second one is one around meter replacement rates. We would anticipate that meters do not themselves have infinite lifetimes, and, in fact, it is suggested to me that meters typically have a lifetime of 10 to 15 years. So there would, in any case, be a natural replacement life cycle of meters.

Q405 **Graham Stringer:** That is interesting. If the decision was made to go to 100% hydrogen in the gas network, or, for that matter, to a partially blended system of 20% or some other figure of hydrogen, how long would it take you to work out the regulatory changes for those two scenarios?

Dr Dennett-Thorpe: The two scenarios being 100% and the blended scenario?

Graham Stringer: Yes.

Dr Dennett-Thorpe: The Government have committed to trials of blending, but it is quite clear that the blending does not get us to 100%. The question is what role, if any, that plays within the transition to a hydrogen economy.

We are working across a range of different thoughts, as I mentioned before. The question is what role hydrogen will have. In the blending scenario, we are working very closely with Government to try to understand what regulatory changes would be needed to enable economic regulation in particular and any code modifications that would be needed in the gas network.

As for the changes for 100% hydrogen, as I said, we are confident that there is a reasonable time for us to make those preparations. It is not that we are standing still waiting for those decisions to be made, but they are clearly a little further off than potentially decisions on blending. If blending is to take place, it is not because it is a route to get to 100%, but it has another role in the energy system, and those decisions are much closer.

Q406 **Graham Stringer:** While you are waiting for the Government to make decisions, is there any evidence that you are looking for that would be relevant to your role and would help you to provide the regulatory framework for domestic heating?

Dr Dennett-Thorpe: Sorry, I was trying—and, obviously, not doing it very well—to suggest that we were not waiting for the Government to make decisions passively, but that we are indeed actively engaged in helping inform Government for those decisions and are considering what regulatory changes would be needed and how they may come into effect. In part, that is regulatory work and, in part, it is in turn informed by the trials and demonstrators that are being rolled out.

Q407 **Chair:** Thank you, Graham. Before I turn to Rebecca Long Bailey, in terms of Ofgem's work in this area, Dr Dennett-Thorpe—you mentioned the HyDeploy programme—I think I am right that £6.7 million has been invested in that programme that looks at a 20% blend of hydrogen in the gas grid, and £9 million has been invested in an H21 programme that looks at 100% hydrogen in the gas network. Given that consumers' and taxpayers' money is being invested by Ofgem in this, I am slightly puzzled as to why the crucial question of whether and how this can be metered has not been considered to date and why we do not have the answer to this yet. Why might that be the case, Dr Dennett-Thorpe?

Dr Dennett-Thorpe: Once again, looking at the phasing of the arrangements, metering—in particular, we are talking about domestic metering—is one of the pieces of the puzzle that needs to be answered by the mid-2020s, and that is indeed part of these innovation projects.

Building a little on my previous answer, for example, if we are starting the hydrogen economy in industrial clusters, we already know that there is probably not a huge amount of regulatory change that is required to get those networks off the ground because they are likely to be simple, point-to-point connections, and we already have small, closed hydrogen networks around the country. We can be relatively sure that that first part of the project does not have barriers, or has fewer barriers, and we can address them from a perspective.

If we start to think about a world in which those networks grow further and start to have a more diverse user base, we need to consider the appropriate regulation and these sorts of questions you are asking here, but we do not need to have the answers now. What we have in place is a programme together with BEIS—and it is ultimately BEIS's programme and BEIS taking the decisions but we are trying to help inform those decisions—to ensure that we are enabling a hydrogen pathway and we know what it would take to deliver it.

Q408 **Chair:** With respect, is it not the case that we do need to have those answers now? For example, we heard from one of the boiler manufacturers that is making available to the market boilers that can be used for both natural gas and a blend of hydrogen. They are being marketed now. Consumers are being invited to make purchases of them. The manufacturers are making a case—not an unreasonable case, if we are going in this direction—that as people are replacing their boilers they should replace them with ones that are hydrogen ready. If they are being invited to waste their money if it proves not to be possible to meter this, surely, your core remit is to protect consumers. How can you be doing that while deferring this analysis?

Dr Dennett-Thorpe: It is not that the case we are deferring this analysis, but I refer back to my opening remarks that the overall framework of smart metering, of the choices of the hydrogen, how hydrogen will be deployed and in what sectors, are for Government, and we work within that framework. Government have the responsibility for

ensuring that the metering policy framework is in place, and we have through the innovation funding provided a way to answer and address some of those questions on a technical basis.

Q409 **Chair:** But you have not so far answered the question as to whether the meters are going to work or not and what modifications they might need. That is clearly important for consumers. You are set up on an arm's length basis not to be a creature of the Government but, to quote from your remit, "to protect consumers now and in the future." Are you doing this on smart meters?

Dr Dennett-Thorpe: As I said, we believe we have the programmes in place. The ultimate decisions sit with BEIS, which is the lead here, and we will be informing those decisions. This is one of the many decisions and many pieces of evidence that need to be brought together before decisions are made about the future of hydrogen in people's homes.

Q410 **Chair:** Part of Ofgem's stated purpose is "to identify important policy gaps that affect consumers." It is hard to think of this as not a prime example of that, surely.

Dr Dennett-Thorpe: I think I am going to be repeating my answer. Given where we are, given what timing the decision is, first, they are BEIS decisions, but we feel that we are enabling the necessary research and development to take place to enable that question to be answered. You talked about consumers wasting money. That is in the wider context of whether hydrogen will ever be used in people's homes.

Q411 **Chair:** The boiler manufacturers said that boilers that are hydrogen ready can be put on the market and are available now, so people can buy them now. If we were not to be able feasibly to meter them, they would have wasted their money, would they not?

Dr Dennett-Thorpe: Metering is one part of the overall situation. As I said, you might argue that they should not be wasting their money if there is never going to be a hydrogen supply. There are many aspects to this.

Q412 **Rebecca Long Bailey:** Thank you both for speaking to us today. Briefly on the issue of storage, Dr Dennett-Thorpe, I know that there have been recent stories that Centrica is in talks with Government about plans to convert Rough into a hydrogen storage facility. What work are you doing to ensure that we have sufficient long-term energy storage, and what role will hydrogen play in ensuring that?

Dr Dennett-Thorpe: Ofgem is the energy regulator. We do not particularly have a role in ensuring that there is sufficient long-term storage. That is not something that is within our remit. I understand that there are conversations afoot. Thinking about how that system all works together is something that Government need to work through with stakeholders.

Q413 **Rebecca Long Bailey:** In terms of the general discussions that you are having surrounding energy storage, are there any immediate challenges that you have identified in these early stages for both hydrogen storage and other forms of energy storage, and how you can work as an organisation to overcome them?

Dr Dennett-Thorpe: The need for energy storage in the future is something that we will be considering as part of our thinking about how we get to a net-zero energy system and what market reforms might need to be in place, but a lot of that policy sits with Government.

Q414 **Rebecca Long Bailey:** Thank you very much. Dr Hanton, is there anything you would like to add to that in terms of any challenges that you are aware of particularly in relation to hydrogen storage?

Dr Hanton: From our perspective, which is obviously focused on the metering, we are not aware of any specific challenges in regard to metering in hydrogen storage, except to say that metering will be an important component in that because you will need to measure the amount of hydrogen that you put into the store and the amount of hydrogen that comes back out in being able to manage that inventory and understand how your energy system works. I would make the slightly bold point that metering is something that is quite often overlooked or taken for granted. The work needs to be done to make sure that metering at sufficient scale that you would be talking about for energy storage is done that you could manage that inventory.

Rebecca Long Bailey: That is very helpful. Thank you both.

Q415 **Dawn Butler:** Dr Dennett-Thorpe, on the back of some of the Chair's and others' questions around boilers, consumers and being ready for hydrogen, would you understand and appreciate the concern that some people watching this evidence session will have in regard to Ofgem not considering the implications of hydrogen technology in the home?

Dr Dennett-Thorpe: I think that I was being pushed on whether or not we had done enough specifically on meters. What I was trying to suggest is that the Government need to take a decision as to whether it is suitable for use in homes and will need to consider a wide range of those things. We in Ofgem are working together with Government to help provide the evidence both through the trials and considering what other evidence would be needed to enable hydrogen in the homes.

As I said, there is a phasing. There is, first, the safety and the feasibility, and then there are also the other aspects, including the economics. Until we have addressed the first two, it is difficult to address, for example, the costs. The costs are deeply uncertain, and, in part, that is because we do not know what is actually needed because the first pieces have not yet been completed, but we are working to try to inform that to ensure that we will protect consumers in the long run.

Q416 **Dawn Butler:** Should you be considering the Government's problems as

Ofgem? Should you not let the Government deal with the problems themselves and you advise as an independent body in regard to meters in the home?

Dr Dennett-Thorpe: We do act as an independent body. That is clear. Given that they are the ones taking the decisions and they have set out a broad timetable for taking those decisions, to have an impact and to ensure that we are protecting consumers, we are engaged in the questions that they are trying to answer and the programmes that they are delivering in order to have an influence to ensure that we are protecting consumers.

Q417 **Dawn Butler:** What is your current engagement with the Government on their assessment of hydrogen as a possible part of the net-zero economy?

Dr Dennett-Thorpe: We will come back to the different ways that we can think about this. For example, on industrial clusters, we have been putting our viewpoints into the upcoming hydrogen strategy; we have been inputting into the hydrogen business model consultation; and we are also engaging with industry and Government on what regulatory and commercial frameworks would be required for hydrogen networks within those industrial clusters. Our role there is pretty uncertain. That is almost the most certain part of the transition.

On blending, we are closely engaged with BEIS. I may have mentioned before that, although the Prime Minister has committed to a rolling out of some trials, what is not clear is what the future of blending is within the energy system. We are working with BEIS and looking at the regulatory framework that would be needed should blending come into the energy system and how we would protect consumers and enable that framework to take place.

Finally, there is the question we have been focused on, particularly with the metering a little bit, which is 100% hydrogen for heat. As I said, we are working with the trials to help identify what the regulatory barriers are to enable the safety cases to be built, and we are also working with them closely to develop a greater understanding of what regulatory barriers there may be and how to overcome them so that we can still deliver, potentially, 100% hydrogen in homes and ensure that we protect consumers.

Q418 **Dawn Butler:** Have you identified any potential safety issues?

Dr Dennett-Thorpe: The regulation of safety is a matter for the Health and Safety Executive. The trials are part of enabling a potential future in which hydrogen is used in the home. One of the aspects that needs to be considered is the safety case, and what those trials are doing in part is seeing what is needed for those safety cases.

Q419 **Dawn Butler:** Are you convinced from the trials that you think there is a big role that hydrogen will play?

Dr Dennett-Thorpe: Sorry, could you repeat the question?

Q420 **Dawn Butler:** In regard to the trials, have you found that from the trials there is a large role that you think hydrogen will play going forward?

Dr Dennett-Thorpe: The trials are not designed to answer that question. They are designed to answer more specific questions. That question itself needs to bring together a whole range of evidence and is ultimately one for Government. I am sorry to sound repetitive.

Q421 **Dawn Butler:** Thank you. Dr Hanton, is there anything that you would like to add?

Dr Hanton: Thank you for the opportunity. The overarching point that I would make is that there has been a lot of innovation work already undertaken, and, as was pointed out earlier, quite a few million already spent on things like HyDeploy, H21 and now H100. As I said before, quite rightly, the initial focus has been very much on the safety aspects, and at the moment very little thought has been given to metering. The fact that we have the capability that we have within our institution actually comes from us. That has not come from the gas sector. That has come from us engaging with the gas sector and recognising the need to provide that facility.

At the moment, with the exception of this one piece of work with HyDeploy, there has been relatively little thought to metering because people's focus has been on safety. Given the fact that things are moving ahead, there certainly is a pressing need at the moment to understand on an evidence basis—that is doing the experiments—what the situation is regarding metering. I entirely agree, in principle, with the assertion of Mr McIntosh from SGN that, if we look at pure hydrogen, the current smart meters probably will not be correct. But that is the point. That is not an evidence-based statement at the moment; that is based on looking at things and saying, "We believe they won't be." What we need to do is collect the evidence because, as with the suggestion that people should start putting in hydrogen-ready boilers, equally, there is no point doing that if you do not start putting in hydrogen-ready meters as well.

I would suggest that it is quite pressing that we start to answer the metrology issues around meters, otherwise it will become the weak link in the chain or the rate-limiting step in terms of moving forwards.

The final point I would make is that the advantage of going down the route of replacing meters and boilers when they come up for replacement with hydrogen-ready variants is this. As long as the hydrogen-ready variant is no more expensive or only marginally more expensive, it is not really a waste of money if that capacity never gets used if you were replacing something that was due for replacement anyway. This is why that kind of approach would make sense because over a long period you would have then replaced a number of appliances that had to be anyway as long as, like I say, the cost differential is zero or very small.

Dawn Butler: Good point. Thank you both very much for your evidence today.

Chair: Thank you very much indeed. Can I thank Dr Hanton and Dr Dennett-Thorpe for their evidence today? Dr Hanton said that metering can sometimes be overlooked or taken for granted. I think it has been evident from our interest in this today that we are very concerned that it should not be. We were surprised, it is fair to say, to hear from the witness from SGN that there was this question about whether smart meters were suitable. Obviously, we will need to reflect on this in our report, but it may be the case that Ofgem may want to reflect in advance of that. I am sure we will take some further written evidence if the plans are live on that. We are very grateful to all our witnesses this morning. It has been a very enlightening session. This concludes this meeting of the Science and Technology Committee.