



Science and Technology Committee

Corrected oral evidence: Long-duration energy storage

Tuesday 24 October 2023

11.25 am

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Members present: Baroness Brown of Cambridge (The Chair); Lord Borwick; Viscount Hanworth; Lord Holmes of Richmond; Lord Krebs; Baroness Neuberger; Baroness Neville-Jones; Baroness Northover; Lord Rees of Ludlow; Lord Sharkey; Viscount Stansgate; Lord Winston.

Evidence Session No. 8

Heard in Public

Questions 60 - 67

Witnesses

Arnaud Réveillère, Head of Green Storage and Net Zero Solutions, Geostock;
Martin Scargill, Managing Director, Centrica Storage.

USE OF THE TRANSCRIPT

This is a corrected transcript of evidence taken in public and webcast on www.parliamentlive.tv.

Examination of witnesses

Arnaud Réveillère and Martin Scargill.

Q60 The Chair: Welcome to the eighth session of our inquiry into long-duration energy storage. This session is being recorded and will be shown on parliamentlive.tv. A full transcript will be taken and sent to you just after the session for you to make any corrections you need to make. If there is anything you think of that you did not get a chance to say or further data or information that you think would be useful to us, we would be very pleased to receive it as formal evidence after the session.

I welcome our two witnesses for this session: Arnaud Réveillère, head of green storage and net zero solutions at Geostock, and Martin Scargill, the managing director of Centrica Storage. Thank you very much for joining us today. I will kick off with the first question.

Previous witnesses have talked about the importance of an overall strategic vision for the UK energy system and the role that long-duration energy storage will play and how it will interact with other technologies. I would be interested to hear your views on whether that is needed, what is currently missing and, if so, what this strategic plan needs to set out to give investors confidence.

Martin Scargill: Thank you, Chair. What is important is to look at energy policy and vision in a holistic, whole-systems way. At Centrica, we do not just look at long-duration energy storage in isolation; we look at it in relation to how we can drive the hydrogen economy forward and decarbonise the power system by no later than 2035—as soon as possible. We have done some work on that recently with National Gas, and I would be happy to share the outcome of the study with the committee.

On the needs case, I agree largely with other witnesses to the committee that long-duration energy storage is essential for energy security, flexibility, resilience and lowering customer bills. I am struck by how the debate has moved on recently in terms of how best to deliver long-duration energy storage in the form of hydrogen, regardless of how much hydrogen we produce and what other uses we might have for it.

In the UK, we start from a fairly low base. Today, only 4% of our annual gas consumption is covered by storage, compared to something more like 25% to 35% in comparable EU countries. Lessons that we have learned from recent years have taught us that we need to boost our energy resilience, and we welcome the Government's commitment to look again at the role for natural gas storage in the energy system going forward. An independent study that we commissioned last year said that, if we had had an extra 35 terawatts of gas storage on the system, it would have reduced wholesale energy prices by £2.4 billion over the winter of 2021-22, so we see an ongoing value case for storage.

The Chair: Is that 35 terawatt hours?

Martin Scargill: Yes, sorry.

The Chair: We are getting very confused between gigawatts and terawatt hours and other things.

Martin Scargill: Yes, that is 35 terawatt hours of storage capacity on the system in the form of natural gas.

The Chair: Thank you.

Martin Scargill: We know that investing in long-duration energy storage reduces the cost of net zero to the consumer. A BEIS report published last summer illustrated a saving of between £13 billion and £24 billion of cost reduction by investing in long-duration energy storage, and the higher end of that range is achieved by deploying hydrogen storage and flexible generation. We are very supportive of the Government's work on developing a hydrogen storage business model in a nascent market. That will be required to kick-start investment in hydrogen storage facilities.

I will say two things about that. First, the model is potentially a bit narrow in its scope, in looking at what asset classes it might consider. We do not think we will get where we need to be in the quantum and the timeframe for hydrogen storage if we just look at new salt caverns. We think that salt caverns and depleted fields will both be needed to get to where we need to be. We also need to think carefully about the interaction between the gas system and the hydrogen system as the two change over time.

Arnaud Réveillère: Long-duration energy storage is needed. In a simple approach, we have unpredictable wind and PV production, and we have demand. You cannot say to someone that they cannot take a train this morning because there is no power. Of course, you need storage at some point. That is the simplest approach, you can understand it easily.

But it is actually more complex. I would follow Martin and say that you need a holistic approach, because long-duration storage is one source of flexibility but you also have other sources of flexibility, whether it is on the production side, with overcapacities and demand-side management on the demand side, or interconnections through interconnectors.

It is difficult to have a clear, quantitative view of what is needed just with the rough thinking that, "Yes, storage is needed". To answer that and to identify the business frames that can be set, you need the analysis that some people are doing—not Geostock—to model all the energy systems, the production side, the demand side, transportation and storage, and try to find the cost optimum. The cost-optimal solution needs long-duration energy storage and hydrogen storage. This is the finding from the holistic model that some people are doing—for example, Enea Consulting and Artelys in France, LBST in a project I co-ordinated – Hystories, the reports of which are public-, and Catapult in the UK. Other companies are doing that, and long-duration energy storage is the result.

One of the inputs for their modelling is political hypotheses or plans. Net zero in 2050 is a very strong input into their models. The base of that transition is set by those kinds of inputs.

The Chair: Can you both comment on how well the Government's current policy is doing at supporting longer-duration energy storage and whether the current electricity and energy market arrangements are appropriate to enable it?

Martin Scargill: The current arrangements are to leave it to the market to determine the amount of long-duration energy storage we have, and that is possibly a reason why we have such low amounts compared to other comparable economies. I mentioned the independent analysis we had done that showed the real value of having more storage on the system, particularly when the market is stressed.

The market reflects pretty much zero insurance value for long-duration energy storage. In a situation where we could have energy security issues on the supply side and infrastructure failures, on the demand side, if the system is too tight and we need to start load-shedding, there is no market valuation placed on the insurance side of storage.

Arnaud Réveillère: I am a witness here and also more or less a witness of the energy policy and business frames. It is more our customers' or clients' job to work on that, so I encourage you to interview them.

The Chair: Understood. Thank you very much.

Q61 **Lord Sharkey:** My question is for Martin and is about Rough. Centrica has said that its ambition is to redevelop Rough to be the world's largest hydrogen storage facility. Could you talk us through in some detail how well developed those plans are and what will be required to realise your ambition? Along the way, what policy action or support do you need from government to make your ambition a reality?

Martin Scargill: Thank you for a brilliant question, I am happy to talk about our flagship project at Rough. We have been working on its suitability for conversion to hydrogen storage for about five years now. We have invested significantly in studies and engineering design work on that project, and the headline is that all the work that we have done shows that the site is very suitable for conversion to hydrogen. We would be looking to start construction on the project, if we could get it consented, within 12 to 18 months. We are quite well advanced.

I should say that all natural gas fields are different, so you need to approach them case by case, based on a number of screening criteria that we have helped to develop over the years. Rough is effectively the jewel in the crown of the gas system. It has worked reliably for 35 years to balance supply and demand, and it is proven in operation.

We call it the Goldilocks field when talking about long-duration energy storage, because it is just right. It is the right size and has been proven over 35 years in operation. It does not leak, and it will not leak with

hydrogen. It is highly porous and permeable, so it can store a lot of gas in whatever form, and that gas can move in and out very quickly. We can deliver a lot of gas to the system when it is needed and back off the system when there is excess renewable generation. We could store between 10 and 16 terawatt hours of hydrogen in Rough in the future.

Lord Sharkey: Would that make it the largest storage system in the world?

Martin Scargill: It certainly would, to our knowledge. There are bigger fields that could be developed, but right now we think it is the most advanced development and could be the biggest field in the world. In addition to the specific characteristics I have described, it has some great locational benefits. It is adjacent to the largest industrial cluster in the UK—the east coast cluster. When you combine Humberside and Teesside’s industrial emissions today, that is 50% of the UK’s industrial emissions that need to decarbonise.

We are close to large offshore wind infrastructure—Dogger Bank and Hornsea wind farms. Power will be landing very close to where Rough is, so there is adjacency, perhaps reducing transmission costs. We are next to the largest import pipeline of Norwegian gas into the UK. Whichever colour of hydrogen production wins out in the end, whether it is blue or green, we are in a good position to take hydrogen produced from either technology.

You asked about what it would take to get the project off the ground. We are looking for two things. As I say, we welcome the work that the department is doing on hydrogen storage business models. We are looking to develop the field as a natural gas storage facility that is hydrogen-ready. We want to get on and build a hydrogen-ready store now that could be used for natural gas in the meantime and then convert it to hydrogen as and when the hydrogen comes on to the system.

We would need to complete field trials to prove that the field can handle hydrogen and behaves in the way that we have modelled. Most obvious—I think we will return to this point—is access to a business model to unlock the investment. We see that as the main barrier to long-duration energy storage investments, given the high upfront cost and the uncertainty, particularly in the nascent hydrogen market, about where revenues will come from for such a facility.

Lord Sharkey: When you talk about storage capacity, are you excluding the cushion gas element of the storage facility?

Martin Scargill: That is correct. It is a working gas volume, as we describe it, which is the amount of gas that can go in and out of the system over time. The 10 to 16 terawatt hours is the working usable hydrogen energy volume that we could put into a field such as Rough.

Lord Sharkey: Do you think there are lessons to be learned by the Government from the energy crisis post Ukraine, or have the Government

actually learned such lessons?

Arnaud Réveillère: Before the invasion we were looking at storage for balancing energy supply and demand; the Ukraine war has reminded us of the need for energy security. Long-term storage of energy is a cornerstone of energy security. If you look historically at why oil storage developed, it started after the Suez Canal crisis. In the aftermath of that, the IEA set the obligation for all its member states, the OECD countries, to have 90 days of imports stored at home. Some different business frames have to be set to make that happen. In France, for instance, it is the responsibility of the distribution side. They need these 90 days of reserves for what they sell at the gas and refuelling stations.

Martin Scargill: In terms of lessons, energy markets have fundamentally changed and we think will continue to change, not least because of decarbonisation and intermittency on the system. The UK today is a net importer of energy and therefore exposed to volatile wholesale markets. While we have a diverse and robust source of gas input supply to the system, we are competing for those import sources on global markets. The way we look at it is that the design of the UK energy system has evolved to be a just-in-time system. It all works when everything works, and that is efficient, but it is time to look again at designing a just-in-case system with more resilience.

The Chair: You have talked about converting Rough to hydrogen, but there is no point in having a big store of hydrogen if it cannot be moved around. What would it take in terms of the hydrogen transport system for you to go ahead with it?

Martin Scargill: We could build a store, but it would be quite pointless to have the biggest store in the country that is not connected to any production or demand centres. We very much welcome the national infrastructure recommendation to get on with building a core set of low-carbon pipelines for hydrogen and CCUS in the UK and connecting the industrial clusters. I mentioned before that Rough is in close proximity to the largest of those. We need the demand centres connected.

The Chair: But it would need the pipelines to be in place.

Martin Scargill: Of course, yes.

The Chair: It would also need the turbines if it was to support the electricity system.

Martin Scargill: Yes, we would need the connecting infrastructure in the transmission system to make the store usable.

Q62 **Lord Winston:** You have both been involved in research on the conversion of depleted gas and oil fields to store hydrogen. Clearly, one of the questions we need to ask is how difficult it will be to do that and how long it will take. Some people I have spoken to seem quite alarmed at the idea of doing it, so it would be good to have some reassurance from you that it is a really safe technology.

Arnaud Réveillère: There may be different questions around maturity and what we should we do about safety. On maturity, there are different technologies—salt caverns, porous media, depleted fields and lined rock caverns. The technology readiness level assessment by the IEA, which is public and accessible on the internet, assesses depleted fields at four to five. I more or less agree. Since it set that mark, it has been evolving very fast. This year, two projects in Europe have injected pure hydrogen—one into an aquifer and one into a depleted field. It is changing very fast, and maybe the TRL would be five or six right now.

For salt caverns, it started 50 years ago in the UK, only 10 years after the first natural gas storage. They did not develop in the same way, but not really due to technical reasons. It was due more to market reasons. The IEA estimate of their TRL is nine or 10. It is seen as mature, and I would say so too. However, keep in mind that mature technology does not mean that there is no more technology development. Bicycles were mature 50 years ago. They are mature now, but in those 50 years they have changed a lot. It is a continuous process. We still have technical developments ongoing. We have a research project at Geostock. We are involved in a lot of them today because it is very active, but it is seen as mature.

The technical maturity of lined rock caverns is probably lower because the assessment cannot be based on a widely deployed industry; there is only one natural gas storage site that has been operating for decades. There are probably more technology developments for this technology. It is appealing and it can be useful in some locations where there is no salt and no porous media, such as in Wales and in harbours, where there is more local storage, but, with more technology development, we are working on that.

Lord Winston: Martin, how long would it take to convert an original natural storage system?

Martin Scargill: I probably should say again that we think both will be needed in terms of the quantum, and the UK is very well endowed with the opportunity to be able to do that. We could oversize and end up using that as an export route for excess renewables.

The lead time is one of the main reasons why we are excited about depleted reservoir conversion. Quite frankly, we do not need to spend the money and time or introduce any environmental impacts in making the store in the first place. It is there and has been there for 200 million years. It has been gifted to us. That in itself reduces the lead time for a project. As I said, there is some work to do to get our project consented. Nobody would currently consent an offshore hydrogen storage facility whether it was in salt, a depleted reservoir or another medium. Speed to market is very important in terms of lead time.

On cost, from some of the information that we have seen published in the Royal Society report, we think that the upfront costs per unit storage for

converting Rough could be as low as half the same amount of long-duration energy storage in salt caverns.

The industry needs to deal with safety regardless of where it is stored. The facilities above ground, the pipework and everything else are the same. You are just looking at certainty around the integrity of the structure. We are very confident. Salt caverns are typically built in salt strata about a kilometre down. Rough field is three kilometres down. Part of the overburden structure is an 800-metre layer of salt, so it will not leak, but we have to prove it.

Lord Winston: Are the skills available to do all that?

Martin Scargill: Yes, we think so. It is an extension of what we have relied on for decades in the oil and gas industry. The supply chain is the same. The skills are very much the same. We just need more of them, as other witnesses have probably described. It is not necessarily a challenge for our project. Our project would create about 4,000 construction jobs over the five years that we have talked about for deploying the project.

Lord Winston: A brief crunch question I have been set is this: how long do you estimate it would take to get a new salt cavern storage site permitted, prepared and actually operating?

Arnaud Réveillère: For a new one, from brownfield construction of the leaching plant and the caverns, I would say maybe six years. In the UK, you have a lot of sites already there, with leaching plants that are already operational, so in that case it might be three or four years. There are also cases of conversion of existing natural gas storages, which may be closer to what Martin said for depleted fields. It can be fast, maybe a couple of years. For a lined rock cavern, it is probably longer—maybe 10 years.

The Chair: Is the permitting for that quite quick?

Arnaud Réveillère: No, I was more giving you an idea of the construction work.

The Chair: Is the permitting typically a bit of a blocker?

Arnaud Réveillère: I think in the UK you have projects that are already permitted for hydrogen underground storage that have gone through the path in several years.

The Chair: Martin, what is your experience of permitting?

Martin Scargill: For our site, it would be re-permitting, so it would be a shorter lead time. We speak to colleagues across the industry, and 10 years is typical, which is why most developers have been calling for early deployment of the business model so that they can get on with confidence, if it takes that long to get a site permitted—a new site in particular.

The Chair: It takes 10 years to get the site permitted?

Martin Scargill: No, for a new site, it is maybe three years upfront and then there is the construction on top.

Arnaud Réveillère: A decade is the right order of magnitude.

Martin Scargill: End to end, a decade, yes.

The Chair: Are the right skills in place for the permitting to happen? When you apply for the permitting, do the planning authorities already have the skills to understand the implications of permitting for hydrogen?

Martin Scargill: As Arnaud mentioned, there are a number of sites in the UK for salt caverns. They have been built over the last four decades to service the gas network, so we can see that it has been done before. The speed at which we need to build is quite stark. If we just go with the Natural Infrastructure Commission recommendation of eight terawatt hours by 2035, that is as many salt caverns to be built in the next 12 years as have ever been built in the UK. It may be less a skills issue per se, but rather one of volume.

Lord Borwick: Would there be any pollution caused in the construction of the salt cavern? What would happen to the salt?

Martin Scargill: I am not a salt expert, but I know that to create the cavern you have to leach it. You have to pump hot water down, which returns a brine stream, effectively salt water, and you have to put that somewhere. One of the reasons we think that depleted reservoirs and other storage media will be important is that salt cavern development will likely get rate-limited by one factor. It can be done, but it takes quite a long time to leach out a cavern. One of the features of the lead time is what you do with the brine. It is not as simple as pumping it back into the sea. It is quite sensitive environmentally. I have heard of projects that used it as a feedstock somewhere, but the rate of the feedstock can be variable as well. It is a challenge but it can be overcome. It is just part of the manufacturing process.

Arnaud Réveillère: Historically, the salt cavern industry started for brine production—for salt production—and storage was a by-product at first. There are still some cases, as in Cheshire where INOVYN is developing projects; it uses the salt as a feedstock, creates the caverns and uses the void for developing storage projects.

The Chair: Can I ask a very quick and maybe very stupid question? If you are using depleted oil and gas fields for storage, do you have any problems with contamination of the hydrogen?

Martin Scargill: There can be risks. As I mentioned at the outset, it is important to screen each reservoir one by one and go through all the criteria that you would need to assure yourself that there is no risk to the development. The first main risk is whether the hydrogen will form any other compounds while it is in storage. We have done some lab testing of our core samples, and that shows very positively that nothing will form in terms of mineralisation.

The second broad category of risk in that department is microbiological activity. Will the bugs eat some of the hydrogen and, therefore, you lose some of the stock of hydrogen you have in store? Again, we are doing some work on that, but there is very low risk in our field. One of the reasons for that is that the average temperature of the reservoir is 95 degrees, which is right at the top end of the survivability scale, if you knew there was such a thing, for microbiological life. It is on a case-by-case basis.

Q63 Lord Rees of Ludlow: I would like to ask about the economics of storage when demand is intermittent over a very long timescale, which obviously raises problems. Would you say a bit about that and bring in the evidence of what happened to Rough? We are told that it was closed in 2017 because it was argued that gas prices were not volatile enough for it to be economic, but in recent years that may have changed. Can you encourage the economics or optimise it so that it is felt to be worth while to develop these storages for hydrogen?

Martin Scargill: On the economics of storage, I think I mentioned previously that the main barrier to investment for developing new storage is the revenue uncertainty and the upfront cost for the investor. That has always been the case, and it remains so. What can be done is the question. We have seen periods when there was sufficient revenue earned in the market for assets such as Rough and other storage facilities. There are times when the merchant revenue of trading gas in the open market is sufficient, but it is very volatile. You talked about the decision in 2017 to close the asset in the five years after 2017, to 2021. The costs for running or just keeping the facility open would not have been covered by the market. More recently, volatility has returned in a way that is not good for consumers.

In terms of where we get to with both natural gas storage investment and hydrogen storage investment, how do we incentivise development so that the investor can get confidence that they will make a reasonable return and how can we tie that up with making sure that the consumer gets the benefits from storage of it being in the system? If we take those two competing demands together and fast forward, we always land in a place where a cap-and-floor type of structure would be something that we think is investible. We think that if you structure the cap mechanism well, you can incentivise the developer and the operator of the facility to generate as much revenue as it can from the market when there are revenues to be made. When revenues are high, some of those earnings are passed back to the consumer to lower bills. We think cap and floor is a good way to move forward, but the devil is always in the detail with these commercial arrangements.

Lord Rees of Ludlow: Thank you. Although this is slightly beyond your remit, I wonder if you would contrast the case of hydrogen, where there are many uses, with other kinds of long-term storage such as compressed air, liquid air, large piles of gravel and things like that, which are really only useful in cases of emergency. Do you think that you have a big advantage over those kinds of storage that are less flexible?

Arnaud Réveillère: I would go back to the first answers we both gave to the question about a holistic view. I am not sure that hydrogen storage, which is a long-term energy storage, is in competition with liquid air energy storage or compressed air energy storage, which are more daily or weekly storages because of their cost structure and because their capex is lower but their opex is higher. I do not see hydrogen as a competitor in the front line with compressed air energy storage. It is complementary.

Lord Rees of Ludlow: Would it be sufficient on its own for the most extreme needs of cold, calm weather, et cetera?

Arnaud Réveillère: The findings of reports that take a holistic approach combine different technologies. You could introduce batteries and demand-side management, not only storage technologies. The reports find that pumped hydro will still be there, depending on the country—it may not be that much in the UK. Hydrogen is the big technology for the net-zero energy systems that are developing. Hydrogen power and power grids are the two energy vectors there.

Viscount Hanworth: For the Rough hydrogen storage facility, where would the electrolysis take place?

Martin Scargill: That is a great question. If there is a network, it does not matter where it takes place. We are looking to collocate large-scale hydrogen production facilities adjacent to the field.

Viscount Hanworth: Out at sea?

Martin Scargill: Yes, we are looking at that as a technology. With green hydrogen production, you need lots of water. There are technologies currently in pilot. We are working with a company called Lhyfe in France that has a pilot scheme where you use already proven technologies to take seawater, desalinate it, put it through an electrolyser and then make green hydrogen offshore. We are looking at that adjacent to Rough, so you could produce hydrogen offshore from wind straight into the facility. As I said earlier, we are looking at either onshore hydrogen production through steam methane reformation by importing natural gas or collocated onshore electrolysis.

Viscount Hanworth: What costs will you save by not transporting hydrogen onshore?

Martin Scargill: I do not think that you would reduce the cost of the overall network. We have seen the vision from the NIC, which we would support, for linking the clusters. You would be able to start local hydrogen networks quicker and more effectively. We see storage as unlocking the chicken and egg, which is hydrogen production and consumption. It is very difficult to balance any hydrogen production profile with any demand profile. In even very small projects, we find that it is very difficult without storage. Storage seems to be the key to unlocking. At least for the consumer of hydrogen, there is a big risk in

moving to it, and an even bigger one if you cannot guarantee that you will receive an uninterrupted supply of the stuff. Storage will unlock production as well.

Q64 Lord Holmes of Richmond: The Government have indicated a “minded-to” position for a cap-and-floor subsidy regime for hydrogen storage. Is that the right approach? What specific features would such a scheme need to successfully enable support of long-duration energy storage at scale?

Martin Scargill: I think I mentioned earlier that we are supportive of the Government’s work on the hydrogen storage business model, and we have arrived at a very similar conclusion, bearing in mind investor confidence requirements balanced with value for money for the consumer. Those are the two things that we are trying to combine to get the right investment model to move the projects forward. We think that it is a very good start. With other members of industry, we have been working closely with the Government to develop that model.

In the next phase, it is important to move at speed. I have mentioned that a fixed cap may not be the most efficient way to incentivise the storage developer and operator to innovate to generate as much revenue from the store as possible, such that any subsidy that may be required would be reduced over its life, very much akin to the CfDs for wind and the design basis for those, where we see a similar correlation.

Arnaud Réveillère: As I said earlier, I am more an observer here of the business frame. I see from discussion with other operators that, in continental Europe, many countries rely on regulated activity for natural gas storage and are pushing that for hydrogen storage as well. There is a project, from a European directive, going in that direction. If your infrastructure is based on regulated assets, your revenues are set and public, and it is controlled, of course, by an independent authority. That is another approach being pushed by many in Europe today.

Other discussions with natural gas storage operators that are pushing hydrogen and developing it—not in France—show that they are looking at risk-sharing, agreeing on a target revenue. They would push for their state to take 50% of the risk, in whichever direction it goes, with a big off-taker taking 25%. They themselves would also take 25%.

Lord Holmes of Richmond: Martin, you rightly identify the need to move at some pace with the development of the detail on these schemes. Do you get a sense that there is that pace in the current process?

Martin Scargill: Yes. I have been quite impressed with the team in the hydrogen storage business model, if I dare say so. I think the team is working well. It is looking at models that have worked elsewhere, which is important. We have talked about the cap and floor. That has a precedent in bringing forward investment in flexible generation, interconnectors being the biggest case study. Yes, it is quick enough.

However, for our project and unlocking the potential of depleted reservoirs, going back to the technology readiness level comment that Arnaud made, we would need to see something in the model that would help mature that technology readiness level by doing field trials. The business model in and of itself might not be enough.

Lord Holmes of Richmond: Thank you both very much. That is very clear.

Q65 **Baroness Neuberger:** Considering everything that you have been involved in, and the energy storage projects that you have been involved with, aside from just the revenue certainty, what are the major bottlenecks in getting them off the ground? I think you suggested one of them just now, Martin. Where could government policy usefully intervene to speed things up? Could it be planning permission, connections to the grid, regulatory approval or what?

Martin Scargill: Our project is quite unique inasmuch as it would be repurposing. It is already a consented field, so we would be looking for support in bringing forward the changes to the regulations that would be needed to move a facility over from natural gas storage to hydrogen. There is work to do. The work has only just started on giving responsibility to the NSTA and the HSE to get on with that. We are helping with that. It is in that space, for sure.

Baroness Neuberger: Are you saying that it could be speeded up?

Martin Scargill: It is early days. We would be pioneering in that space. It is going as quickly as it probably needs to, although it might change. Grid connections could become an issue—you are probably sick of hearing about them. That is not just specific to storage sites, but more generally. Storage site facilities will need grid connections, particularly if they are new, so that may again become a rate-limiting factor in the rollout of the capacity over the time periods that we have already discussed.

We know the skills exist. We have some great technical skills. We have a great supply chain in this country that has done decades-worth of great work in this space. It is there. It is more about making commitments early enough so that we can guarantee that skills are assigned to particular projects. It is really about developing a strategic pipeline of projects where skills can go from one project to the next and we have continuity of work. That is a real challenge for the UK in energy transition as we ramp up. We need to be spending £50 billion a year on capital investments for energy transition projects by 2030 and hold it there for 20 years when that is probably double the long-run average. Skills would be the big one.

Baroness Neuberger: Thank you. Arnaud, would you agree?

Arnaud Réveillère: Yes. Business cases are key for all underground storage technologies. Permitting can be in some countries, though not in the UK. Besides the business case for industrial-scale projects, the industry still needs support for salt caverns, even if they are mature.

Technology development is a continuous process, and there is still a need for some questions. Hydrogen is creating new steel embrittlement questions and some new technical questions. That is for the most mature technology.

For depleted fields, Martin mentioned the risk of microbiological activity. That is extremely specific, and today it is very hard to assess its impacts at industrial scale. We know that it will happen, but whether it will impact and by how much is very difficult to say. It is also very difficult to assess from a lab and modelling perspective, so we need pilots. We are talking about millions of pounds for pilots and billions of pounds for industrial projects. It can be worth it, especially for very specific risks, like microbiological impact.

It is the same for lined rock caverns, which are probably even less mature. If it has to be pushed, it has to be supported for earlier project phases.

- Q66 **Lord Krebs:** I want to start by asking Arnaud about international comparisons. You have already alluded a bit to different market mechanisms in different countries. Are there other countries that are further ahead in the implementation of long-duration energy storage or planning for it? If there are, what lessons might the UK be able to learn from the successes and failures of other countries?

Arnaud Réveillère: From my view of the global deployment of hydrogen underground storage, I would say that from a European perspective it is not that easy to see that all the research over the past five to 10 years has been mostly produced in the UK and continental Europe, but if you look at pilot projects, I think there are nine today in Europe that are financed. There are many more websites, but in actual construction or testing I think there are nine. I could probably give detail for each of them, but we have no time for that. Seven of the nine are injecting hydrogen today, and it was zero 18 months ago. There are a lot of pilots.

In the US, in March they started drilling, and are now leaching, two caverns in Utah. In Canada, there are plans and, I think, financed projects on an industrial scale for hydrogen caverns. From our European perspective it may be difficult to see that a lot of the research efforts have been done there in the past few years and that there are a lot of industrial projects in the US or in North America today.

What else can we say about international comparisons? We have frames in the EU and in France with ZIBAC, zones industrielles bas carbone. In the EU, they are called hydrogen valleys and in the US hydrogen hubs. That is considering deployment at the hub scale, more or less, starting at a relatively local scale but gathering production for off-taker storage to start an infrastructure in a hub, and then connecting the hubs and deploying that at the national scale. There are frames in place for that.

Lord Krebs: Thank you. To repeat it back to you so that I understand, you are saying that the projects in other countries are still at the pilot

stage, and no one has actually developed full-scale hydrogen storage for a long-term energy storage system.

Arnaud Réveillère: As far as I know, no final investment decision has been taken for an industrial-scale hydrogen storage project in Europe. There are projects, yes.

Lord Krebs: We have alluded to other technologies, such as compressed air or flow batteries and so on. Are there other projects that are further ahead in those technology areas?

Arnaud Réveillère: For long-term energy storage?

Lord Krebs: Yes.

Arnaud Réveillère: The historical long-term energy storage is pumped hydro, but it is constrained by topography and acceptability. Putting that aside, there are some compressed air energy storage projects. There are other projects for long-term energy storage. I am a technical expert for the European Commission for some projects for energy storage—any technology, not only underground. At the scale we are talking about, from the perspective of net zero by 2050, hydrogen underground storage is the most visible. Yes, there are other technologies, but not really at the scale of what is needed for net zero by 2050.

Lord Krebs: Thank you. Martin, does Centrica Storage look to lessons from other countries?

Martin Scargill: We are familiar with the projects that Arnaud listed and we are working with a couple of those projects to learn, because they are further ahead of the curve. We are working particularly with two projects to look at learning from their field trials so that we can apply that to what we want to do at Rough. We have been supporting and contributing to those European research projects for the last three years. They use core samples from Rough; they use Rough all the time as a case study in terms of how we have developed that work so far. It is at the stage of field trials now, and we are looking forward to taking those forward with lessons from other operators.

The Chair: Do you think that in the UK the controversy we still have about the scale and roles for hydrogen is hindering progress towards us making some least-regrets investments and getting on with addressing the urgency of this?

Martin Scargill: That is a very good question for the industry in general. We have been involved in a couple of hydrogen production projects. Away from the village trials, there is not a huge amount of controversy in the projects that we have seen. That is my honest answer. If anybody gets it wrong, clearly it could set the industry back by a long way. Those in the gas industry are probably best placed to take forward the learnings from handling natural gas and applying those to hydrogen. Absolutely, we must take the public with us, and each project must prove that the

technology is safe. We handle hydrogen all around the world every day, so we know that it can be done. It is just about application.

Q67 **Viscount Stansgate:** My question is really a summary question for both of you. Do you have a take-home message or key recommendations for government policy to support the growth of long-duration energy storage at scale?

Martin Scargill: Yes. I am grateful for the question, and my answer is around finding solutions to deliver more long-duration energy storage. First, we think that, for many of the reasons that I have discussed, fields such as Rough being converted to hydrogen storage is a very attractive, low-cost, low-risk opportunity. I would go as far as saying that it could be a no-regrets option if there was policy harmony between natural gas and hydrogen.

Second on the wish list, we need pragmatic and timely decision-making. As I say, we welcome the design of the business model. We need to see delivery, and specifically we want to see inclusion of support for field trials for projects that are well placed for conversion to hydrogen.

It has already been touched on, but if I may I will return to the main issue around long-duration energy storage investment as we see it, which is revenue certainty. We need to see business models come forward. As I say, the devil will be in the detail of how they are designed. We will end up needing salt and depleted fields with the quantum and the timeframes that we are seeing. We are not playing off one technology against the other. We will need both, and diversification will be a good thing to have in the system.

Arnaud Réveillère: The biggest challenge or take-home message is the chicken-and-egg problem that we have to solve. We should probably keep in mind that our existing infrastructures—natural gas, power grids—took centuries to develop. Now we are talking about net zero in 2050, in 27 years, which is a huge shift and a huge change in pace. You are setting the pace. Industry will follow. We said that it is technically feasible for some technologies to store hydrogen underground. It is also technically feasible to transport hydrogen through transportation grids.

You have to set the pace to be ready for net zero. It is a real change. What is different too compared with these historical infrastructures is that, although it is at country level, there are interconnectors with other countries. It is not fully at country level any longer; it is at European level, because you rely on flexibilities in other networks. It is also being done in days when social acceptance is different from what it was a century ago. There are challenges in deploying the infrastructure in 27 years. It is a big change.

Viscount Hanworth: To satisfy my curiosity, what is the microbiological activity that you referred to that affects hydrogen storage, and what is its product?

Arnaud Réveillère: Hydrogen is reactive—more than natural gas. It would react without life above 200 degrees centigrade, but below that the reactions are prevented because they are too slow; they are infinitely slow. Storage conditions are below 200 degrees centigrade, and although the reactions do not happen without life, the microorganisms are able to use thermodynamically possible reactions. They trigger the reaction and they use the energy for their own metabolism to live. There are mostly two reactions. There is methanogenesis, which uses CO₂ or carbonates with hydrogen to produce CH₄, which is not necessarily such a big problem. There is also sulphate reduction, where they use sulphates with hydrogen to produce Hydrogen Sulfide, which is a bigger concern.

What is difficult is to assess the scale of those reactions. It can happen, but the scale is different and it is very site-specific. Hopefully, in salt caverns, where salt has been used for preventing life and to preserve aliments for centuries or thousands of years, life does not develop that well. Very few families of microorganisms can trigger that in salt caverns.

In depleted fields, it is very case-specific. Above 90 degrees, as Martin said, very few families of microorganisms can live, and the impact may not be the same. In a general way, the problem is probably more stringent because you do not have high salinity and you have much more exchange surface between gas and liquid in each pore—

Lord Winston: They live in very high salinity in certain circumstances.

Arnaud Réveillère: For me, the quantification is the issue. They live and you will find some, but whether that will develop and impact at industrial scale is really difficult to answer. You can find microorganisms that are able to survive in incredibly harsh conditions, but they are few and they cannot perform the activities they could in better conditions for them.

Viscount Hanworth: The danger of hydrogen sulphide would presumably be acidification.

Arnaud Réveillère: Yes, it has several impacts. It also brings more embrittlement problems to steel and acidification questions. It has to be treated at the surface before you put it back in the pipe. It consumes hydrogen.

The Chair: Thank you both for your contributions to this session. Martin, you mentioned that there might be a report that we would find useful and that you would send us as further evidence. Thank you very much indeed. We very much appreciate your time. The session is concluded.