HOUSE OF COMMONS

Scottish Affairs Committee

Oral evidence: Hydrogen and carbon capture in Scotland, HC 83

Monday 16 May 2022, Methil, Fife.

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Watch the meeting

Members present: Pete Wishart (Chair); Mhairi Black; Wendy Chamberlain; Sally-Ann Hart; Douglas Ross.

Questions 1 - 59

Witnesses

I: Angus McIntosh, Director of Energy Futures, SGN; David Wallace, Senior Strategy Manager, Offshore Renewable Energy Catapult.

II: Dr Nigel Holmes, Chief Executive Officer, Scottish Hydrogen and Fuel Cell Association; Dr Jillian Couto-Phoenix, Programme Manager, National Manufacturing Institute Scotland.

Examination of witnesses

Witnesses: Angus McIntosh and David Wallace.

Q1 **Chair:** Welcome to the Scottish Affairs Committee, rather unusually in the H100 facility in the Fife innovation park here in Methil. We are absolutely delighted to be here today for what is our first session in our hydrogen and carbon capture and storage inquiry. We are thrilled to have a couple of stellar guests with us to kick things off, who I will now allow to introduce themselves. We will start with Mr McIntosh.

Angus McIntosh: I have been in the energy industry for over 20 years, working on hydrogen for over a decade. In my current role I am director of energy futures at SGN. What we have been working on with the UK and Scottish Governments is the hydrogen option and that is an option for transforming the system for customers; conversion ultimately of the gas network to 100% hydrogen.

We have a parallel programme of research and development that is managed collaboratively with all the other gas distribution networks and many other partners across the whole energy chain, and we are working on trying to prepare the system transformation options towards a heat policy decision in 2026.

David Wallace: I am with the Offshore Renewable Energy Catapult. I have been in energy technology since 1990 in public and private sector capacities. The Offshore Renewable Energy Catapult supports innovation for the benefit of UK supply chain manufacturers, primarily in offshore wind, wave and tidal, but also in the technologies and the systems that we need to integrate large amounts of renewables into our future energy system or future decarbonised energy system, hence our interest in hydrogen as a means of helping that.

Q2 **Chair:** We are grateful and thank you both very much for that. As I said, we are here in Methil next to the H100 Fife project and we have all been up close and personal to that wonderful turbine that you have just round here.

Can we kick things off and possibly get both of you to tell us how important and valuable you think this project is, what you hope to achieve by this specific project and what your experiences of this have been so far? We will start with Mr Wallace.

David Wallace: The integration of offshore wind or renewables generally with our energy system is certainly going to include production of means of storing that energy. As we get more renewables there is more of an imbalance between when wind turbines, solar or whatever are producing their energy and when it can be used in our households or businesses. Just as we have big stocks of energy, and still some coal, oil and gas, we are going to need stocks of energy in the future stored to some extent.

There is potentially a big export market in green hydrogen, in supplying other countries that see that they have a need and don't have the abundance of renewable energy that we have in Scotland and in the rest of the UK. We will have to prove that the integration of our research turbine that we have here—a 7MW research turbine with an electrolysed facility producing hydrogen—and our engineers and researchers have very valuable information, very valuable research for working with UK businesses, researchers and universities to advance our technologies and to advance the opportunities for UK businesses.

Q3 **Chair:** Mr McIntosh, what impact do you think the H100 Fife project will have on the hydrogen landscape throughout Scotland and the UK?

Angus McIntosh: This is a critical national project, both in Scotland and the UK, for evidencing a decarbonisation solution. There is no doubt that we need to decarbonise. This forms part of the "Ten Point Plan" that has been set out by the UK Government and the UK Prime Minister, which is a series of stepped, evidential projects towards a heat policy decision for a system transformation conversion of the gas distribution network.

The absolutely critical thing for me is that the customer has quite often missed out in the decarbonisation debate, so this is about replacing for those customers, in a low disruption way, the appliances that they are used to. We think that will be very attractive but that is what we are testing under this programme, along with myriad technical evidentiary things. Fundamentally it is: is this a solution that customers want and need?

Q4 **Chair:** For those who are not familiar with what is happening here in Fife, could one of you describe to us exactly what is happening? What are the steps to this project and what are you hoping to achieve out of it?

Angus McIntosh: This is a bit of glimpse at what the future looks like. It is a turbine tip to burner solution, so the turbine will generate power, will be taking direct power from the turbine to supply an electrolyser. That electrolyser will split good old Scottish water into hydrogen and oxygen. That hydrogen will be stored, and then we will distribute it to customers direct to their households. We will be providing the appliances for the customers in the home; these appliances have the same footprint as their existing natural gas appliances, so the boiler is exactly the same in terms of its size as a natural gas boiler, the cooker is the same size as the existing natural gas cooker, and similarly you can have the fires in any shape or form that they want. It is a turbine tip to burner demonstration, and we will be proving all of these aspects.

Another critical part of the design of this will be the demonstration home for the customer to come and interact with the appliances and see what they look like in their property before they sign up. All of that is being constructed here in Fife as a world first.

Q5 **Chair:** I think we were told this morning that initially there are going to

be 300 customers that are going to be signed up. Is that right?

Angus McIntosh: That is right, and 300 is not an arbitrary number. It is a magic number, because what you are trying to understand is the scalability. In energy terms, there is a thing called diversity of use, which is the likelihood that customers will be using energy at specific times. Those 300 homes give you sufficient information to scale the evidence up so that you can identify your requirements for larger off-scale wind for hydrogen production for the whole of the UK.

Q6 **Chair:** It is obviously very exciting to see what is happening here. What do you think you will require to make this scale up for more practical and further use across the UK?

Angus McIntosh: We need to complete all the research and development streams that we are working on currently. We have other parallel projects that are being undertaken; another one in Scotland that we are leading is for a local transmission system, which is a pipeline that we are converting between Grangemouth and Granton in Edinburgh. There is a collective programme of that work that concludes roughly in 2025, in advance of a heat policy decision.

The next stage under the "Ten Point Plan"—this is what is called the neighbourhood—is the first 300. Then there will be a village where the trial will be in the north-west and the north-east of England, potentially, and then there is the hydrogen town and the larger-scale development and deployments across the country. Our test for the customer is an opt-in, so we are asking customers to opt in.

The next phase will be testing legislation for opt-out, so that will be where you are saying, "Natural gas is no longer compatible with net zero so you can retain your supply and we will replace it with hydrogen or you can opt out and install an alternative heating solution, if you wish, under the next phase," which is the village trial.

The critical things that we are going to need is to prepare ourselves for that heat policy decision and to accelerate and make sure that we are ready to have the deployment plans off the shelf. We are doing a huge amount of work with the supply chain to ensure that we have the right skills, capabilities and people beginning to be mobilised.

Q7 **Chair:** Excellent. Lastly from me—and maybe you could help us with this, Mr Wallace—given that this is all new, are there any safety concerns expressed to you about any of the issues concerning this?

Angus McIntosh: From a safety perspective, there has been a huge amount of work done already to date. This is not just starting. We have been working on it for the best part of a decade and we are very confident that all the safety aspects are covered. Safety is sacrosanct for a company like ours. That is what we live and breathe every day with natural gas, and we transfer that same mentality into hydrogen distribution.

We are working very closely with the Health and Safety Executive. In fact, all the appliances that have been developed will be accredited to the same level as natural gas and we have received a letter of assistance from the Health and Safety Executive saying that it is very happy with the process through which we have gone to evidence it.

There are differences between natural gas and hydrogen, but fundamentally it is a hazardous substance in the same way as natural gas and electricity, and we have the means to manage that.

Q8 **Mhairi Black:** Forgive me if I am covering things you have already answered for us, but am I correct in saying to begin with that it is possible to have a hybrid system of both hydrogen energy and natural gas?

Angus McIntosh: When you say "hybrid" do you mean a hybrid of natural gas and hydrogen?

Mhairi Black: Yes.

Angus McIntosh: Yes, it is possible to have a blend or a mix of hydrogen and natural gas. In fact, for the first 150 years of the gas industry, hydrogen was about 50% of the volume of natural gas when it came from town gas, so it is not necessarily a new thing. Going to 100% is new, so it is possible. Currently, we could only blend up to 20% by volume into the system. The reason for that is the constraint around the domestic customer. The current boilers that are installed would be compatible with that but if you went any higher, they would need to be replaced.

Q9 **Mhairi Black:** In terms of the national energy grids that are available, the National Transmission System and also the gas distribution network, how does hydrogen work with both those systems?

Angus McIntosh: At the moment, what tends to happen is the natural gas is brought in from, say, the North sea or from interconnectors or from liquefied natural gas into terminals into the UK. Those terminals supply the National Transmission System. From that National Transmission System, we reduce the pressure and distribute it into towns and cities and that is the distribution component of it. That is the current structure.

The structure for hydrogen conversion may be a bit different, so certainly for the pipes in every street, in every city they would not change. We would repurpose and reutilise those, but some of the transmission assets through both the process of conversion and connecting the new sources of hydrogen would be additional infrastructure.

Q10 **Mhairi Black:** What would it take to convert the current national gas network to be 100% hydrogen?

Angus McIntosh: That is what the full R&D research is doing, and the customer as well is going to be an important factor in that. You cannot

have part of the gas network on 100% hydrogen and next door have the other part on natural gas. Once you have converted it, it is then with hydrogen. What it would require is a mandate to change that out for the customers and that is being tested by the legislation proposed for the opt-out. It is important to establish that customers want it and are happy with it.

Q11 **Mhairi Black:** For my own context, if this was to be fully invested in and we were to move the whole of the UK towards 100% hydrogen, would it have to be done 300 houses at a time or could it be opened up to large-scale and do a city at a time? How do you envision it working?

Angus McIntosh: Absolutely. We have completed a concept study on that for Scotland specifically, which was designed for the accelerated hydrogen pathway for the Scottish Government's 2030 targets. Within that we set out how that might work in terms of conversion. It is roughly a 12-year period that you could do it. Of course, it is a function of how many resources, how fast you want to go and what is the optimum. What is quite important in the conversion process is there is clearly a tolerable time that customers would be willing to be without their energy supply. At the moment we would say that is 24 to 48 hours. You can speed up if you extend that, and there is lots of optimisation you could do around that, but we would estimate that it would be approximately a 12-year programme, which could be expedited.

Q12 **Mhairi Black:** Do you think this would require commitment from Governments, basically, for it to be a success?

Angus McIntosh: It absolutely requires the mandate. At the moment we are duty-bound to supply natural gas to customers. If we have that demand warranty, we could certainly support it. You also have to look at the market overall. We are not the only actor in the market. We are just the distributor and the transporter, not the producer, so you must look at the whole market chain.

Fundamentally, the hydrogen option is about infrastructure. It is about: do you want to build that infrastructure, and do you have the right market models to make that happen?

Q13 **Sally-Ann Hart:** Good afternoon to our panel members. I think you have both indicated that the UK Government's hydrogen strategy does not match with the potential of hydrogen in the UK. Can you describe how the UK Government's strategy for hydrogen could become more ambitious? For example, should we look more at the supply chain? Could we, should we, look at producing more green hydrogen, for example?

David Wallace: The Government strategy does recognise some of the benefits and recognises that we are in a strong position in many of the key technologies for production of green hydrogen, so that is electrolysers where we have leading companies. The Government, in shaping some of their policies in how they are going to deliver support, are thinking about what the pathway is for increasing the projects that

those companies will be able to get stimulated by the Government programmes. What are the projects they will be able to get that will put them on the right path to be able to compete with all the other countries and all the other companies that are chasing this opportunity as well?

One of the key things where we think greater clarity or commitment would be important is funding for organisations, like ours, to work with some of these key companies and technologies. For example, at the moment we are doing a project with a UK developer of electrical control systems that are very important for any renewables in the offshore wind turbines that we develop. This company is working with our research electrical engineers, but now we are also working with them on what these systems need to look like to supply the market there will be for electrolysers working with renewables.

There are many opportunities like that that need big demonstrations at scale of integration of those technologies with operating wind turbines, which are also able to pick out—as we are doing with offshore renewables—those promising UK technologies and innovators. At the moment, I think that the Government have set the resources for that based on what things looked like a few years ago. A lot of interested voices are saying there is so much happening now in green hydrogen around the world that there are even bigger opportunities than we hoped for just a few years ago.

Q14 **Sally-Ann Hart:** Is there enough export potential outlined in the Government strategy? What more could the Government do to increase the opportunities for export? Can you export hydrogen like you can export natural gas?

Angus McIntosh: I will take that one. Going back, there are a lot of positive things in the hydrogen strategies. There are still some issues around the business models, which are great to stimulate initially but we need to look at how we go beyond the 10GW of production. Fundamentally, that is about market creation as well and obviously projects like H100 Fife. If you can create that mandate you can allow hydrogen to become a ubiquitous fuel in the UK and beyond, and that gives you a great opportunity for export both of skills and hydrogen itself.

It is important to look at export and there is great potential in Scotland. I believe one of the studies suggested that there are 180GW of recoverable installed capacity in Scottish waters, which vastly exceeds both Scotland and largely the UK's requirements. It could be a fantastic export opportunity. For me, the value is demonstrating that and getting it moving in your country in the first place, so that the indigenous population benefits from that energy before you focus on exporting it.

In terms of the practicalities of exporting it, pipeline technology is the best way to move hydrogen about. You can move it about in a secondary form, such as ammonia or even methanol to some extent, but the best way is through pipeline technology.

Q15 **Sally-Ann Hart:** Does that already exist for natural gas?

Angus McIntosh: There is a lot of pipeline technology that is former oil and gas that is abandoned in the North Sea, pending some decommissioning. The compatibility of some of these pipelines forms one of the studies that I mentioned earlier that we are doing between Grangemouth and Granton. Some of those could be repurposed, but even new pipeline infrastructure to move that hydrogen about at scale would be a valuable investment.

Q16 **Sally-Ann Hart:** Looking at the ambitions of the strategy, it is not just about the export of gas. It is about skills and manufacturing goods and so on. It is probably fair to say that the UK was the leader in wind turbine technology, but you could say that we missed out on maximising the jobs and the manufacturing industry. What are the main risks of what we see now in hydrogen potential, in manufacturing, skills, exports, if our strategy is not ambitious enough?

Angus McIntosh: If you take the hydrogen supply chain, at the domestic level we are working with UK manufacturers Bosch and Baxi—two of the largest in the world. For the fire manufacturers it is largely UK manufacturers, including Scottish manufacturers. For the cookers it is all UK manufacturers. Electrolyser technology is an area that we need to ramp up in terms of support for developing that skillset within the UK. Other storage technologies will absolutely be key as well, which require more of the supply chain focus.

If you look at the resource and the people, transfer of skills from oil and gas to hydrogen is not a major challenge. In Aberdeenshire you have about 70,000 people employed in oil and gas. Those people, with all those pipeline and chemical engineering skills, are transferable to hydrogen relatively easily without major retraining.

If you look at it from a plumbing perspective, the people doing the work in the home, the appliances they will be installing, are simply an extension of what they already do for natural gas. There is no significant difference. The resource piece is about having all these people already employed in a sector that could be upskilled and able to deliver it. From a manufacturing perspective, there is a strong UK base to this, but you could go further with a bit more stimulation.

Q17 **Sally-Ann Hart:** Therefore, the benefits are not just in mitigating climate change and reducing carbon emissions and the potential is huge?

David Wallace: A lot of the value that we have in the oil and gas industry is exporting our skills and expertise to the global oil and gas industry, which is going to decline very rapidly. Potentially, we would miss out on the opportunity to preserve all the skills and move them into this new emerging global energy market of green hydrogen. That would be a huge, missed opportunity.

We have been incredibly lucky in Scotland, in particular, in falling into oil and gas, having all the benefit of that and creating the industry and revenues from the oil and gas, and now having another incredible opportunity that is way beyond what any other country in Europe has, for example. It will potentially put us in a similar position to where we have been in oil and gas. We are not going to be an enormous supplier of green hydrogen. That is going to be the middle east suppliers and Australia is going into this in a very big way. We will almost certainly have a strong, valuable niche in that global market as it emerges, if we take it.

Sally-Ann Hart: We must not let that opportunity slip between our fingers.

David Wallace: Absolutely.

Q18 **Wendy Chamberlain:** Thank you to both our witnesses. I would like to continue a bit on Sally-Ann's theme around ambition. At the moment we know that part of the reason that we are looking at these things is the drive to net zero, but there is absolutely no doubt that the cost of living and consumer costs for energy is another factor. From an ambition perspective, could we move more quickly than we are currently, David Wallace?

David Wallace: What we have seen in Ukraine, with the disruption to energy supplies to Europe, shows us that a lot of people have taken their eye off the ball on that energy security aspect. That adds to the impetus of the increasing drumbeat of: we are not doing enough for net zero. We are not going fast enough. In that big picture sense, absolutely, we could and should be going faster on our renewables journey.

The announcement of a target of 50GW for the UK overall, the ScotWind round of licensing for offshore wind and the 50GW target from Westminster for offshore wind is very good in that regard. We need to accelerate the demonstrations of technology development to make sure that we will be able to do something with all that energy, to balance out the future energy system and reap that full potential. It is a challenge for every country. Things must accelerate and even more so now.

Q19 **Wendy Chamberlain:** This morning one of the things that came through very strongly is that the H100 Fife project here is not just the technology, it is the social aspect of getting people's buy-in. Is this potential support for cost of living and more smooth cost of energy something that we can utilise to bring people on board?

Angus McIntosh: Absolutely. There are lots of different ways in which you can manage the market and how you can structure it. Once we have made the decision that we want to go for hydrogen as an option then there are a couple of things we need to do. We need to accelerate the design work, to put the things through planning to make sure that we fully understand all these barriers.

We have the new legislative processes, things like storage, particularly geological storage, so do we have the right legislative frameworks for these? My suggestion is we need to accelerate that towards the heat policy decision in 2026 so that we are ready to deploy. When you are looking at how this is paid for, there are great ways of potentially doing that that are not necessarily the current market model. The current BEIS business models for hydrogen are essentially a contracts for difference-type scheme, which is very focused on production and is a good way of stimulating production. However, from a customer perspective, this is fundamentally about infrastructure. Investment in infrastructure suits a regulatory asset base model investment, where you can socialise costs over, say, 40 years between current and future customers. We should be very open to different market mechanisms on how we design and deliver this.

Q20 **Wendy Chamberlain:** My other question is around the twin-track approach that the UK Government have recommended in their strategy, supporting both green and blue hydrogen. Again, from our time this morning, what came through to me is there is no one right answer. I suspect I know how you are both going to answer this, but what do you think of this twin-track approach, Mr Wallace?

David Wallace: It makes sense as a means to accelerate hydrogen technology generally. Anybody looking at it in today's context would have big concerns over the financeability of blue hydrogen projects—so that is taking natural gas and from that natural gas producing the hydrogen—without Government support of major projects based on natural gas because of the volatility in natural gas price because of the security of supply issues, which could potentially be exacerbated by taking natural gas supply to create hydrogen.

Q21 **Wendy Chamberlain:** If there are challenges around that, do you think we would be more likely to reach net zero if we were looking simply at green hydrogen?

Angus McIntosh: I think you must separate the engineering from the market aspects slightly here. You have blue hydrogen or green hydrogen and that gives you more sources of energy, and what we benefit from with our current network is that interchangeability of sources. The current market model, where it is fundamentally index-linked to either Brent crude oil or natural gas prices somewhere else, is extremely volatile, because you have a dominant production in Russia and a dominant demand in Asia.

If you separate that point—and we are developing lots of new fields now or considering developing our own indigenous fields—there are potential obligations that you could put on them to develop X percentage of hydrogen as part of the consenting. That would be one example of the kind of things that you could do.

Both have their advantages and disadvantages. Blue hydrogen gives you a means of doing it very quickly. If you look at the conversion on the scale that we are talking about, we could convert the networks a lot quicker with blue hydrogen because you have that guaranteed source. With green hydrogen you can do it, but you need to balance that with storage, because the key value of green hydrogen is the maximum economic recovery of energy from offshore wind, managing that intermittency. Having them both at the same time does benefit. Therefore, the twin-track approach is sensible but that does not mean that there are not things that you can do within the market to help.

Q22 **Wendy Chamberlain:** Therefore, for that ambition in terms of moving quickly, that twin-track approach is required. My final question then is: from a Scottish perspective, given the UK Government are supporting that twin-track approach, is there a challenge with the fact that the Acorn carbon capture is only one of the reserve projects?

Angus McIntosh: Yes. The Acorn project is important from several perspectives, one of course being there is a very significant amount of people employed in Aberdeenshire who we want to be able to transition. The effect of not being in the first cluster is that they will lose out on some of that technology development as well and some of the early deployment. We hope that would be fast-tracked and we want to be ready to support that, as and when it happens.

You are going to need a mixture of blue and green to move at scale, so without the Acorn project that would restrict our ability to do that in Scotland specifically, albeit there are other options with the shipping of CO_2 and there are a variety of ways of doing it. Yes, the Acorn project would be an important way of speeding up decarbonisation with hydrogen.

Q23 **Wendy Chamberlain:** Do you agree, Mr Wallace?

David Wallace: With some caveats that I have already mentioned.

Q24 **Douglas Ross:** Good afternoon to our witnesses. To follow up on that point, Mr McIntosh, you said we need to be ready to support the fast track. What are you doing in preparation for that? How are you working alongside the bid as a reserve cluster, probably, as we all hope, to get into the next round as quickly as possible?

Angus McIntosh: From an SGN perspective, we are preparing a design of a pipeline system. We have just undertaken what is called a pre-feed, which is the pre-front-end engineering design towards a detailed design study that goes through into consenting. We will seek to progress that through with our regulator to be ready for when the cluster will potentially come online.

We are doing a lot of work, including how we would design the sectorisation of Aberdeen's customers right through to green hydrogen as part of that pipeline system. There is a significant project called Dolphyn

Hydrogen, which is very exciting, which is direct production of hydrogen out in the sea where they have in-built desalination and electrolysis. We are trying to prepare ourselves to be ready. I think that is the bit that we need to accelerate so that it is a relatively low-regret option to get you to the point where you could make that heat policy decision and go for it.

Q25 **Douglas Ross:** Another thing you said in response to the Chair is that customers missed out in the decarbonisation debate. Can you explain that further? How have they missed out, and who is to blame for that? Is it people like yourself, or politicians or a mixture of both?

Angus McIntosh: It is a bit of a mixture, so I don't necessarily lay the blame. Sometimes engineers get very focused on engineering and sometimes companies get very focused on what their perceived solution is. Indeed, the energy trilemma is security of supply, price and decarbonisation and does not mention customer.

In my view, what is absolutely core to whether we can decarbonise at pace is if the customer is happy with the solution. Customers don't buy a car that they don't like, even if it is cheap. They want their energy in a form that suits them, which they can use, and we need to make sure, when we are designing decarbonisation, that it is a solution that they want.

Q26 **Douglas Ross:** Also, that it is an opportunity for them. In many parts of Scotland—and we have not touched on this—even being on the grid for natural gas isn't possible. I don't know how up to date these figures are, but in my own constituency of Moray 20.1% of people are not able to be on mains gas. In neighbouring Aberdeenshire, it is 5% but if you go to neighbouring Highland on the other side it is 72%. What do we do for large parts, particularly rural areas, of Scotland that cannot even get on to natural gas when they are seeing other parts of the country moving on to hydrogen?

Angus McIntosh: You must look at this from a whole-system perspective, which is almost quite an abused phrase because, when I talk about "whole system", I mean everything from waste through to transport, to your power network and your gas network—everything. When you look at the advantages of the potential of hydrogen being a ubiquitous fuel across all of these, it completely changes the investment potential in each of these areas and their ability to develop their own localised systems. My answer to that would be that we are looking at several off-gas grid locations where you can get the right ingredients to perfect that recipe but there is a bit to do yet in terms of proving them.

Q27 **Douglas Ross:** Could you give examples of that? People may be watching our proceedings or read about this and feel like they have been forgotten, not just in this session or recently, but for years as they have struggled being off grid. For some it is a choice. They want to live in a remote rural area. However, these are some of the people who suffer from fuel poverty more than anyone else. Here in Fife in 2023 there will

be 300 homes that will be fuelled by hydrogen. Yet, in other parts of Scotland we are miles, years or decades away from that. What comfort can you provide them?

Angus McIntosh: Fundamentally, if the demand is there, you can build it.

Q28 **Douglas Ross:** The demand could be from one person. I have cases for example with broadband. Someone desperately needs fibre broadband. That demand is there for them but the cost to do it to one property is prohibitive. We are surely going to see something similar with the properties who currently are not on the grid.

Angus McIntosh: When you look at it at an individual level then it is expensive. In fact, any of the options for providing energy to individual properties is a very expensive thing. What conversion of the gas network allows you to do is generate this system transformation solution to get hydrogen mainstream and ubiquitous. That does not mean that it can easily be transferred into every individual property. There are means, of course, of transporting tanks of hydrogen—and that could be used that way—similar to the likes of LPG at the moment. However, that is not the immediate thing that we envisage but it could be something that is born out of hydrogen becoming a widely available fuel across all sectors.

Q29 **Douglas Ross:** Mr Wallace, I understand you are looking more at offshore generation but in the renewables sector how much are we going to have to look at on and offshore wind, and other forms of renewables to generate enough green hydrogen, if we are going to see this rolled out as much as possible across the country?

David Wallace: To come back to offshore wind, one of the huge advantages is there is such a big resource of offshore wind compared to onshore wind, where for the scale of energy that we hope to have to decarbonise and to create an export market as well you very quickly run out of the cheap or sensible or acceptable places to develop a lot of onshore renewables. Thinking about scaling up faster than we have been doing, the scale of that natural resource means that is a good option for basing your strategy on in taking offshore wind to large scale.

Q30 **Douglas Ross:** There are still competing demands in offshore wind. I think the Skipper Expo was on in Aberdeen this weekend, and there are more and more concerns raised with us—certainly myself as an elected representative for a coastal community—that there could be a balance between renewables offshore but also there are industries that are struggling as a result. I am not diminishing the responsibility and opportunities for offshore wind, but what about hydro or solar? How much are you looking at smaller, maybe even community projects to meet some of the big targets you are going to have in the future?

David Wallace: Smaller community projects bring a higher value that can offset some of the costs of solar, which is very highly variable. Solar in the UK is much more variable than offshore wind, particularly in

Scotland where when you get further offshore that is an incredibly stable renewable energy resource in terms of the production and how little it varies over the year day-to-day.

That is one of the key advantages that when you have a highly variable resource, such as solar in the UK or Scotland, which is going up and down and has a huge swing in the amount of energy it produces in winter relative to summer, if you have a lot of that there are very high costs and difficulties in arranging all of the rest of the energy system to cope with that. For me it is a case of niche applications, which would work very well and perhaps provide local community benefits.

Angus McIntosh: There is a lovely phrase in German called "Dunkelflaute", which describes the dark, gloomy bits where there is no sunshine or wind. One of the advantages of hydrogen is it is about maximum economic recovery of energy, so it is about: can you use fewer resources generating hydrogen all the time, rather than trying to manage all this variability within your energy system? Yes, every single renewable type has its potential role. It is how we integrate them to maximise that recovery of energy and deliver it to customers in a form that they want and need.

Q31 **Douglas Ross:** A final question: we have targets to get to net zero in 2045 in Scotland, 2050 from the UK Government. This scheme that we have seen today is going to deliver for 300 homes here from next year until 2027 and then there is the next scale-up in the north of England for bigger areas. At what stage could you envisage almost every home, or every home in Scotland, being covered by hydrogen consumption and the opportunity to have hydrogen?

Angus McIntosh: I suppose that goes back to the point about mandate. If we have the mandate, which is theoretically going to be considered in 2026 for that system transformation—

Q32 **Douglas Ross:** Is this the opt-out?

Angus McIntosh: Sorry, this is the UK Government's heat policy decision in 2026, which can determine that the natural gas system is to convert to hydrogen. Given that indication, we need to accelerate and make sure that we are ready to deploy, and that is one of the things that we need to do. We need to move forward with the detailed design and consenting work now, so that we are ready in 2026 and not be too worried about that ultimate decision date. It is about trying to accelerate the option in time.

The study that I referenced earlier, which I am happy to share with the Committee, was the accelerated pathway for Scotland, which you can tweak up and down depending on how you put the resources in with roughly a 12-year conversion process.

Q33 **Chair:** The very last question. Your response will have to be brief because we must get to the next session. The Government have now put

forward a business model for low carbon hydrogen, which was published a few weeks ago. I think as part of that there is £100 million of funding for up to 250MW. How far do you think this will go towards achieving some of the targets and ambitions we have for this?

David Wallace: The Government have stayed in very close touch with what the plans are from industry, so that first tranche I think they are expecting there will be a very strong response from people with projects, fairly large-scale projects. Let us just say that they will have their pick of good projects probably to use up everything that is available very quickly.

Q34 **Chair:** Do we need something like contracts for difference to make this work and happen?

Angus McIntosh: Those business models are great, in the sense that they are going to stimulate some hydrogen production and that is their design. Beyond that, you need to look at whole system and all the different demand applications that you have, rather than either just industry or one focused area, and look at it as a ubiquitous fuel. Quite often the existing market dictates these behaviours. When you look at transport it is very much a different price point than heating, which is different from electricity, which is different from all these other sectors.

Once you have hydrogen flowing everywhere the price would be the same across all those sectors. If you take a further step back and say, "Well, in the long term, what should dictate the price of all these markets?" it would be the carbon price, which has nothing to do with the current set points.

Chair: Excellent. That is all we have time for. We could have asked you a number of further questions but unfortunately we are up against it. Thank you very much for your contributions today.

Examination of witnesses

Witnesses: Dr Nigel Holmes and Dr Jillian Couto-Phoenix.

Q35 **Chair:** Welcome to the Scottish Affairs Committee. What we will ask you to do is to say who you are, who you represent and anything by way of a short, introductory statement. We will start with Dr Holmes.

Dr Holmes: Good afternoon. Thank you for this opportunity to join you in Methil. One of the things I would like to say about Methil—and you have probably heard it already—is the dock here used to be Scotland's largest coal export hub. We have now seen the transition with Methil. I believe it was the site of one of the first oil rigs to be built in Scotland and we now have the H100 Fife project going ahead, so energy transition happening over many years.

I represent the Scottish Hydrogen and Fuel Cell Association. I have experience in the energy sector going back to the late 1970s when I first worked for the Central Electricity Generating Board. Since then, I have worked in the manufacturing industry, petrochemicals, and I have been in this role for about 10 years. It has been a fascinating journey, starting from quite a small potentially technical association to where we are now, seeing far wider interest in terms of the deployment of hydrogen as one of the key solutions to help us get towards net zero.

Dr Couto-Phoenix: Good afternoon. I am here representing the National Manufacturing Institute Scotland, or NMIS, where I manage a national transition training fund. In terms of what NMIS does, it is a group of industry-led manufacturing R&D innovation and skills facilities supported by a network of partners across Scotland, all working together to transform the future of manufacturing. NMIS is operated by the University of Strathclyde. It is supported by the Scottish Government, Scottish Enterprise, Highlands and Islands Enterprise, Skills Development Scotland, Renfrewshire Council and the Scottish Funding Council. It is part of the UK's High Value Manufacturing Catapult.

In preparation for this panel, I would like to acknowledge fruitful conversations that I have had with colleagues at NMIS, at University of Strathclyde, as well as Skills Development Scotland, the Scottish Funding Council, Scottish Enterprise, the High Value Manufacturing Catapult, Doosan, PA Consulting and BIBB in Germany. Thanks for the opportunity to be here this afternoon.

Q36 **Chair:** Thank you both very much for your very concise introductions. I will start with a general question, which we did not ask of the first panel: is hydrogen the future and, if it is, why do you think that is the case. Dr Holmes?

Dr Holmes: Hydrogen is absolutely part of the future, but it will not be the only way we can get to deliver net zero. The important thing here is to understand how hydrogen can complement other pathways to decarbonisation, for example electrification, and the use of hydrogen could be in heating, transport and industry, all of which require choices and the optimum solution is often a mixture of more than one approach.

Q37 **Chair:** Is that your view, Dr Couto-Phoenix? What role do you think hydrogen has in that mix, and is it going to be a significant player? Is it going to be the majority or is it just going to be part of the general mix?

Dr Couto-Phoenix: I agree it will definitely be part of a mix, and it depends on what we would like to do with it and how we see the mix playing out. We are at a point where we can determine what we would like that energy mix to be and what our energy future will be like. To do that we need that unity of purpose and that comes with alignment of strategy.

You can make hydrogen in so many ways. It is not like you can just extract it and use it. There are different ways of doing it and every single path you choose will have knock-on effects on what you invest in and what skills you are going to need, so it really depends. Yes, I agree with Dr Holmes, but it is up to us to choose whether it is our only future or whether it is part.

Dr Holmes: To meet net zero we will need hydrogen. We will not be able to reach net zero without hydrogen. Similarly, we will not be able to deliver net zero without carbon capture and storage and this is where we need all the technologies working together if we are going to deliver net zero.

Q38 **Chair:** What do you make of the Government's targets? The UK Government's ambition is to have 10GW by 2030, while the Scottish Government's ambition is 5GW by 2030. Do you think these are satisfactory targets and ambitions to meet and do you think they will meet them?

Dr Holmes: The targets keep changing. Will we meet them? Yes. With all the work that is going on I think we will, but we need to be very careful. These targets are setting up capacity to produce hydrogen and that does not always translate into tonnes of hydrogen being made. You could have lots of capacity but, if you do not use it wisely, you will not get lots of hydrogen.

Similarly, you have heard from David and Gus already about building up supply. We also need to think about how we build up the demand to match the building up of supply. The business case does not exist without the demand, and we need to find ways of balancing that supply of hydrogen with the demand for hydrogen, either in Scotland or the UK or more widely.

Q39 **Chair:** Are the targets overambitious? Do we need interim targets?

Dr Couto-Phoenix: I have nothing more to add to what Dr Holmes has said.

Q40 **Chair:** We have been around the H100 Fife facility here and it is very impressive. I think the whole Committee were very much knocked out by what we have observed here, but we have a long way to go. Where do you think the most significant contribution from hydrogen could be made? Obviously, we are looking at heat here and there is transport to be covered. Where could hydrogen make the difference?

Dr Holmes: I could start on that. What you saw with H100 is the ability to produce the hydrogen. You have the demand for the hydrogen but also within that system you have the storage of the hydrogen and that ability to store energy, so that you can decouple when you produce the hydrogen to the time when you need the hydrogen. That is one of the critical characteristics of hydrogen. You can also extend that.

As Gus said, you can move it around by pipeline so you can move the time when you produce the hydrogen and the place where you produce it into different places and times when you need it. That is a very important part of the use of hydrogen in the complete, full energy system going forward.

Q41 **Chair:** Again, for people who are observing our proceedings, we have discussed blue hydrogen and green hydrogen and you have mentioned carbon capture and storage in one of your previous responses. If we were to pursue one in particular, what one should the most investment go to? Is it a matter of getting them both right?

Dr Holmes: This is a great question. If I can give an example, which was just before lockdown: I was in a discussion in Aberdeen around green and blue hydrogen and one of the comments from another panellist was, "Well, the customer is colourblind. We can make green hydrogen. We can get blue hydrogen. We can put it all in the pipes and they do not need to know what it is when it comes out."

However, from what you heard earlier from Gus, in terms of the work that they have been doing with the customers here in Methil, it shows clearly that the customer does know the difference between blue and green hydrogen and they are starting to express preferences for, ideally, if they are going to decarbonise their homes and do all this work to make a change they want to go for something that they think will make a lasting difference. That is not to say that blue hydrogen does not have a place. This is just to say where the customer preference is coming from.

That is not unique to the consumer. We are also seeing the same from industry. We have examples where industries are starting to look to go to net zero on an accelerated pathway, but then saying, "We want to do it with green hydrogen." In Scotland we have some of the best examples where the whisky sector is expressing very keen interest in using green hydrogen to decarbonise distilleries.

As Mr Ross said, the need for energy is not just in centralised areas—current industrial areas. It could be dispersed around Scotland. Again, this is where some of the characteristics of where you can produce the hydrogen locally and start to use it locally is absolutely one of the strengths that we can start to play to.

Dr Couto-Phoenix: Again, green hydrogen is one where it is completely clean in the sense that we have so much wind in Scotland, so wind, water and electricity. You can produce it via electrolysis. However, as well as thinking more pragmatically about the work, I have been looking at skilling the transition. Given that we have these deadlines of 2030, 2045 and 2050, it seems like we will need to have a route to green.

Right now, we have oil and gas looking to phase into renewables and blue hydrogen seems to be a way that we can phase our workers into the hydrogen economy and then, as this is happening, we can scale up

green. Absolutely, it would be great to go straight to green, but we must carbon capture as well as produce. Green hydrogen is one of those options that might, in terms of workforce skilling and transition, be able to get everybody up to where they need to be over the next 25 to 30 years.

Q42 **Sally-Ann Hart:** The UK Government's hydrogen strategy discusses the export of hydrogen-related manufactured goods, expertise and skills. I think you were probably here with the earlier panel when we discussed the export of hydrogen. Do you think that the Government strategy should be looking at export of hydrogen as well? What is the most effective area to concentrate on when it comes to hydrogen exports?

Dr Holmes: The Scottish Government's strategy is very explicit on building up capacity for hydrogen production in Scotland. It is more about the 2045 scenario where there would be considerable overproduction of green hydrogen in Scotland, so meeting Scotland's need for hydrogen but then having additional capacity for production and that then being available for export. It could be into the UK. It could be into other countries where there is demand, similar to what we have now in the North sea where North sea oil and gas could be used either in the UK or more widely.

The UK Government's British energy strategy talks about building up the export potential for goods and services but is not so explicit around how you might start to export hydrogen. It talks about putting in place a standard for low carbon hydrogen. I think it mentions to have that in place by 2025. If we are going to start exporting hydrogen, we need to think about having the standards in place sooner rather than later.

I think David Wallace mentioned some of the speed at which people are starting to move. The speed in Europe and countries like Germany, they are making a very rapid transition away from being dependent on Russian gas to try to find alternative ways of importing natural gas and also future proofing those facilities; redeveloping ports so that they can then import either hydrogen or hydrogen derivatives in the very near future.

The danger is that if we are not quick to act—in the same way that we missed the opportunity with onshore wind—we may start to miss some opportunities with building up the position of Scotland, the North sea as a major producer of hydrogen for not just UK and Scotland but also for the whole of Europe.

Dr Couto-Phoenix: I agree on the potential for export, and it is quite explicit in the Scottish Government's hydrogen action plan. However, if this is how we are going to go, if this is that purpose, we need to drive that forward because there is so much that would need to be done in terms of the early technology as well as how we roll it out and scale it up in order to be able to export hydrogen.

For example, we have the ScotWind projects at the moment. I was speaking with SFC about one of the sites and it said that infrastructure from one of the sites—because these are large infrastructure projects—would need 5,000 welders just for the one site, and we have eight sites that we would like to develop. I am not saying we need 40,000 welders, and that is just the welding jobs for one site.

When we have all the wind up and running and if you are going to produce hydrogen, the electrolysers, you are going to need that capacity of electrolysers. You will need all the water to try to figure out what type of water you need. Are we desalinising all of our water and the scale of that? Then to ship it, it depends on where you want to ship it. If there is pipeline infrastructure that is great. If there is not then you have to either ship it compressed or cooled to minus 253 degrees Celsius or, as ammonia, minus 33 degrees Celsius. These are all very big engineering and research projects that will have to be scaled up very quickly.

If this is what we want to do, we need to have a very different conversation about transitioning our workforces: what skills do we have? What skills do we need? How do we need to invest in it? I have been managing a transition training fund. It is a stimulus package from the Scottish Government, and it was two six-month tranches of funding. What we found was it is clearly not enough time to transition workers, even if it is short and sharp transition training.

If this is what we want to do, we need a long-term transition training fund where we plan. It will give us the ability to work together across all the provisions. From higher education, further education, workplace, working with SMEs and companies that are working on the ground transitioning their workforces, we all need to work together to forecast what we need. That is what we need to export green hydrogen.

Q43 **Sally-Ann Hart:** Looking at building up the supply. When there comes a point where Scotland or the United Kingdom could export hydrogen—you mentioned, Dr Holmes, about some of the measures that might be needed to be put in place—what other support would be needed to make the most of international trade opportunities for the export of hydrogen?

Dr Holmes: To take most of the current opportunities, countries like Germany are looking to start to import green hydrogen derivatives—methanol, ammonia—in the not-too-distant future. They are starting to go out having dialogue with—and we have heard it mentioned already—the middle east and Australia, as countries who are interested in supplying.

Why this is important is that we have heard about contracts for difference for supply, so essentially Germany is putting in place some of these early contracts for difference for supply but what is fascinating is they are also looking at contracts for difference for demand. As well as starting to find out who is bidding to supply hydrogen from outside Germany, they are looking inside Germany saying, "Right, who is going to use this

hydrogen?" So, building up this early demand because again if you do not have the market demand for that hydrogen then the whole construct falls apart. There is something important about what Germany is doing in starting to stimulate this early demand as well.

Why does this all matter for the UK? Because along with these early contracts for difference that Germany have put in place, they are looking at about 10-year contracts with CFDs, which essentially would help to underpin investment in early hydrogen production projects. That then becomes part of where we have ScotWind projects starting to set up. They need to have a customer to sell that hydrogen to. Without that customer they do not have a business case. This is where both in terms of customers within Scotland, UK, but also Europe, we need to identify those opportunities if we are going to realise the full benefits and get the projects happening sooner rather than later.

Sally-Ann Hart: Thank you, that was very comprehensive. Dr Couto-Phoenix, do you have anything to add?

Dr Couto-Phoenix: No.

Q44 **Wendy Chamberlain:** Dr Holmes, I think we met at St Andrews—the COP26 event?

Dr Holmes: Yes.

Wendy Chamberlain: I knew I placed you from somewhere. Thank you very much, both of you, for your time today. Dr Couto-Phoenix, if I can come to you first. I am interested in what you were saying about the transition training funds. Mr McIntosh, in his evidence earlier, suggested that there were some more straightforward transitions in terms of end users. I could certainly see gas engineers, and so on, having to do an additional qualification to their certification in order to be able to input boilers. But you were also talking about much more complex transitions. Can you tell me a bit more about what kind of jobs that would be?

My other question is around certifications. My own experience of oil and gas is they are not very good as an industry at recognising qualifications in different sectors. Is that something we are going to be on the front foot with in relation to hydrogen?

Dr Couto-Phoenix: To address your question first in terms of the jobs. It depends on the technology pipeline but, from querying about SFC and Skills Development Scotland who work quite closely with the oil and gas industry, there is a lot of potential to transfer things like working in high pressure environments, for example, from the oil and gas industry. Skills is one thing, but what I have noticed from working in this area is that it is all about the people. You could have the skills, but it depends on whether you see the potential to transfer and the demand for the jobs needs to be there at the same time. We cannot transition a workforce if there are no jobs for them.

Q45 **Wendy Chamberlain:** Do you think the UK and Scottish Governments have given clear enough signals for the industry or individuals to feel that certainty to start to move?

Dr Couto-Phoenix: In short, no. We do need that unity of purpose. Lots of potential but we do need to line up our thinking so that we can start to plan, because this is the first time ever we have deadlines that are quite important. In order to plan for those and to make the most out of it we do need that. That is why I proposed a longer-term transition training fund, specifically to focus on this because it is a very big task.

To address your other question about certification. Again, I did float this around people I had spoken with, and it is complicated. It is not something we could tackle in an afternoon, but it is something that universities are aware of, further and higher education, institutes are aware of, and it is something that we will have to work with assurance and trade bodies to start to think about.

It will be something that we transition because the Centre for Energy Policy at Strathclyde had a nice report and it said for just transition we cannot do business as usual. That means thinking about everything that we do and, certainly, the people and making sure our workforce is trained to overlap with the demand is going to be important. Yes, assurances and how we tackle those will be very important.

Q46 **Wendy Chamberlain:** Dr Holmes, do you recognise that? How urgent is it for us to ensure that there is work training happening for workers in both blue and green hydrogen?

Dr Holmes: Absolutely critical. We already have companies who have heritage in the oil and gas sector who are starting to be active in the hydrogen sector. One example would be Hydrasun, who do a lot of assembly of components and systems. Its experience with high pressure fluidics from oil and gas into hydrogen to produce mobile hydrogen refuellers that can be used to help to stimulate and grow the early demand for hydrogen in transport. That is one example. Howden in Renfrew manufactures compressors. It is starting to get inquiries around compressors for hydrogen systems. We have companies also coming through from the hydrogen fuel cell sector who are starting to scale up; Logan Energy based just outside Edinburgh being one example. I think you mentioned that in your submission. We have all of this happening.

The other comment I would like to add is that some of the work done by the University of Strathclyde includes analysis of the job intensity of different forms of hydrogen production. A couple of years ago, Professor Karen Turner did some analysis on this. The number of jobs per tonne of hydrogen for green hydrogen is two to two and a half times higher than that of blue hydrogen. It is just a reflection on the type of equipment, the scale of equipment and the way it is deployed between green and blue hydrogen. Essentially, green hydrogen per tonne of hydrogen produced is more job intensive on a local level.

Q47 **Wendy Chamberlain:** That is interesting because, obviously, we were talking about a twin-track approach, but it does sound like it is a twin-track approach with an end goal of moving to green hydrogen, full stop, because not only the net zero benefits of it but clearly job opportunities.

Dr Holmes: Absolutely. Blue hydrogen is seen as being a way of scaling up quickly. You have the hydrogen production and then you have the carbon capture and storage. The hydrogen production of blue hydrogen may stop but the carbon capture and storage, the expectation is those are assets that will be needed in the long term to keep sequestering carbon emissions. It is a no-regrets approach. You develop the carbon capture and storage, use it for blue hydrogen but it then stays there to be used for a very long time afterwards.

Q48 **Wendy Chamberlain:** Scottish Government in its hydrogen policy statement said that if Scotland exported green energy to Europe—going back to Sally Ann Hart's questions—it could result in over 300,000 jobs by 2045. I am very conscious that in this space, and we heard it in our previous inquiry as well, there is lots of talk about job opportunities and numbers. Given that the transition of oil and gas we are talking about 100,000, does 300,000 seem right to you? Are we in the right ballpark in terms of that level of jobs ambition?

Dr Holmes: I think so. Some of the UK numbers are slightly higher than that but it is big numbers. The GVA numbers are also very considerable to a point where, essentially, the development of the hydrogen production could substantially replace the income lost by the decline of the oil and gas production in the UK North sea. Going forward, this is a big transition, but it will not happen overnight. Even when we get to 2045 I would expect the onward building of offshore wind farms and the building of further hydrogen capacity will continue, because there will probably be an increasing demand going forward for hydrogen as part of a net zero energy system; not just from the UK but more widely around Europe.

Wendy Chamberlain: Very positive and positive to hear of future revenues as well. Dr Couto-Phoenix, anything else to add to that?

Dr Couto-Phoenix: No, I think Nigel has captured it quite well.

Q49 **Mhairi Black:** If I could just dive a little deeper into the skills issue and transitioning employees over into hydrogen. How adequate are the current transition plans for people who work in other energy sectors?

Dr Couto-Phoenix: I do not think we have a framework for transition, so they are not adequate. Covid was a massive disruption and disruptor and there was a prediction of lots of unemployment. The impacts of covid were not what we expected in terms of employment. At that point there was the transition training funds that very much put the onus on an individual to start to transition themselves. Given the timeline, if we are going to do this, we will need to have a framework for transition. We work across the UK High Value Manufacturing Catapult as well with all of

the skills agencies in Scotland and we are looking at proposing a framework.

There are plans in place of having a transition framework where you not only have provision but you also have to incentivise workers that want to do it, as well as have employers who will take the time to train their workers. You cannot have somebody transition into important jobs like this on their own time on weekends. They have to have time at work to do this. It needs to be very structured and very co-ordinated. We do not have that but this is something that would benefit the transition.

Q50 **Mhairi Black:** Is that something that both Governments are open to or is it something that you are choosing to do independently and getting on with it?

Dr Couto-Phoenix: No, obviously skills is a devolved issue and so it works slightly different in Scotland versus the rest of the UK. However, because we work with catapult, they had a good report. It was manufacturing the future workforce, and this was a report where they looked at not only the work that we were doing here but also looked at other economies across the world where they are not quite industrialised. Again, the lessons learned from that is that we do require this. I know that Skills Development Scotland is looking at working with this framework, and NMIS is part of this because we are working across Scotland.

This is something that I think the Governments would be open to but, again, we would need that continuity of funds to be able to plan a demand-led skills model to 2030 and then to 2045 and then 2050.

Dr Holmes: One of the aspects I would like to bring in relates to whether you deploy hydrogen into the real market—whether it is, as Gus mentioned, households, whether it is using hydrogen for transport. Gus brought in the question of safety. Safety is absolutely key. If we don't do things safely, we will lose the public's confidence in hydrogen. We need to bake this in right from the start. Some of the skills and training we need are, for example, with the first responders, so people go out and tackle it when things do not work as expected. The number estimated there was about 20,000 skilled responders in Scotland requiring retraining in various ways.

We are also seeing this with the projects in Orkney where they are starting to move hydrogen around. They are putting hydrogen in tube trailers. They are putting tube trailers on the ferries, using that to move the hydrogen. They had to go through a lot of training for the staff on the ferries but also the first responders before everybody was happy that this was safe to do.

In building up the skills it is obviously key that we have the people who can manufacture the equipment, who can deploy it, design it, all these good things. However, we need the people who can also use it, maintain

it, respond safely and, at the end of the day, take it away and recycle it. Increasingly, we are going to have to look at recycling of some of the key materials. When we start to look at the deployment of these systems there will be some of the critical raw materials. We need to try to make sure that we have access to and then can keep using those on a sustainable basis as well.

Q51 **Mhairi Black:** Is that not a big stumbling block, though? At the start of this session, we asked about: where do you see hydrogen energy in the future and how big a role does it play? The answer is: we don't really know. It is whatever we make it. In that sense, you have a chicken and egg situation of: how can you be training people for jobs that do not exist but how can you try creating jobs if there is nobody trained up in them? Does that not create a vicious cycle? How do you break out of that?

Dr Holmes: What we have seen in Orkney is an example of how they have started to create some of the training modules. They have put them in place. They have taken people through. That is just one example at a small level, but it shows how this can be done relatively quickly so you can start to see the first steps being taken. The key thing here is learning from doing. Getting the experience on how you deploy things in practice.

Dr Couto-Phoenix: Exactly what the framework for forecasting your skills would be. From trying to get evidence for this inquiry we looked at working across the education providers; so higher education, further education, as well as HND and all the way down to the learners learning for schools. It is very clear that that skills provision needs to marry up very closely with the innovation because they are very new technologies that are coming through. That way we can inform each other very quickly and we can train.

The last component as well, which is important, is the early skills adapters, who are exactly these people in Orkney but also companies like Logan Energy, for example. They were a wealth of information because they are doing it and they are already training their workforces. We all have to work together because otherwise we will have this piecemeal provision, which does not work when you want to scale up very quickly. We have to have everybody working together in order to do this.

Q52 **Mhairi Black:** If that is the case, who should be leading the charge?

Dr Holmes: This absolutely has to be a collaborative approach. I do not think there is maybe any one organisation that needs to be leading the charge. There needs to be maybe somebody who is bringing this all together.

If I could just add one comment about the skilling. To reskill we have the existing workforce, but we also need to think about the workforce that will be coming through over the next few years. How will we engage and attract the people? This is a tricky issue in terms of STEM engagement for schools and colleges. As an example, the hydrogen office here, part of

the work that it did for about 10 years was engaging with local schools, primary and secondary schools, even the nursery over there was involved in naming the wind turbine on the dockside.

Going from that into the college areas, I think there were about 80,000 pupils and students in the Fife area that they engaged with over that time. We need to continue that. We are continuing that through, for example, initiatives like the fuel cell challenge that has been run in Aberdeen—during COP26 it was run as well. This is all about getting people involved and engaged in the hydrogen and fuel cells.

Q53 **Douglas Ross:** Good afternoon to our witnesses. To follow up on that because I was thinking, as Wendy and Mhairi were speaking, understandably we look a lot at the current workforce and the transition from those who work in oil and gas to these new sectors but that sounds very positive about what is being done with young people here. This is on their doorstep. How do we translate that to other parts of Scotland where there could be young people with an interest but there is no local footprint for them to make that connection between hydrogen now, what they might be planning to study or doing exams in at the moment and future careers? Is there enough done to extend outwith the locality of where there is a base of interest?

Dr Holmes: A very good point. There have been some discrete local initiatives—here, Aberdeen, Glasgow—but we need to do more, and we need to do it more consistently. This is where hydrogen and what we are doing should not be taken in isolation from the need to basically engage young people around the wider science technology, engineering/maths subjects. This is where working with some of the existing initiatives—the STEM ambassadors, for example, that go to schools throughout Scotland—we are starting some of the discussions about how our sector could start to participate and contribute towards these activities because this will be key going forward. It is not about creating something that is separate from other initiatives. It is trying to see how we can build on those initiatives to take forward.

Q54 **Douglas Ross:** Do either of you have concerns at the moment that, in some areas, there is not the availability for young people to learn all the subjects that they would need? Some of the sciences are restricted because there are not enough teachers, there are not enough young people choosing those subjects and, therefore, we could have great opportunities but because maybe over the last five or 10 years there has been a restriction in the amount of sciences that young people can study. That is going to have a huge knock-on effect not just for them but for the industry going forward.

Dr Holmes: Yes, potentially. What we do have in Scotland is a very good network of colleges and, through the Energy Skills Partnership, they are taking a very active role in this. We can also think about some of the work that the Open University has done as well to allow access to people

who cannot attend university on a permanent basis. It gives them more flexibility. There are approaches that could be very useful.

Dr Couto-Phoenix: Going back one step to STEM in schools and the general awareness building of net zero. Skills Development Scotland's climate emergency skills action plan—the CESAP—one of the objectives is to build a green jobs skills hub and this is something that everybody can access. There is also the My Climate Path initiative. It is an ambassador-type role, and you go into and work with schools to try to understand net zero. It is at the early stage of our energy transition. It is just building up that general awareness of net zero and hydrogen certainly being part of the energy mix.

But across society there is not the understanding that needs to be in terms of where we are for our targets for net zero, and certainly this is something that we could do more of if we had more of a directive for transition training. We are building momentum and, certainly, with NMIS and the work that we are doing with the manufacturing skills academy, there is a lot of work targeted at young people and developing that young workforce. It is coming.

Q55 **Douglas Ross:** Looking wider than just younger people, if we had had this discussion about hydrogen six months ago at the peak of COP26 net zero was a buzz word everyone was using. The world has moved significantly since then. Do you think global events such as the energy crisis, the situation in the Ukraine, clear sanctions against Russia, has changed the public's mood on net zero and, while everyone is worried about climate change, it is not the priority it was for a lot of people six months ago because of these global events?

Dr Couto-Phoenix: Net zero, in the sense that net zero and sustainability and we definitely were thinking about—we came across this when we were trying to develop CPD for one of our transition training programmes, and you call it a buzz word but it means so much. The general awareness piece is something that we need to do more about, if we are to get people to take action on net zero, because it can mean different things to different people.

In order to translate that into a green job, we have to understand that our jobs will be greened over time as we transition. It will be workers who are transitioning. It will be provision; how our provision will transition. Students now might have to be going into jobs that are not green at the moment but will become green as they move towards. In hydrogen you might have to start in oil and gas and then move to blue and then move to green, and that was from people working in Skills Development Scotland looking at the new provision.

At this moment in time, it is that awareness piece across all of us and how we are going to have do that. How are we going to transition? What then informs how we get people into jobs and how we educate everybody about the transition?

Q56 **Douglas Ross:** Dr Holmes, you were saying at the start of your evidence that some people are very immersed in this and choose between blue and green, so they clearly have an understanding of what is going on. We also saw some information earlier on today that, while a significant proportion of the population is happy to make adaptations to their homes to help tackle climate change, when they are asked to pay for that, particularly now in a cost of living crisis, their eagerness to do so diminishes because there are other priorities.

Dr Holmes: Yes, it is a difficult situation but there could be opportunities where we can achieve both the climate targets and also security and supply of energy at a reasonable cost, but we would also need to be pragmatic about how we approach this. One of the opportunities for hydrogen is deployment into transport markets, and the work that has been done in Aberdeen is using hydrogen fuel cell buses, which is great. The buses are super quiet, with no pollution, but there are also opportunities to use hydrogen to displace directly the use of diesel in engines, so you have combustion engines that run on hydrogen.

You probably would not want that in a bus but for a heavy goods vehicle that is driving up and down motorways for a lot of the time that could be a very appropriate way of decarbonising the transport. If we can achieve some of the targets with the scaling up and the cost reduction of the hydrogen, the price of that hydrogen for transport markets will be super competitive with the existing petrol and diesel. It starts to get us away from that dependency on any imported fuels.

There are, I believe, areas where we can make things better on both fronts, but we probably need to be very pragmatic about how we do that. Do not just go out looking for the perfect solution. Look at some of the ways we can make big steps that get us towards greenhouse gas reduction, and that can get us a long way there.

Q57 **Douglas Ross:** That leads me on to my final question. Dr Holmes, you mentioned whisky. There are more whisky distilleries in my Moray constituency than anywhere else, and the vast majority of those are situated in Speyside where we do not have access to the grid. Do you see this progress towards hydrogen happening at the same pace between residential properties and businesses and industry or do you think industry will go ahead first and then hydrogen in homes will catch up? Or will they both roughly move at the same pace?

Dr Holmes: That is a very good question. Do not hold me to the answer. Can I give an opinion on this?

Douglas Ross: That would be good, and we will come back to you in a few years' time.

Dr Holmes: The work that is going on in Invergordon maybe gives a sense of how this might pan out. Scottish Power is deploying a green hydrogen production project and it looks like one of the anchor demands will be the grain distillery, which is adjacent to the Invergordon site. At

the same time, SGM was looking at the potential as a concept. That grain distillery currently gets its gas coming up the gas pipe from Inverness. It thought about turning the gas distribution transmission network around and pushing hydrogen from Invergordon back down to Inverness. It was a pipe and Gus will probably say, "You cannot do that," but, in principle, you might be able to make it flow both ways.

Why does that matter? For example, in Speyside you have distilleries like Tormore, I think, and Glenlivet is on its own little gas network that was put in quite recently. That also leads towards areas that could be suitable for renewables. You could possibly start to have a little micro-network within Speyside, and what would prompt that? It could be if the distilleries are saying, "We want to go for net zero sooner rather than later." There is the infrastructure in place that could potentially open up this is an opportunity.

The answer to your question is: it could be industry-led to start off with. The whisky sector is very much looking at decarbonising early. Why? Because the whisky they produce now they do not sell for another 12 or 15 years, and they are starting to anticipate what will the market want in 2030s, 2040s. The answer probably is a luxury product. People will be looking for very high environmental credentials going with that product. It is a fantastic opportunity and hopefully, in five or 10 years' time, we can test to see whether this is right. The whisky sector could be a major factor in helping to move this forward.

There are others who can help as well. For example, the water utilities are also going very much for net zero by 2030 and they could also be a key part in helping us to move forward on this.

Dr Couto-Phoenix: Industry is also motivated by regulation and legislation, as consumers were motivated by how much our energy bills are going up or down or what the cost of living is. If it is cheaper then homes, if we could get it in a way that would not lead to fuel poverty, then yes, our residential networks would be the first to take it up, but industry has that with the SECR (Streamlined Energy and Carbon Reporting) legislation for large companies and then they are wanting to decarbonise their supply chains.

There is definitely that motivation. There is a clear driver. There is also being a business that is certified and doing the right thing. For consumers it is very much with cost of living, on whether we can afford it not.

Q58 **Chair:** Where do you think we will be in 10 years? Will we be along the path of the "Ten Point Plan"? Will we be securing and realising our ambitions? In answering that, one thing that struck us about our visit here today and the public engagement exercise that is going on just now, perhaps we can describe it as maybe not the most understood of technologies. There is a discussion about maybe we should just call it green gas as opposed to hydrogen with all its similarities with the Hindenburg or the periodic table. What do you think we have to do to get

there? Do you think we will get there? Are you optimistic that we are going to meet these targets?

Dr Holmes: I think we should call it hydrogen because that is what it is. When you talk about Hindenburgs and H-bombs, these are absolutely the things that come in people's minds when we start talking about deployment to hydrogen either in terms of in homes or in transport. To dress it up as green gas would probably cause more concern than just calling it hydrogen. Let's call it what it is.

What we need to do is then work carefully as a sector to make sure that as we deploy things these are done in absolutely the right way. You heard that from Gus in terms of the requirement to make sure that the safety of using hydrogen in homes for heating is absolutely correct. We need it in the transport sector to make sure that cars, buses and lorries are all done safely, the refuellers are done safely, because if we do not do this and if there are instances that will undermine the public's confidence in hydrogen as a fuel.

We have seen this, to an extent, happen already. In Korea, there was quite a bad accident, which undermined public's confidence in Korea. There have been demonstrations in some locations against the deployment of hydrogen systems. We need to learn from not just what is going on in the UK but also keep an eye on what is going on more widely.

The other key thing is some of the communications we put out about hydrogen in the UK we need to be consistent with what is going on elsewhere, because in a world with social media you will get images from anywhere. Where hydrogen is being deployed you will get comments from anywhere. We need to make sure that we are consistent but that we are also ahead of the curve when it comes to the deployment.

Q59 **Chair:** Dr Couto-Phoenix, do you think we will get there and realise our ambitions?

Dr Couto-Phoenix: I am an eternal optimist when it comes to these types of things, but if we want to have a good chance of getting there, we will need to plan because otherwise we definitely will not get there.

In order to plan we do have to see it as a transition and have a very focused plan on how we are going to get their skills. It will be a very important part. It is about getting skills up on that front page because they will be able to get us where we need to be if we plan for it.

Chair: On that very positive note, we will have to end these proceedings. Thank you both for joining us today. Once again, we thank everybody in the innovation park today for their hospitality and putting up with us for the course of what has been most of the day.