



# Select Committee on Science and Technology

## Corrected oral evidence: Role of batteries and fuel cells in achieving net zero

Tuesday 20 April 2021

11 am

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Members present: Lord Patel (The Chair); Baroness Blackwood of North Oxford; Baroness Brown of Cambridge; Viscount Hanworth; Lord Krebs; Baroness Manningham-Buller; Lord Mitchell; Baroness Rock; Lord Sarfraz; Baroness Sheehan; Baroness Walmsley; Baroness Warwick of Undercliffe; Lord Winston.

Evidence Session No. 7

Virtual Proceeding

Questions 81 - 89

### Witnesses

Isobel Sheldon OBE, Chief Strategy Officer, Britishvolt; Chris Pennison, Chief Executive Officer, Hyperdrive Innovation; Dr Colin Herron CBE, Managing Director, Zero Carbon Futures.

### USE OF THE TRANSCRIPT

This is a corrected transcript of evidence taken in public and webcast on [www.parliamentlive.tv](http://www.parliamentlive.tv).

## Examination of Witnesses

Isobel Sheldon, Chris Pennison and Dr Colin Herron.

**The Chair:** Good morning, everyone, and a particularly good morning to our witnesses: Isobel Sheldon, Chris Pennison and Colin Herron. Thank you, all three of you, for making time to talk to us today. We appreciate it very much indeed. I hope the questions will be crisp and I hope you can make the answers crisp too, because we have a lot of questions to go through and we have to pick your brains all the time. We would like to pick your brains as much as we can. Lord Mitchell will ask the first question.

Q81 **Lord Mitchell:** I am very delighted that we have three people here from the cutting edge, entrepreneurial side of battery technology. We all probably know the answer to this question, but I am very keen to hear it from your point of view. Where do we stand as a country with respect to technologies?

**Isobel Sheldon:** I am the chief strategy officer for Britishvolt. We are the first full-scale 30-gigawatt hour manufacturing facility for lithium-ion batteries that has been announced for the UK. Subject to planning permission being granted, we will start construction late-Q3 / early Q4 this year. I have a long history in the lithium-ion battery industry: I was one of the first people in the world to put lithium-ion cells into vehicles and run them around on the road. Since then, I have held various senior positions within industry, including Ricardo, Johnson Matthey and Cummings. I was also on the executive team that set up the UK Battery Industrialisation Centre.

To answer your question, the UK is actually quite a long way behind. We only have roughly two gigawatt hours of manufacturing capacity in the UK. Believe it or not, we actually led the field. We had the only automotive-grade battery manufacturing facility, which is the Nissan plant, now owned by AESC, up in the north-east. Since we had that lead, the rest of Europe has overtaken us. Significant battery cell manufacturing capacity has been announced in Europe.

In the Far East, the Chinese, the Koreans and the Japanese have had a significant lead and have been investing heavily in the battery industry for a very long time. I would point out that we invented the lithium-ion battery here in the UK, in the late 1980s. Considering the inflection point in the electric vehicle market, just imagine where the UK could be if we had had the foresight to invest in scaling up and industrialising that technology. We have a lot of catching-up to do now, to overtake.

**Chris Pennison:** I am CEO of Hyperdrive. By way of introduction, I joined Hyperdrive five years ago from what I would class as more traditional manufacturing. I was an OEM supply chain plant manager looking after our traditional automotive sector. Stepping into Hyperdrive, which is really all about battery technology, we have commercialised. We are No. 2 in the line. Isobel and Envision are delivering batteries to us

and I am converting them into finished articles to support the various sectors outside the automotive sector.

I echo what Isobel has said. One of the challenges we see with setting up our business is having direct access to UK manufacturers and lithium-ion battery technology. It is really pleasing that Isobel is setting up her plant very close to us in the north-east, but our customers and I need choice in the supply chain, and we do not have that now. I access Envision for cells for us, but I can also buy batteries from other manufacturers. If I am not buying from Envision, I am buying offshore and having to import lithium-ion tech cells for us. That is not really where I want to be as a UK-based manufacturer. We have global reach with our customer base, which we will touch on as we go through the hour, but I echo the comments. We are behind where we should be. I am sorry to say that the rest of the world is overtaking us and has overtaken us.

**Dr Colin Herron:** I run a small consultancy, which is completely owned by Newcastle University. As a bit of background, I have been in the automotive industry for 48 years. I joined Nissan in 1987, as it was opening, and I got involved in the localisation, which was to bring on UK suppliers to supply the plant. I then got involved with the then Government around 2008–10 to negotiate to bring the existing small battery plant to the north-east and the Nissan Leaf production. I have been on the engineering side of the logistics of opening up a large facility. I support everything that Isobel has said. Interestingly, I have the figures for battery plants: China has 149 planned by 2030, Europe 19, the USA 11 and the UK two.

**Lord Mitchell:** That about sums it up. If you had the opportunity to instruct government or BEIS to do something, what would you want government to do to reverse the situation?

**Isobel Sheldon:** Expand the support on offer. Government support is really important for a couple of reasons. I caught the back end of your previous discussion, and investment in UK gigaplants is significant. You are talking £2.5 billion to £3 billion to have 30 gigawatt hours of manufacturing capacity stood up. It takes about two-and-a-half years to build those plants, and then several more years before you get into turning a profit and making a margin.

This is a long-term game in a fairly low-margin industry. There is a market failure piece in between starting the projects and actually turning a profit, and that is where the support from government is required. The £1 billion the Government have put in is a really good start, but it pales in comparison with what is on offer in the European Union with IPCEI, the important projects of common European interest, which stand aside of the state aid regulations over there.

It is not just grant funding through the automotive transformation fund. We have been through that process. It is also encouraging the equity markets and debt markets. You need to go out and borrow a significant amount of money. State-backed guarantees for loans is a tool that is often used, especially in Europe, to encourage investment and to de-risk it for the financial community. Do not forget that the UK finance industry

is very risk averse. It is much easier to raise money in the US, for example.

The investment push in China—Colin identified the number of plants being put up there—is because, 10 years ago, the Chinese had the foresight to say, “This will be a significant industry in the future”. Not only do they have the majority of the manufacturing processes for the cells themselves, but they have stood up a significant supply chain and invested in that. You have the critical raw materials, which we all need to encourage companies to start digging out of the ground, but it is also about the conversion processes.

A lot of those conversion processes are happening in China, and a lot of them are very energy intensive and run off coal-based electricity, which means that there is a high carbon content. The battery industry in general has a carbon content problem, and we need to address that. If we want to repatriate those conversion processes in the supply chain to the UK, we cannot simply pick up Chinese-based manufacturing process and plonk them in the UK, France or Germany. They are too polluting; we will never get them permitted. We need to re-imagine what those conversion processes are in order to reduce the energy content in those processes and to get the carbon content as low as possible.

Some of your previous speakers talked about the materials development piece. It is all well and good creating these new materials, but we need to have much more energy-efficient and lower-cost manufacturing processes that go along with that to make sure that we can build them in an environmental and sustainable way here in the UK. It is about more investment for gigafactories, easier access to the money—government wheels tend to turn quite slowly, while capital markets and the industry move very fast—but also about looking upstream into that materials supply piece and making sure that we can capture the added value for the UK economy in the supply chain.

**Q82** **Baroness Manningham-Buller:** I would like to continue with this discussion on investment, which we have heard from the previous panel as well as you all. Can you give us some clear information on what proportion of the investment is coming from government—you have said that it is modest, frankly, although welcome—and what is coming from industry? I have no idea, but maybe you do, what is coming from private-sector investment, even without back-up and guarantees. Can you give us an idea of the proportion and the spread of investment?

**Isobel Sheldon:** The proportion of investment coming from the private sector, equity markets, debt markets and private investors is the vast majority of it. It is a percentage in the high 90s. They have put £1 billion into the automotive transformation fund. They have £500 million for disbursement over the next couple of years. We can access only a proportion of that, because it has to be spread around very thinly. If we are looking at a £3 billion investment and maybe a grant of £200 million to £250 million, the majority of the rest—in the high 90s—has to come from the equity and debt markets.

**Baroness Manningham-Buller:** At what stage is that money being put into the developments? Is it the early stages or later stages?

**Isobel Sheldon:** The Government want to lower risk, so they are expecting you to achieve certain milestones before they will disburse the money. They are looking for offtake agreements from customers, which takes some time to achieve. They are looking for certain milestones to be achieved as far as actually getting the facility up and running. Acquisition of the land for the site up in Cambois, which we competed on Monday last week, was one of the conditions that we needed to meet for the Government to get some confidence that the project was going to proceed.

That money will not be front-loaded from government; it will be spread over two to three years. We need to use it as a signal to the financial markets to say that we have government support. That encourages people to stump up the investment money that we need, which we will be raising over the next 18 months. If the government money does not come, or does not come quickly, it is a significant problem.

All the other jurisdictions in the world, especially in Europe under the IPCEI, as I have said, but also in North America, China, Korea and Japan, are much more proactive with their funding from central government. It is much, much easier to create the business case to build a gigaplant in the UK as a result.<sup>1</sup>

**Chris Pennison:** I am one step removed from what Ms Sheldon is doing. As a manufacturer, when we set this business up we did it on a small amount of government funding through a local angel fund. We have basically self-invested all the way through. We need agility. I cannot be constrained by long application processes for funding. We have managed to grow our business and have now managed to access customers. Hyperdrive has been funded by 95% non-government-funded or grant money.

We have self-funded to allow ourselves to push into the market and to develop the business from what was an embryonic business in 2012 to what we are now, with some way to go but with some really ambitious plans. To answer your question, it is the same as Isobel said: it is all being done privately.

**Dr Colin Herron:** If I could go back to the original battery plant coming to the UK and the negotiation 10 years ago, it was completely constrained, as ever, by state aid. Other regions in Europe that were developing could offer more state aid than the UK did. To win the contracts, we also had to be very inventive and try to supplement the value with such things as substations and power. The amount that could

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<sup>1</sup> Governments around the world have been highly proactive in supplying significant funding to stand up battery manufacturing capability in their home countries. Notably, China had the foresight to do so more than 10-years ago. Government support is extremely important in any country's national strategy to become a large-scale player in battery cell manufacturing for electric vehicles, the UK is no different.

actually be put in was only around 6% or 7%. It sounds like a similar ratio to what Ms Sheldon is seeing at the moment.

**Baroness Manningham-Buller:** If the committee was thinking of making a recommendation in this area, building on Baroness Brown's question to the previous panel about the gaps, what government investment would each of the panellists like us to recommend? I have the messages about speed and less bureaucracy, but is there anything else that you would like us to note—in a few words, please, because time is tight?

**Isobel Sheldon:** The first is speed and quantum of grant. More grant money needs to be made available. A more coordinated process for the state-backed loan guarantees will be required. The UK investment bank is not quite up and running yet. You cannot have those conversations, and time is short. We are all in race to get capacity on the ground to serve this rapidly growing market, and there will be a shortfall of capacity. There is no worry about building gigafactories that will remain empty, because demand is outstripping supply. This is a golden opportunity for the UK to capitalise on that. Certainly, the loans are important.

Q83 **Lord Krebs:** I want to continue questioning the panel about the establishment of gigafactories. We have just been talking about the financial side of it. I want to ask you about three other challenges. One is the availability of skills. The second is the specific challenges associated with developing batteries for different applications, for example automotive versus grid. The third is the operation of the factory itself and the different processes, such as electrocoating, cell assembly and, importantly, safety checks.

**Chris Pennison:** In summary, taking in the cells from people like Isobel and our other suppliers is key for us. We are driving skills. We are seeing skills gaps. We are doing self-training. We are developing our own team. There is clearly a skills gap, in answer to your first question.

For us, touching multiple sectors, we know from commercialising what we are doing that you can have a base battery cell technology, but, critically, you need to understand what your end user is using it for. I may take a cell from my supply chain, which could be Britishvolt, Envision or anybody else, but I have to understand what application my end users are using it for. That is important.

Safety checks are absolutely important. I do not touch the automotive sector, because I have OEMs that do that quite ably, but I am taking an automotive-grade cell into multiple sectors for multiple applications. There is a raft of other specialisms that we need as a manufacturer, in taking a cell and moving it into a path, which are critical for us to develop, in parallel to the things that Isobel is looking for in developing a gigafactory and adding into the supply chain.

**Isobel Sheldon:** The skills challenge is a global one. The talent pool is very shallow, so we have to grow the skills and training capability here in the UK to make sure we have the staff we need moving forwards. Different applications need different chemistry solutions and different cell

designs. This is not a matter of copying what is done today. The factory will not be up and running for two-and a half to three years. Therefore, we have to gaze into our crystal ball, look at what the demands will be in 2023 and 2024, and design appropriate technology for that time for each of the different applications.

The operations side is multidisciplinary. There are different processes. We are looking at advanced mixing technologies to lower energy content. You have coating and drying. We are looking at how we can run those dryers more efficiently and use less energy. We have slitting, cell assembly, formation, ageing and testing, before going out to customers. It is quite a complex manufacturing process inside. The environmental conditions that you need to maintain in order to do that at high quality levels are quite challenging. It is not just the equipment; it is the stuff you pack around it that makes it work.

**Dr Colin Herron:** I will address the skills. There is a lot of work currently under way nationally about a curriculum to support battery development and manufacture. I would ask you to consider that skills are often misunderstood. I know I am from a university, but a lot of money flows into research, which is also classed as skills. From my background, skills are also the people who put these things together and repair them.

The HE market and the FE market are very, very different. The further education market, where people are trained in these skills, is a competitive, financial-based environment. For people who wish to move into this sphere, it is very difficult if their local college does not provide these courses. There is a need for short courses and CPD-type work to allow people to upskill for the inevitable change that is coming. At the moment, there is no funding for people to do short courses.

Q84 **Lord Winston:** Isobel Sheldon has partly answered this question, or just brought it up, but let me continue with it. We have been told that every stage of the manufacturing process could theoretically be improved, but it is not clear how much appetite there is from manufacturers, investors and researchers. Can we look at machine and process development for a second? Where do you think there are issues about what we could do to innovate and research in those areas?

**Dr Colin Herron:** The immediate thing I would say is that the research money is very, very difficult for process improvement. The money all goes into basic materials. Working with the battery manufacturers, my university is now trying to move into the engineering aspect. When the Faraday Institution was set up, there was no appetite to look at the engineering. If we want to apply the manufacturing and capability of the universities to making viable factories that can produce materials with the right carbon footprint at the right price, we have to change the focus of the funding scheme.

**Isobel Sheldon:** Now that I am on the board of trustees for the Faraday Institution, I have said that we need to start thinking about investing money into optimising manufacturing processes. The speed of manufacture affects the cost of the cell, but there is also making sure

that those processes are much more energy efficient than they are at the moment. A lot of what is available from the equipment manufacturers—and coincidentally not many of them are in the UK; they are mainly abroad—is legacy production processes.

We find ourselves saying that we want to do things differently and to be optimised, as far as energy and process are concerned. We are having to start to do the research and design work to modify those pieces of machinery in order to make the process much more efficient than it is today. That is a competitive advantage that the UK can have. If we can invest the right amount of money in the right places in the manufacturing process and take some of the cost of manufacturing out, it will offset things like the high cost of energy that we have in the UK, compared to our competitors in China.

**Chris Pennison:** On how we manufacture efficiently, as Isobel said, if we look at something, we are looking three or four years out because we know we are in a deflationary market. We know we are under pressure from offshore importers and other assembled battery manufacturers. We are doing the same. We are looking at processes now and trying to move them forward three or four years. Our struggle is to make sure that we have that foresight to drive efficiencies into our processes. That is clear.

From Isobel at the front end to me putting packs together, it is always about trying to manage three or four years out to see what is happening. Our manufacturing support supply chain is probably not thinking in the way that we think.

**Lord Winston:** Colin Herron, you have been in this game for a very long time. What are the future innovations that might make a difference?

**Dr Colin Herron:** We have to look at cycle times, because they are too long and are very, very energy intensive. We have to go back to the base principles of the production process. There are two sides of it. One is the processes that Britishvolt and other battery manufacturers would like to bring into the UK. We need some collective thought as to how we can bring those processes in, make them clean and make them energy efficient.

Secondly, we have to look at the scaling-up of processes. How can we scale up what the universities are doing? That is another area that needs some investment. I previously heard about making about one-kilogram batches or two-kilogram prototypes. We need to start doing that. Those are separate skills from those in engineering research, which are about getting into the battery plants, looking at their energy consumption figures and presenting academic minds with the challenge of how to reduce the CO<sub>2</sub> coming out or how to shorten cycle times. If we can shorten the curing cycle times, we can reduce energy consumption and CO<sub>2</sub> footprint.

**Isobel Sheldon:** There is a bit of a gap as far as the scale-up piece is concerned. You have gram and kilogram scale, which can be done at the universities. You have the tonne scale, which can be done at UKBIC. We sit on the kilotonne. To enable that manufacturing optimisation piece that



Colin, Chris and I have talked about, it is the multiple kilo scale, that pilot line scale, that is missing. If you want to do that research at an industrial rate, you need to do between 25 and 50 kilos. That just does not exist in the UK at the moment. There is nowhere we can go to access pilot-line scale facilities at the level that we can do the optimisation work on. A significant amount of investment needs to go into that range.

**Q85 Viscount Hanworth:** Chris Pennison, how do you imagine that the manufacturing landscape for batteries in the UK will develop towards 2050? Do you envisage that manufacturing plants will exclusively develop particular applications, such as automotive applications, or will plants develop and serve multiple applications? This is a question of the likely ownership of plants and the nature of the supply chain.

**Chris Pennison:** I think we will see the landscape change completely. As we are an assembler of cells supporting many sectors, I have to be agnostic. In my customer base, I have the construction industry, AGVs, rail and off-highway. I have multiple customers with a global footprint. I have to be able to support all my customers in how they want to drive their applications or to drive electrification.

I see the landscape changing completely. We will have to grow. My business plan is to grow exponentially. I am growing at a rate of 100% a year. Even in the Covid year just gone, the turnover and the volume that left this business grew at 93%. I need a supply chain, such as Isobel, that can offer me multiple types of batteries for my customers. But Isobel and Envision alone are not enough for me to supply the needs of our customer base and all the different sectors that we have to, which are now electrifying really rapidly.

**Viscount Hanworth:** Is your technology sufficiently flexible to allow you to serve all these customers?

**Chris Pennison:** Yes. For Hyperdrive, I developed a baseline product that is scalable, but you can then make some small changes with the chemistry that we have to support multiple sectors. I need multiple types of cell technology, the things that Isobel is talking about as a cell supplier coming into me, to give me more choice. The challenge we have is that our customer base is becoming far more sophisticated in its wants, needs and desires. Three years ago, people were saying, "I just want to electrify". I do not want to say that it was immature, but outside the automotive market, if you look at everything Nissan did with the Leaf, it was quite immature. The scale and speed of change that we are seeing now is driving us to make sure that we have a strong foundation, which can support these multiple sectors.

One thing I know is that, if we cannot do it, we will get offshore competition for our customers. They are already saying, "We'll come and do that. We can manage this. Let's do it". We have to be fleet of foot and agile. All the things we have talked about in the last 35 minutes, such as supply chain, skill levels and being able to react to customers, are crucial for the future of the country, never mind Hyperdrive.

**Viscount Hanworth:** You are talking of lithium-ion technology and

saying that it is very adaptable.

**Chris Pennison:** It is really adaptable, but you have to understand what the end users want to do, so we can then feed that back up the supply chain to make sure that the right chemistries and the right offerings from people such as Isobel are available to me, as the next tier in the manufacturing.

**Viscount Hanworth:** Perhaps we should ask Isobel, then.

**Isobel Sheldon:** Cell manufacturing is a scale game. You have to build large factories to do that cost-effectively. You cannot produce a few megawatt hours a year; you have to go into the tens of gigawatt hours. The market is shifting. We have seen this at Britishvolt, because most of us have been in the industry for 20 years, so we have been watching it a long time. The one-size-fits-all cell strategy, where you get a cell and sell it to many customers, will fade as the automotive industry grows.

In the past, electric vehicle sales were never sufficient to fill production lines. Now that those volumes are starting to build, the automotive industry is looking at the battery technology and saying, "We've differentiated ourselves on powertrain for the last 100 years. That's disappearing out of the window. We can't all go using the same technology, because there's nothing to differentiate us from our competition". You start to wonder why you are spending £100,000 on one car and £40,000 on another when it fundamentally has the same stuff inside. We will see much more customisation and tailoring of cell technology to meet the application requirements that Chris has talked about.

Now that the volumes are building in the automotive industry, which is the first market that is moving to mass adoption, we can start to look at the individual brand values and attributes and ask manufacturers such as BMW and Jaguar Land Rover, "What do you need from a cell?" rather than us selling what we have. That is a fundamental shift in the market. The same thing will apply to things such as aerospace and stationary energy storage.

At the moment, everybody is leveraging passenger car sales. That will not work for heavy-duty applications where vehicles are used much more. You need something tailored towards those life cycle and durability requirements, as that volume builds. That is what we intend to do and it is one of our competitive advantages in the marketplace, because we have all the skills that enable us to do that development work.

**Viscount Hanworth:** I have heard some very disparaging opinions about the potential for grid storage. Do you believe that grid storage is an option?

**Dr Colin Herron:** It is an option and it is being used on a very large scale. The biggest example was the Tesla site in Australia, at a huge scale, actually. It has to be recognised that, once battery storage is in place, it is in place. For the UK, if we determine the size we want and we build for it, it is actually in place, whereas the battery industry is about

replacement as it goes along. There is no question that there is a need for battery storage.

**Viscount Hanworth:** Is that for grid storage, rather than simply controlling the frequency?

**Dr Colin Herron:** Sorry, that is a slightly different thing. Yes.

Q86 **Lord Sarfraz:** Why would anyone want to build a gigafactory? We have heard that it is high capex, low margin and long payback. The machinery is not easily available and banks are hesitant. Should we be in the business of gigafactories in the UK at all?

**Isobel Sheldon:** We definitely should be in the gigafactory game, because there is a lot of optimisation and innovation that can give you a competitive advantage, and you can build at industrial scale. The battery industry, due to the growth it has had and the amount of money that has been invested so far, changes course very, very slowly because of all that legacy capex that has been deployed.

We are coming in with a clean sheet of paper, so we as companies are finding that we can reimagine what the manufacturing process and supply chain look like. As a UK economy, we can capture a lot of gross value add by making sure that we pull the right strings, ring the right bells and tie that together in a world-leading manufacturing strategy. We have an opportunity to lead the world on this and we must not squander it.

Q87 **Baroness Brown of Cambridge:** Can I ask a follow-up question to that last discussion? Given the competition we are now in, are we suffering from an imbalance of our research focus? We have a huge focus on new chemistries, whereas Isobel is telling us that a strong research focus on process improvement could give us a real advantage in the near term. Isobel, am I interpreting your view correctly?

**Isobel Sheldon:** You are right: it is imbalanced. I would not want to see the materials research programmes starved of cash and change focus, because that work has to continue. It is additive. We need to start thinking in broader terms about how we can do research, development and optimisation, and innovate in other areas of the battery industry. Manufacturing is a critical one.

**Chris Pennison:** I agree. We cannot take away from one side of the process to give to the other. It has to be additional. To the previous question, should we be in gigafactories? We absolutely should, because in the UK we need to have access to and choice of a supply chain that is robust and onshore, if I am honest. That is not because I am protectionist.

**Baroness Brown of Cambridge:** Can I come to that in a minute? I was really just asking about the research funding.

**Chris Pennison:** To answer that question, yes, we should.

**Baroness Brown of Cambridge:** Do we have a clear battery manufacturing road map to get us to 2030, say? Do we have a vision that is shared between the industry and government on that?

**Isobel Sheldon:** It is a work in progress and has been for a long time. Things have come along that have changed the playing field dramatically, such as the trade and co-operation agreement with the European Union. Do not forget that we will be making cells that go into cars that get exported into the European Union. If they do not have the appropriate levels of local content, there is an import duty of 10%. On a £40,000 car, it is a £4,000 tax if you do not have rules-of-origin-compliant materials going into those vehicles. That is a really, really important point that people are just starting to get their heads around.

As soon as the TCA came out, we were all over it like a rash and made sure that we understood it. We set our initial supply chain up to be rules of origin compliant. That is heavily dependent on the European Union, because we can take materials from the European Union and still be ROO compliant in the UK. We do not really want to be doing that. We want to shorten those supply chains. We want to make sure that we control the carbon content better. We want to reduce the work in progress.

Co-locating that supply part with Britishvolt at the Northumberland site and feeding it off renewables is the ideal opportunity to start to change the landscape as far as cell manufacturing is concerned in Europe. In fact, we have the leading site in Europe for cell manufacturing and a co-located supply chain.

**Baroness Brown of Cambridge:** Chris, is there more that should be done to develop that agreed road map?

**Chris Pennison:** There is, because at the moment, speaking as a user of batteries, we are not quite as joined up as we could or should be. Isobel is talking about making sure that we are rules of origin compliant and that we are talking to each other. As businesses, we do talk to each other, but it needs that more holistic, joined-up view that we are not all separate islands. We have to bring that together in the whole supply chain.

**Baroness Brown of Cambridge:** Is there a role for the Government to co-ordinate that?

**Chris Pennison:** They certainly need to be involved in it. We have been asking, "Should funding do this? Should we do that?" Government should see that holistic view. As an industry, we can manage ourselves, but the scale of importance of electrification per se should have that government view and intervention to have a watching brief and support the growth. We have to compress lead times to our customers and build plants, as Isobel is doing. It is about all the things we have talked about for most of the morning. Yes, there should be a real, active role for the Government.

**Baroness Brown of Cambridge:** A lot of people have mentioned how much of the supply chain we do not have domestically and how much we have to import. Isobel has flagged up how critical that will become in terms of being able to export to the EU. What can we do with the supply chain domestically? What are the really strategic things that we need to be able to do domestically? What are the gaps that we very much need to fill?

**Dr Colin Herron:** Folding the last question into this one, the automotive industry in the UK has not fully decided what it is doing yet, because we largely do not have a decision on it. Several of the big car plants have no signs of making electric vehicles as of yet. Whether those plants will stay is questionable. Honda is leaving. I do not have any evidence of an electric vehicle for Toyota. Nissan is making only 40,000. The chances are that, in the short timeframe they have until 2030, when technically they will have to have a battery that requires a plug, they will plump for a known chemistry. That is one of the reasons why we need viable capacity by 2030. That is one of the challenges.

To put in a viable supply chain of product, unfortunately, economics-wise we have to know what the market is. We have a challenge in that we are still indecisive about what heavy goods vehicles, trains and buses will be. As it stands now, we can guess the extremes of the market and the bottom end of the market. We can guess what the chemistry is and we know what the profit margins are, but some are trading quite erratically. The challenge we have is the business case for somebody to start putting in a viable supply chain, because quite frankly at the moment we do not know what the market is.

**Baroness Brown of Cambridge:** That sounds a bit like we do not have much hope. Isobel, if you could choose the key suppliers you would like in the UK, which of those do we already have and what would you like to see us develop?

**Isobel Sheldon:** The majority of the cost of the cell, 35%, is the cathode-active material. The NMC, LFP or sodium-ion NMC is the chemistry that we need to be focusing on, as well as high nickel materials.

Anode-active material is a really interesting one, because we have the best raw material to make synthetic graphite in the world. It is pumped out of the North Sea and comes onshore in north Lincolnshire. Phillips 66 has a big refinery that makes the best needle coke, which is what is produced. At the moment, that disappears off to China and Mongolia. It gets graphitised, jet-milled, carbon-coated, and then sent everywhere else. The whole process is run off coal-powered electricity.

From an environmental perspective, it is complete nonsense for that to go around the world several times and be driven in a high-carbon process. We intend to repatriate that process to the UK and co-locate it. We cannot pick up the existing process, because it is too dirty for the environment and you will never get it permitted, so we have to reinvent the graphitisation process to make it work here.

The advantage of that is that we have the raw material geographically right next to the manufacturing facility, not on the other side of the earth. It is things like that—reimagining what the supply chain needs to look like and what we need to do to make that practical. It is the same thing with cathode-active material, but also things like copper foil, aluminium foil and separator technology. We already have some electrolyte plants here in the UK, so that is one we do not need to worry about. Those conversion processes need to be reimagined and made fit

for purpose in the jurisdictions that we want to put them in. At the moment, you just cannot pick them up and move them.

**Baroness Brown of Cambridge:** Copper foil and aluminium foil do not immediately sound like truly strategic parts of your supply chain.

**Isobel Sheldon:** You have to remember that what we use in lithium-ion cells is a much more precision-made material than the Bacofoil I would use in my kitchen to cook my turkey. It has quite an advanced manufacturing process. It is similar to what is used to make those materials but more tightly controlled. For example, copper foil is not just rolled foil; it has to be electrodeposited. You need some very specialised equipment to make it within the quality control that is needed for lithium-ion batteries, because the distances and sizes we are talking about here are absolutely minute. Small imperfections can cause big problems, with recalls on quality.

**Baroness Brown of Cambridge:** Chris, what would be your dream strategic suppliers in the UK?

**Chris Pennison:** I echo what Isobel has said. My supply chain is different from Isobel's for gigafactories, but if I look at my interior components outside the cells—a lithium-ion cell is 50% to 60% of the cost of our finished modular pack—it is the traditional manufacturing industries that we need to make sure do not go out of business. They use a lot of wiring looms, harnessing and metalwork. I have a different challenge to the one that Isobel has in terms of anode and cathode. We can manage our supply chain. The bit for me that is absolutely clear for onshore is making sure that we do not lose our skillset in and around the more traditional manufacturing sectors that I tap into for my supply chain. We can manage with what we are doing at the moment, but we have to make sure that we do not lose the skillset.

**The Chair:** Isobel, can you comment on production economics related to metal anode thin film?

**Isobel Sheldon:** Lithium metal batteries have had a bit of a chequered history. There are some safety concerns if you are using a liquid electrolyte, which is why you need to go to solid state-type technologies to make that work. You may have heard from the scientists in the previous session that there are still multiple challenges to overcome; 2027 and 2028 are when we think it might start to become practical. That is the third phase of our 30 gigawatt hours. We are doing 10 in 2023, 10 in 2025 and 10 in 2027. That ramp-up and that modulisation has been created to make sure we can pivot into those new technologies and capitalise on the developments that are going on in the Faraday Institution with the academic community.

Thin film itself is just a different method of manufacturing, with different layers and thickness of material. Some thin film devices are already used in medical equipment but scaling those up to the 100-kilowatt hour battery capacity, that we need for an electric vehicle, is quite a challenge. Thin film will not be the route to go for EVs. It will be lithium ion,

advanced lithium ion and then pivoting to solid state, which to all intents and purposes is a thick-film device.

**Q88** **Baroness Blackwood of North Oxford:** The message I have received from this evidence is that, if we have not quite missed the train on battery manufacture and development, we are running alongside it and trying to catch up, compared to competitors.

Looking ahead to next-generation battery technologies, where we might be able to be a bit more strategic, how well placed are we to manufacture those technologies at scale, which of them are closest, and how might we be a bit more strategic about our investment and pace with them?

**Dr Colin Herron:** To manufacture to scale, in basic terms, at the moment, it will be one plant, the Britishvolt plant, because we have no other capacity to do that or any planned. If we are to move to the next level, it will be the 10-gigawatt hour capacity that Isobel said is available, which will be short of the 170 gigawatt hours that we need. Unless we put in more capacity, we will not do it.

**Isobel Sheldon:** Future technology is an interesting question. There are lots of people constantly scratching their heads over that and have been scratching their heads for 20 years. It falls into two areas. You have the longer-term view, which is solid state. That is where everybody wants to get to from a safety, performance and range perspective for electric vehicles. The final 10 gigawatt hours and making sure that we can pivot into that technology with the right support, research and development, are important. Do not forget that this has gone through four of the 10 doors in development that it needs to complete before it becomes practical and commercially viable. We then have to figure out the manufacturing process to make it, which nobody knows at the moment, so there is a lot of work to be done in that area.

There is also an interim step, going to high nickel and reducing cobalt content to get to zero cobalt if we can. That will have a significant impact on the cost of the cathode materials and, therefore, on the cost of the cells as they get manufactured. It is two things: zero cobalt as a target, and then getting to solid state and commercialisation at the back end of this decade.

**Baroness Blackwood of North Oxford:** If you could make one recommendation for how, as a nation, we could be strategically ahead of the game on future technologies, it would be really helpful for the committee.

**Chris Pennison:** I have to watch what the likes of Isobel are doing and where the technology is taking us to forward plan what I do for my next generation. I am in the same boat: I am watching to see where the technology goes. I have probably about an 18-month programme for when I bring a new technology in. We are waiting to see, so I cannot give you an easy answer. We are also mindful of those step changes that Isobel is talking about.

**Baroness Blackwood of North Oxford:** Are you looking to the

Government for R&D investment, for scale and pace, or to change the loan arrangements? What would you look for to stimulate this sector?

**Chris Pennison:** I would look for stimulation in being able to drive to the next level of technology. You would have to ring-fence the fund that drives the capacity to transition out of the academic side and all the future developments into the front end of manufacturing, which is Isobel's end, to allow it to come back down to me, to provide an opportunity to our sectors and the customers we have in them.

**Dr Colin Herron:** In short, we need to make sure that we are completely aligned or have the intelligence to know what the end user will do, and then get the battery companies and the research to work as a partnership. To a large extent, we are now following what we are told the market is. We are having to guess what the carmakers and others are doing. If we can do anything, it is a proper collaboration.

**Isobel Sheldon:** It falls into four areas. Get a state aid policy in place as quickly as possible, because we are still working under the shadow of the European state aid regulations, even though we have left the European Union. That change in thinking has not quite filtered through into the funding streams yet. We need speed and streamlining of these funds, how they are offered and how they are deployed. This industry moves really quickly, and we are in an absolute screaming race to get capacity into the ground. Other countries are ahead of us. We have to deploy funds and support in a much more streamlined way than we have done. BEIS has been fantastic with the ATF, but it is still working in a very slow framework. It has taken us from October through to today to get to where we are. We still do not have an answer and we are four weeks away. That is way too slow.

The quantum being deployed in the right research areas and the right support areas to get these facilities up and running needs to be rethought. It needs to be increased. It needs to go across research, development and support for getting the industrialisation done and the facilities built.

Q89 **The Chair:** Isobel, where do you see Britishvolt in three years' time compared to Northvolt and other competitors?

**Isobel Sheldon:** In three years' time, we will be starting production, because that is how long it takes to get the facility up and running. I look forward to inviting my customers, members of the UK Government and Members of the House of Lords to our shiny, state-of-the-art, world-leading battery facility, which is cutting the legs out of the competition. That is where I would like to be.

**The Chair:** We will challenge or congratulate you in three years' time—congratulate you, probably. Thank you very much, all three of you, for joining us today. It has been a most interesting session. We wish you all good luck and hope you end up as leaders in the marketplace worldwide.