HOUSE OF COMMONS

Environmental Audit Committee

Oral evidence: Technological innovations and climate change: supply chain for battery electric vehicles, HC 77

Wednesday 16 June 2021

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Watch the meeting

Members present: Philip Dunne (Chair); Duncan Baker; Mr Robert Goodwill; James Gray; Helen Hayes; Caroline Lucas; Cherilyn Mackrory; Jerome Mayhew; Dr Matthew Offord.

Member of the Business, Energy and Industrial Strategy Committee present: Mr Mark Pawsey.

Questions 1 - 55

Witnesses

I: Isobel Sheldon OBE Chief Strategy Officer, Britishvolt; Professor David Greenwood, Professor of Advanced Propulsion Systems and CEO of the WMG Centre, High Value Manufacturing (HVM) Catapult, University of Warwick; and Matthew Ogg, Senior Policy Manager, Society of Motor Manufacturers and Traders (SMMT).

II: Stephen Gifford, Chief Economist, Faraday Institution; Vikki Roberts, Head of Supply Chain Strategy, Development and Control, Johnson Matthey Battery Materials; and Jeff Townsend, Chief Operating Officer, Critical Minerals Association, and Director, Technical Critical Minerals Ltd.

Written evidence from witnesses:

- WMG (pdf) (html)
- Society of Motor Manufacturers and Traders (pdf) (html)
- Faraday Institution (pdf) (html)
- Johnson Matthey (pdf) (html)
- Critical Minerals Association (pdf) (html)

Examination of Witnesses

Witnesses: Isobel Sheldon OBE, Professor David Greenwood and Matthew Ogg.

Q1 **Chair:** Good afternoon and welcome to the Environmental Audit Committee. We are having a session today—a one-off hearing—on the supply chain for battery electric vehicles as part of our ongoing inquiry into technological innovation and climate change. In this session, we are looking to consider the large-scale development potential for UK manufacturing capacity in the production of batteries and the associated supply chain required for electric vehicles.

In our first session, we have witnesses from the motor industry and the battery sector. I would like to start by inviting them to introduce themselves very briefly, starting with Isobel Sheldon, from Britishvolt. Welcome, Isobel.

Isobel Sheldon: Thank you, Chair. My name is Isobel Sheldon and I am the chief strategy officer for Britishvolt. We are a new company putting in 30 GWh of manufacturing capacity here in the UK, based in the north-east.

My background: I have been 30 years in the automotive industry and 20 years in the battery electric vehicle industry looking at lithium-ion technology, and I was one of the first people to put lithium-ion cells into vehicles and on the road. It is a pleasure to meet you all.

Chair: Thank you. Welcome to Professor David Greenwood from the Warwick Manufacturing Group.

Professor Greenwood: Good afternoon, everyone. I am professor of advanced propulsion systems at the Warwick Manufacturing Group at the University of Warwick. I am also the chief executive of the High Value Manufacturing Catapult Centre at WMG. We have the largest research group in the UK looking at batteries, from fundamental chemistry through application into manufacture and looking at recycling at the other end. We are also very active around motors, power electronics and vehicle engineering.

Chair: Thank you very much. We are also joined by Matthew Ogg from the Society of Motor Manufacturers and Traders.

Matthew Ogg: Good afternoon, Chair. Matthew Ogg from the SMMT. I have responsibility for leading on the competitiveness, industrial transformation and EU-UK trade policy areas. SMMT represents the automotive industry at home and abroad. I am delighted to join you here today.

Q2 **Chair:** Thank you very much. We are all eagerly awaiting the Government's transport decarbonisation plan but, in this regard, the 10-point plan for a green industrial revolution, announced by the Prime Minister last autumn, gave a very clear signal to the motor trade that electric vehicles are the future and that the sale of new internal

combustion engine vehicles will cease from 2030. In order to ensure that we have enough vehicles to meet this radical change—the most significant change in 100 years in how we propel ourselves around—we clearly have to understand what the UK's capacity for building electric vehicles is going to be, if we are not going to import them all and export a large number of jobs.

Matt, could you give us a sense from your members of the key criteria to ensure that we maintain significant-scale vehicle manufacturing in the UK? Is it the case, as we are led to believe, that gigafactories for battery production are an essential prerequisite for the future vehicle industry?

Matthew Ogg: First, it is important to note that the UK automotive industry is not homogenous. We have volume manufacturers, specialist manufacturers, buses, coaches, and a diverse range, right through to the supply chain and aftermarkets. Notably, many of these large manufacturers also have plants in the EU. We operate across the world.

Therefore, the question is: where is the optimal opportunity to locate new models and manufacturing as we go through this generational transformation? UK-specific vehicle manufacturers are certainly likely to look for and to develop a local supply chain, but some of the smaller vehicle manufacturers, for example, could not sustain a gigafactory alone, so certainly they will be looking at cost, capacity and quality and that will all feature in conversations that are happening right now about where to locate future manufacturing.

If we want UK-based manufacturing, it will be harder to compete if there is no local supply chain and, indeed, no gigafactories. It will be difficult to overcome trade barriers and logistical costs, as batteries are difficult to move. If we can get a supply chain in the UK, that will help us to secure product allocation and new models.

It is also worth noting that 80% of UK production is exported and 55% of exports are to the EU, so I am sure we will talk about the UK-EU trade deal at some point today.

The gigafactories are the bauble on the tree. We still need to focus on the root and branch, and there is a great wealth of opportunity for the UK in the fully electrified powertrain and supply chain. The Advanced Propulsion Centre has identified about £12 billion-worth of growth opportunities. Gigafactories are probably the most tangible asset that we could think of that could secure UK manufacturing. We would be absolutely delighted if they could be located here. That would certainly help our industry both today and in the future, but we should look at the full electrified supply chain and not lose sight of the competitive conditions that we need, because this is an international race. We are currently chasing mobile investment that could go to other locations, and we would like it to come here to the UK.

Q3 **Chair:** I think we all understand that there is more to a vehicle than just the battery but, as I understand it, the battery is the heaviest element of

the vehicle and, without battery industrial capacity in this country, surely manufacturers will locate elsewhere, given as you say it is a very mobile industry by definition and by design. It is possible for motor manufacturers to locate wherever is most convenient and most efficient, given they will be going through the largest investment in new models because the whole model has to change. It is not like you can bring out a new iteration; you will require a new plant to be able to make this change. Surely, if we do not have battery capacity in this country, we may risk losing much of our industrial infrastructure.

Matthew Ogg: I agree. There is an element of risk here, and it is now incumbent on the UK Government to help create those conditions that make inward investment in this country the most able it can. You are right that logistics mean that co-location is preferable, but we know that a vast majority of the supply chain already comes from Asia and, while it is ideal to have more local supply, there are other avenues that our members have explored. We hope we will see that in Europe and the UK. There is definitely the opportunity. There are certainly conversations around the potential. However, they are only conversations at the moment. We have not yet converted many of them into spades in the ground.

Certainly, the timeframe that we are working to, with the end of sales in 2030, and indeed some of the provisions in the trade agreements that we are signing up to, mean it is imperative that we get to that stage now. Therefore, we hope manufacturers here will source here, because allocating new models here will be dependent on the whole of the competitiveness and that looks at energy costs. We are going to be looking at incentives in the market to make sure that we have a healthy new-car market here.

There are a number of elements playing into this incredibly complex landscape. Britishvolt and my other colleagues here on this call will have looked at this in detail, given they are taking those decisions at this time. I am sure they will be able to give you some very good insight into what they are considering as their very specific needs, alongside energy costs and energy grid connections that will make these plans viable. There are few sites ready today in the UK to put spades in the ground.

Q4 **Chair:** We will come on to locations in a minute. David, you indicated that you would like to respond to this question as well. When you do, could you also give us your sense of whether the Government's industrial strategy in this area is coherent and whether there is enough encouragement and confidence in the trade to be able to respond to this demand signal?

Professor Greenwood: First, I echo Matt's points. I agree with all of them, particularly the fact that the battery is not the only thing that we should be focusing on in the move to electrification. There are other opportunities as well.

However, the battery is a pivotal component in the vehicle. It is about 40% or 50% of the total bill of materials cost of the vehicle. In other words, the cost of the components before they are assembled. In addition, it does not economically ship large distances. While the volumes are small, as they are today, it makes more economic sense to ship batteries from Asia rather than build a brand-new plant if the volume to sate that plant when it arrives on site is not there. That situation changes very much as the volumes increase and it becomes uneconomic to be shipping long distances.

The reason I say the battery is a pivotal component is that, if the UK is able to secure the supply chain for its own battery supply, there are tens of billions of pounds worth of value per year to be generated in the UK. As you hinted at, the downside is that, if we are not able to do that, there is a high likelihood that manufacturers may move the assembly of vehicles with batteries closer to the battery plants from where they secure their supply. If that supply is from Europe, for instance, which would be entirely compatible with the European free trade agreement, it would be the other 50% of the vehicle's value, which could over time migrate from the UK, leaving us effectively with what by 2030 and 2035 will be legacy internal combustion engine manufacturing.

How does the industrial strategy play to this and how are the Government doing on it? I would say the industrial strategy, and particularly the industrial strategy challenge that came from it, has done an exceptionally good job of building a joined-up research, development and industrialisation infrastructure in the UK. I work with organisations in places like the US and Germany and many other places in the world. They are quite envious of the way in which we have managed to structure that joined-up infrastructure. We have a very good mechanism in place.

The challenge we have is that that mechanism is becoming a little bit short term, because of the short-term spending reviews that we have had over the last few years. Obviously, the timescale over which industry wants to make its investments is measured in the five-year to 10-year period and, at the moment, many of the mechanisms that were set up in 2017 only have one or two years of duration left on them. Therefore, we need to be able to give industry the long-term confidence in support mechanisms to allow it to co-invest so it does not have to be the Government doing all of the spending.

Lastly, the quantum of support that we are offering in the UK is falling behind the level that you would find in places like Europe or the US. For example, if we look at things like the Automotive Transformation Fund, which is there to put in capital support alongside people willing to invest in manufacturing capability, gigafactories in the UK, those facilities typically cost somewhere between £2 billion and £4 billion to build. The kinds of incentives that are offered across the globe, generally speaking, are around £750 million per plant, so it is likely that the first couple of plants, or even three plants, may need some level of subsidy in order to make us globally competitive, because this is a global race. Governments

around the world have recognised those billions of pounds worth of value and we are competing against them, and particularly competing against Europe in practice, to get the locations, the jobs and the value.

In summary, we have a good mechanism; we need to push it harder and we need to give it greater longevity so that industry can co-invest with us.

Q5 **Chair:** I will come to you in a second, Isobel. Professor Greenwood, if you are saying you think we need £750 million of subsidy per plant, how much is currently on the table?

Professor Greenwood: We have visibility of about £400 million. Obviously we are pending the spending review, and we hope that number will change.

Q6 **Chair:** In your evidence, David, you mentioned the EU trade agreement, but you indicated that the country-of-origin rules are going to come into play from 2027 and that, therefore, in reality the cut-off date for the sale of new vehicles is 2027 rather than 2030. Could you explain to the Committee why that is? Is it to do with the 80% export point that was made by Matt Ogg?

Professor Greenwood: The sale of vehicles is governed by the 2030 to 2035 announcements from the 10-point plan. The significance of the 2027 date, which is attached to the EU free trade agreement, is that that is the point by which, in order to qualify for free trade between Europe and the UK, the manufacturer of the battery pack and the cathode material, which is the most expensive component of it, has to come from within the UK or the EU. If it doesn't, a 10% tariff is applied to the vehicle and, given that the vehicle cost can be in the order of £30,000 or more, that is a very significant commercial penalty.

It means that manufacturers will have had to make their decisions on manufacturing locations in Europe by 2027 at the very latest. They need to be active by 2027, which means they are going to be making their decisions within the next few years. Whether they choose to put their plants in the EU or the UK does not matter from an EU trade agreement perspective, but when we think about the interests of manufacturers in the UK who export outside of the EU, if we have good trade agreements with those third countries, there is a greater incentive for them to invest in the UK in order that trade from the UK to any of those territories is tariff free. Otherwise, they could just as easily import from the EU at slightly higher cost but a not hugely higher cost. That 2027 date is the point by which product needs to be rolling off manufacturing lines either in the EU or in the UK.

Isobel Sheldon: I would like to build on the points made by Professor Greenwood and Matt Ogg. Their points are 100% valid.

One of the industry's problems is the capacity gap emerging in the middle of this decade, and there is a race to get battery manufacturing capacity

cemented into the ground. If we are a little bit delayed or are laggards, we are going to miss out significantly because an awful lot of cycle plans are coming on stream in the automotive industry around 2025 to 2026, representing the first time some of those models have been put on to the market. Capturing those cycle plans is absolutely vital. If we do not get the capacity in the ground now, it will happen in Europe. Europe will win that business and automotive manufacturing will start to leach away into continental Europe.

The other thing I would like to point out is about sticky IP. There was an approach from Government in the past that we should get one of the big six to come and invest foreign direct investment into the UK, which is all well and good, but that is not sticky IP. That is R&D capability being imported from abroad. It can easily move elsewhere, and it is certainly not taking advantage of the money, the time and the effort that I and David, and a number of others who will talk to you later, have put into the ecosystem in the UK to make sure that the R&D is stood up to support this industry.

We need to make sure that we are joining the dots between the applied research and the collaboration with R&D programmes, all the way through to scale production, to really take advantage of the fact that we have some of the best minds in this country, in fact, some of the best minds in the world in this country who have been working on battery technology for a long time. Let's not forget that we invented it in the first place. If we had had the foresight to commercialise it, just imagine where we would be now.

Another thing that is important is that it is a scale game. You cannot do this in a small way and build up over time. You have to go at it in a very big way to get the economics to work right. The conversion costs of improvements happen in the high single digits, nearly double digits, of GWh capacity. That means this is a front-end loaded capital exercise; huge amounts of capital are required to build up the core and shell of the buildings and put the machinery in. That means there is a market failure piece; there is a gap between investing that money and getting a return on the investment.

Certainly, we have the ambition from the Government with the Industrial Challenge Strategy Fund and the ATF programme. The quantum is not enough, as David has pointed out. Subsidies of £750 million to major plants is pretty much the norm in this region, and we have less than half that available for the whole programme, so that is a bit of a problem.

The additional problem with Government funding, especially from our perspective, is that we came into this being the first company that is going to go through Government support requests and programmes after coming out of the European Union, when there is no state aid legislation yet in place to encompass it, so pretty much we have been told as a business to look at the European Union rules and follow those. You have

to start to question the effect of coming out of the European Union and things getting easier on the state aid front because they are not, for sure.

The third thing I would like to mention is the supply chain. The gigafactory is the headline factory that fronts all of this. This is what is front-facing to the automotive industry, to Government and to key stakeholders and investors. Investing in the supply chain is very important because at the moment a lot of these materials are disappearing off around the world several times. They are being converted into the finished products that you put into the back end of the gigafactory in economies that have very high coal content on their electricity grids and there is a pollution problem. So even though, if you do the lifecycle analysis for an electric vehicle versus an internal combustion engine vehicle, the electric vehicle is better, there is room for improvement. Moving those processes to the European geographical area, preferably to the United Kingdom, means that we have to reimagine those processes because they are not very efficient. Most of the energy goes into heating up the equipment and less into heating up material, for example. Innovation is required on that front, and that drives it back into the R&D piece.

David's point about the slightly short-term view of funding for institutions like the Faraday Institution is causing significant problems. I am on the board of trustees, so I see these things at first hand. When you are giving a post-doc a nine-month contract when you should be looking at a three-year contract, that is a very difficult discussion to have with those individuals and to encourage them to be dedicated and in for the longer term.

Q7 **Chair:** You have addressed much of what I was going to ask, but may I pose a quick final question before we move on to colleagues?

We have seen a lot in the news this week that Northvolt is locating its factory in Sweden, which I think is somewhat larger than your plans, and doing so to take advantage of the renewable energy in that location in Sweden. Can you describe why you chose Blyth? What advantages do you have there? Why did you choose the scale of plant that you are proposing to build? Are you able to tell us the scale of grant that you have yet to receive from the UK Government, or have been promised?

Isobel Sheldon: The reason we chose the Blyth site: we started with a list of about 120 sites, and that was done working in conjunction with the APC as part of the Faraday battery challenge, going out and scouting those sites and seeing which ones were suitable.

You need to take care of a number of site fundamentals. Fundamentally, if you do not have access to a strong grid connection and renewable energy, you cannot build a gigaplant. It is as simple as that. We looked at a number of sites around the country. Putting a grid connection in place can take two, three, maybe even four years and it costs around £50 million to £60 million, so the strength of the local grid was one of the critical things for us. Blyth, being an ex-power station site, already has

the existing grid connection. Therefore, we do not need to pay for it to be installed; we do not need to wait. One of our critical metrics—we have already mentioned getting cemented into the ground as quickly as possible—was having a site ready to go, shovel ready, and we will be breaking ground in summer this year on that facility.

Another thing that impressed us about the Blyth site was that it was flat, it was clean, it was a brownfield site and it was already approved for industrial application. It required no change in planning usage, although we have had to go through the planning commission process, which is normal in this country. Thankfully, that is quite short compared with France, Germany, Spain or some of those other countries. That has enabled us to get going quickly.

Other site fundamentals: it is a coastal location, so we have a deep-water port; we can bring materials straight in from less than one kilometre from the facility. If you are in the middle of the country, you have hundreds and thousands of lorries on the road, congesting the roads. That supply chain element was very attractive.

We have a rail line that already comes in on site that we can take advantage of, but also we have that 1.4 GW connector with the North Sea Link connector with Norway, with 100% hydro coming in. We will not be able to use 100% hydro, because that is the supporting connection for reinforcing the grid, but certainly a good proportion of that energy will be renewable and we will have to balance that up with solar on the roof.

One big UK-wide problem is the cost of energy. If we compare ourselves with the likes of Sweden, where Northvolt is, their energy price is about one quarter of what we are going to have to pay. We need to focus on trying to get that energy cost down because that is not a problem just for the battery gigaplant in our area, it is also a big problem for the rest of industry. But certainly, if we want to get this up and running, we want to make sure that we have the best levels of profitability and we need to focus on the energy cost.

Quite simply, a coastal district is where you put a gigaplant. You don't put it in the middle of the country because you choke up the roads and you don't have access to the energy that you need. It is quite straightforward and simple.

Q8 **Chair:** I think others will want to come in on that. Are you able to tell us what support you have had, or have been promised, from the Government thus far?

Isobel Sheldon: We have had zero Government support so far. We have an Automotive Transformation Fund application in. We started that process at the back end of September last year. We have not yet concluded it because it takes a long time to jump through all those hoops. We should be coming to a conclusion in the next couple of weeks—hopefully.

Chair: I am sure David wants to challenge the geographic location point. If he does, I would like Mark Pawsey to ask his question because I think that is related.

Q9 **Mark Pawsey:** I was interested in what Isobel said about not in the middle of the country, because in the middle of the country is the historical home of the UK motor industry where we have a load of manufacturers. My constituency is adjacent to Coventry, which is a motor city.

Perhaps David might come in on that. Isobel has just told us the reasons for Blyth, but how many sites are there in the UK that are ready to go right now?

You spoke about needing to have vehicles running off manufacturing lines in 2027. Scrolling forward from that, when do we need to get a new plant operational—there will be testing to go through—and where are the locations that could conceivably enable us to compete in this international race?

Professor Greenwood: Mark, thank you. Your question leads exactly into the point I was going to make. A coastal location can be beneficial, but I don't think it is essential. If you look at where the battery plants are in mainland Europe, in Poland, in the Czech Republic, around Germany, they do not have a coastal location. Transport is on both the input and the output, so you need to think about where the car manufacturers are as well as where the raw materials are coming from.

It would be interesting, Isobel, if you were to comment on how far down the list you were able to get of those 120 sites that met your criteria because I am pretty sure the answer was one, and you have chosen it. As the UK is going to need multiple gigafactories over time, we need to think quite carefully about what we are doing to prepare suitable sites for the next ones that come in.

The logical centres for battery manufacturing in the UK are the north-east, Blyth, that sort of area, particularly clustered around things like the automotive industry for companies like Nissan, but thinking also about some of the offshore renewable activities that happen there. The other very logical centre is around the Midlands, which is where you will find the aerospace and automotive sectors that will be the other large consumers of batteries.

We are not over-endowed with sites that have all the requirements that Isobel stated. Timing is a major issue. We talked about a plant being £2 billion to £4 billion to invest in, but equally it turns over a very similar number every year, so a month's delay is hundreds of millions of pounds of missed business. Timing is critical and so is the ability to do things like provide power to sites in advance of requirements, or get outline planning permission in advance of immediate requirements. Those kinds of things could knock down some of those barriers for companies like Isobel's.

Q10 **Mark Pawsey:** Presumably, Matt, putting aside the source of electricity, the manufacture of batteries and the cost of freight to bring vehicles into the UK, we can meet climate objectives regardless of where the vehicles are made. What we need to do is transfer the skills that we have in existing vehicle manufacturing into the new technology. How can we make sure that happens?

Matthew Ogg: Absolutely. The two big costs in vehicle manufacturing are labour and energy, and it is important for us to tackle those. We can envisage a skills gap as we need to transition. The automotive sector is blessed in that we have had a strong workforce in this country. It is highly skilled and highly productive. We have very low turnover as well, so I think we have to focus on retaining and retraining staff. We have identified that in the next few years, up until around 2024, about 14% of jobs will be impacted, so there is clearly an opportunity to focus on that. One of the challenges with retraining is that you have to take your staff off the production line to do it. We want to continue to produce today while preparing skills for tomorrow, and there is clearly a role for a green jobs national strategy to help with that.

Another challenge is the emphasis on STEM. I am sure we will be getting on to skills shortly, but some of the skills we will need will not be automotive-specific or battery-specific. We will be fishing in a talent pool that is increasingly being targeted by the electronics sector, the wider tech sector and others who are in this space. We will need to access the global talent pool to make sure we stay at the forefront in both R&D and engineering, and right through to the factory floor. If there is anything specific, Mark, I would be very happy to write to you.

Q11 **Duncan Baker:** I want to turn to skills more specifically, first with a question to the whole panel.

Notwithstanding the fact that we need an awful lot of gigafactories to be built by 2040, there is certainly a lot of work to be done in the next few years on the people who will work in them. What must the Government do to deliver this skilled workforce, when the relevant skills are probably already in short supply?

Isobel Sheldon: We have to recognise that there is a global shortfall in skills. This industry is accelerating rapidly and in all areas of the world where battery facilities are planned or exist, they are looking at increasing their workforces and employing more people.

We probably have a slight advantage over the European Union. The Faraday battery challenge is part of the Industrial Challenge Strategy Fund. It recognised this as an issue back in 2016 and started putting in place some of the fundamental first-mover points to try to address it. The Faraday Institution is clearly investing in R&D, in degree, PhD and post-doc courses and employment to make sure we have academics coming through the training that we need them to come through to deliver the skills into the industry we need them to work in in the future.

Probably one of the biggest problems—and it is the same all the way across Europe—is at the technician-level grades. These are the people who we need to get into the facilities. They are not just the people who are running the machines or watching the bits of componentry go past them and monitoring; they are the maintenance technicians, the engineers, the people who are skilled in making sure that we can run these plants, keep them running, keep them running efficiently, and also create improvements. That is where we have to focus.

A skills programme is being put in place. We are in discussions with David Greenwood and the Faraday Institution about apprenticeship-level skills and courses that we need to collaborate on and make sure we get in place. As a company, we have also signed MOUs with Northumbria, Northumberland and Newcastle Universities, and we are starting to talk about training courses in education for local people in the north-east. We have a very strong focus on making sure that the local economy around Blyth benefits significantly from Britishvolt being there so that we can play our part in the levelling-up agenda, making sure that we have people in jobs.

People are talking about heating their houses or cooking their food; they cannot do both. We want to be part of the solution to that problem. We are setting up a foundation in the north-east. It is a major, pro bono outreach programme with our construction and consultancy partners to make sure we have the appropriate social outreach programmes to educate people as to what a future career at Britishvolt could look like, and the routes to achieving it. We have picked up the mantle to try to make sure that we understand what the challenges are and trying to provide proactive solutions, so that we can capitalise on the good work being done within the academic institutions to try to prepare the country for this new future that we are all walking into rather rapidly.

Q12 **Duncan Baker:** That is excellent progress. It is good to see that you are not just saying, "What is the answer?" but are providing the answer.

Professor Greenwood, could I turn to you with that same question?

Professor Greenwood: The good news is that we have got a good handle in the UK on the scale of the challenge. We know we need roughly 30,000 people in the battery manufacturing industry, and probably about 50,000 people in the supply chains that support it. We also know that the likely centres will be around the Midlands and the north-east. That makes the problem a lot more tractable because we do not necessarily need to be looking at a national programme; we can be looking at something that is, in the first instance at least, a regional programme.

The Faraday Institution has been working together with the Automotive Council and now has a complete curriculum framework for level 2 through level 7. That is from technician level through to senior technical specialist level. There is an identified skills framework and set of training courses that can be delivered in order to get to those levels. The challenge now is knowing where the people are going to be coming from.

Coming back to Matt's point, we have two types of people that we need to give these skills to. We have a group of people who are in industry at the moment and need to be reskilled to the new area. Somehow, we need to find a way so their employers can release them to gain the new skills while, at the same time, running the business that is paying for that to happen.

The second group that we have to bring in is the school leavers who will come into the system. Our major challenge there is STEM retention rates in the UK. The sorts of outreach programmes that Isobel talked about are very welcome, particularly in the regions. We need to concentrate on STEM retention from primary school through into secondary education, into university or technical college as required, and then onwards into industry. It is a big gap for us at the moment.

Diversity and inclusion will be one of the biggest answers to that. We see that we are only addressing a proportion of the population at the moment in bringing people forward. The better we can get at diversity and inclusion, from primary school upwards, the more chance we will have of having the right number of qualified people to staff our organisations.

Q13 **Duncan Baker:** It is an enormous challenge, when you start looking at those sorts of numbers, 70,000 or 80,000 people having to shift across in what is a very short period of time.

Matt, can I have your thoughts on that last question about how we will start to fulfil our supply chain and the skills that we need for this transition?

Matthew Ogg: I echo the points that David made. The foresighted work by HVMC and the Faraday Institution has been invaluable and it needs continued funding. Things such as the Emerging Skills Project and others have been very helpful in understanding the needs and developing a curriculum. For delivery, we need to see more modular content in net zero and digital, and certainly STEM retention is a challenge across the board.

Another thing is that the current apprenticeship levy is not very flexible, not specifically for automotive, anyway. Funds that are already locked up could be better distributed to help fund some of our challenges, and that is something the Government have so far not shown much interest in. We know we have major members who are paying into that fund but not necessarily withdrawing from it to full potential. There is definitely some opportunity there.

Retention and retraining are challenges. About 80% of jobs around the powertrain at present will be impacted in the next 10 years. The UK has been exemplary in driving, delivering and engineering combustion engines for the first 100 years of this sector, and we are about to transition, in less than 10 years, to a completely different powertrain. You can clearly see the risk and jeopardy there for those working in that

space as we move towards the 2030 end-of-sale date. I think this is an opportunity as much as a risk, if we put the investment in now.

Going back to Isobel's earlier comments, we need to frontload this. We want training for those skills going in today. That workforce will be needed pretty soon, and if we don't push this forward, we are going to be struggling to access the talent that we need for any of the dates that we have spoken about today, but certainly to populate the pool of operators and technicians. That is 75% of the workforce in a gigafactory, give or take, and is at Level 3 and upwards from a skills point of view. Within the 25%, we need the doctorates, the engineers and those who going to help us, not just meet the challenges today but keep pace with development, research and advanced manufacturing globally, as we look forward beyond 2030 to our 2050 net zero commitments.

Q14 **Duncan Baker:** Building on one of the points you made, in your capacity at the Society of Motor Manufacturers and Traders, you said—I am looking back at some of my notes—that there needs to be far more importance put on the High Value Manufacturing Catapult's Emerging Skills Project. We have all heard about the Faraday battery challenge. I am also keen to pick up on the point about the apprenticeship levy. That is a good point. If we could add up how much of the levy is sitting there waiting to be spent, not being spent by employers, it would run into millions and millions of pounds.

It is all very well to say that we need to come up with a better way for the Government to use that apprenticeship levy. There is also an argument to say that we need to come up with a better way to help businesses start to use it. There is something of an opportunity in the Skills and Post-16 Education Bill. You said we would need to move towards more adult technical education. If you had that opportunity, perhaps with the apprenticeship levy and legislative changes, what would be needed to bring forward an employer-led model for adult technical education?

Matthew Ogg: I think that question is probably for David Greenwood to start with, but I will happily come in off the back of it.

Professor Greenwood: I am happy to contribute. At WMG we run a large degree apprenticeship centre. Over the last nine months, we have managed to get a battery manufacturing degree apprenticeship approved and ready to rock from September. We have been able to do that by taking existing degree apprenticeship standards from adjacent fields and reclassifying and re-contenting them for this particular application. With the right levels of flexibility, we can get these offerings on the ground remarkably quickly.

One of our challenges is that the amount the apprenticeship levy provides to contribute to an individual degree apprenticeship does not come that close to covering its cost. At the moment, we are in a position where we can offer the training but we are also having to ask employers for a top up to enable us to offer the level of education they need to see. As you

say, there is a surplus of funds available and yet we are unable to spend them appropriately because of the fact that we effectively have some caps on how much we can put on an individual degree apprenticeship. Some flexibility on that could give you the quality of output that you need and the mechanism to get it to market quickly.

Matthew Ogg: I do not have much to add. David Greenwood has covered it well. We are certainly keen to see what comes out of the Green Jobs Taskforce, which we have worked on with Government. We expect the recommendations on that pretty soon. I would be happy to write to you afterwards about what we could do there, once we understand what direction it is going in.

Q15 **Duncan Baker:** I have been looking at a bit of research, looking at the data on how many people are coming through. The numbers of mechanical engineers outstrip electrical engineers by a significant margin. I notice two of you nodding. My stepfather was a chemical engineer, so neither of those, but having some knowledge of the field I was quite interested to see how many people are coming through. There is a significant shortage of engineers. Putting it bluntly, what can be done to develop curricula in technical colleges and universities to give us the skills we need? It seems we need to have more electrical engineers coming through. They are not just the people developing the EVs of the future, but the people who will be servicing them, which we don't talk enough about. How are we going to harness that?

Isobel Sheldon: We need a blend of skills. I don't think if you went and did a degree in electrical, mechanical or chemical engineering you would be equipped with the broad range of skills that you would need to deploy into the battery industry. There are so many different elements of those disciplines involved.

Something that sticks out in my mind is about the people who have had a career in the automotive industry, have trained in mechanical engineering and have been successful, have reached a level in life where they have had a regular income for the last 20 to 25 years, and suddenly are facing being retrained into a different industry. I think that is a significant problem.

In the education programmes, the apprenticeships and stuff that we want to do on STEM and in schools and colleges, we are looking after the younger generation, but what about the mid-life employee who needs to transition to something entirely new at the age of 40, 45 or maybe 50 years old? They are not on the scrap heap. We cannot look at them like that. We have to make sure that we give them equal opportunity to get into this new and exciting industry, because they have useful working lives in front of them and contributions to make to the economy. To overlook these people and not include them in the retraining programmes or strategies would be a significant error and mistake. We would just create a problem further up the age range unless we address that.

Matthew Ogg: I agree with everything Isobel Sheldon said. The focus on

adult learning will be key. We are concerned that it will be an area that is underserved.

On apprenticeships, we have also had a challenge in the last year or two where the apprenticeship levy does not necessarily cover the cost of apprenticeships. We have lost a couple of cohorts through Covid and the pipeline of talent has been impacted by an inability to onboard young talent that we had hoped to bring through in the medium to long term. Focusing on the young is going to be a challenge, not just in our industry but more broadly.

Chair: Very briefly now, because we need to press on. Thank you, Duncan.

Professor Greenwood: I will be as quick as I can. First, I would say that a modern mechanical engineering degree is much broader than it used to be. Isobel mentioned the demographic issue. Mechanical engineers who have been in the business for 20 years or so would have received a much narrower degree than a university leaver of today.

I am not so worried about the crossover between, say, mechanical and electrical engineering. I am a mechanical engineer myself. What I am worried about is the lack of skills in manufacturing and chemical process engineering, because those are not well represented with degree-level courses in the UK. That is something of a gap for us, which I think we will also talk about soon in the context of R&D.

Chair: An upskilling opportunity for your stepfather, Duncan. Over to Jerome Mayhew on research.

Q16 **Jerome Mayhew:** Professor Greenwood, I am going to rattle through these questions to try to get back on track. In your written evidence, you said that clarity is needed on the future support for innovation in batteries. I was slightly confused by that. Where exactly do you want the Government to provide additional clarity?

Professor Greenwood: Perhaps a better word for me to have used would have been "visibility." I think we have very good clarity on mission and requirement. What we don't have is enough long-term visibility to be able to make the kinds of commitments that are going to be needed to have impact.

This is the thing I was talking about earlier, the fact that successive short spending reviews have unfortunately left us working to one-year and two-year timelines where industry needs us to be working to five-year to 10-year timelines.

Q17 **Jerome Mayhew:** Jumping ahead slightly, is this where the ARIA timeframes could be better, where they are guaranteed their funding for the next 10 years? Is that the sort of thing that you are looking for?

Professor Greenwood: That's right. Things like UKRI and ARIA, where we have longer-term commitments—if we could see those same kinds of timelines applied to things like Innovate UK, APC, Faraday Institution,

what are currently called the industry strategy challenge programmes, if we could see that sort of timeline, that is exactly what is needed.

Q18 **Jerome Mayhew:** Isobel, what areas of electric vehicle research should be targeted in order to give the UK a competitive advantage in the future?

Isobel Sheldon: There is a range of things. It is not just about batteries; it is about power electronics, improving efficiency, aerodynamics, changing the way the vehicles are designed, cell to chassis instead of going cell to module to pack, where you cut out the module piece to get more packaging efficiency. A range of skills is required to be able to achieve that, from electrical and mechanical engineering through to structural engineering.

Such a broad bench of skills and requirements are needed that we have to start to join the dots as far as the R&D environment is concerned. We have been very successful in that, to a certain degree and in small pockets of areas, such as marrying up battery technology with power electronics and electric machines. Those are joined-up fairly well but now we need to penetrate the rest of the vehicle development. Fundamentally, in the past, in compliance vehicles, you were stuffing batteries into converted combustion engine vehicles and now you are designing an EV from the ground up and there are different requirements. The vehicles are designed differently. They perform differently. They perform a slightly different function. Our current R&D efforts need to be expanded and be more comprehensively planned to make sure that we have a more holistic approach.

I think Professor Greenwood's points about the visibility of funding are absolutely bang on. I am on the board of trustees at the Faraday Institution, as I mentioned before, and we are looking at some rather tricky funding allocations moving forward because we only have visibility of funding through to 2022 for programmes that need support for a minimum of three years and more likely five years, and if we can give 10-year visibility, we can do an awful lot more because we can plan better and more thoroughly. The short-termism view of supporting R&D activity does us no favours whatsoever. It is not the case in the rest of the world. They take a longer-term view of this. We need to make sure that we sort this out as quickly as possible, otherwise we are going to lose the significant advantage in R&D that we have built up in the last three or four years.

Matthew Ogg: When you talk about competitive advantage, we need a focus on step-change battery technology. There is an expectation at the end of this decade that we will get to solid state technology, which there is lots of hype around. But that is not a two to three-year project, it is for a much longer term, and that goes to the point about long-term funding visibility.

Things that will focus on the efficiency and chemistry of current lithium-ion batteries, particularly with some of the critical materials that are

scarcer or have ethical challenges: we have seen improvements in reducing the cobalt content of batteries. NMC 622 through to today's NMC 955—that is nickel, manganese, cobalt—has reduced the content from about 20% to 5%, but clearly that will be a challenge because the demand for these materials is only going to go up as other countries take a trajectory similar to ours in their electric revolutions.

I suppose that also speaks to recycling and our ability to retain and redeploy assets from existing batteries in future and give a second life to some of these technologies. There is an opportunity there that would bring competitive advantage against new batteries, too.

Q19 **Jerome Mayhew:** I am going to wrap this up. There is clearly strong agreement between you that one to three years is not a suitable timeframe for R&D. It is five to 10 years. That is the key message.

One challenge from me to you: this is clearly an area of intense interest and excitement for manufacturing businesses, so why aren't they funding this R&D? Why does the industry need Government to come in? There is big money to be made here and if you are not prepared to invest in your own business, why should the Government do it for you?

Professor Greenwood: The issue is particularly around supply chain signals. If you are a company in a supply chain for a vehicle, you wait until your buyer gives you a signal that they are going to buy something from you before you stick a plant in the ground ready to make it. They are quite long signals.

When an OEM decides they are going to create an electric product, they find a tier 1; the tier 1 then has to signal to its supply chain. You have a baton pass, and don't forget that it can take anything up to two to five years to stand up one of those elements in the supply chain so, if you are not careful, you can have an accumulation of two to five years.

What we need to do in the UK is move from a situation of everybody watching the next person in the chain to a de-risking, so all of the supply chain can march in step. That de-risking requires, effectively, Government policy and Government support to come in to help those companies do something that will ultimately become commercially sustainable. Business should be co-investing. We should not be doing this for free. But we need to do something that de-risks it in the absence of a firm order or supply-chain signal.

Q20 **Jerome Mayhew:** To cap that, we have a clear market message from the Government, which is that it is going to be EV sales only, or rather not ICE, post 2030. Isn't that the clear, long-term message that you are talking about? What else do the Government need to do?

Professor Greenwood: Manufacturers would probably like to know that the product is going to be bought from them rather than somebody in Europe, for instance.

Isobel Sheldon: Just giving a market signal by saying you are going to

ban internal combustion engines does not mean that somebody is going to suddenly buy 15 GWh of battery from you just because you built it in the UK. You need to have access to the technology to be able to deliver on that.

Don't forget that we are going from a standing start. We are behind in the scale game, as far as batteries are concerned, and we have to catch up. It is front-end loaded and capital intensive. We have to spend a lot of money to get these facilities in the ground. For the initial period, we are going to rely on the funding support and the academic research to start generating the technology that we are going to launch in 2027, because we are busy building a facility at the moment. We will get to a point where we are much more self-sustaining, but we are going from a zero start and we have to get going quickly, so unfortunately, Government support is needed.

Q21 **Jerome Mayhew:** Okay. If Government support is needed in the short term, that means Government are taking the risk and you will give them a super dividend in the medium term. Is that right?

Isobel Sheldon: Of course. All our employees are going to pay tax, businesses are going to pay tax—

Q22 **Jerome Mayhew:** What about dividend? Not tax, dividend.

Isobel Sheldon: Well, if there is a golden ticket that the Government would want to take, we can talk about that.

Chair: Now to Cherilyn Mackrory, who joins us fresh from the G7.

Q23 **Cherilyn Mackrory:** The discussion so far has been fascinating. I am going to turn it slightly to the sourcing of critical raw materials. As the Chair indicated, I am a Cornish MP, so I have an interest in lithium in particular.

With the advent of the electric vehicles and the batteries that come with them, the eye is on where the components are sourced from. Currently we get cobalt from the Democratic Republic of Congo. Lithium is coming from China. There is nickel and so on as well.

There are associated consequences of human trafficking and modern slavery, although some sources are now certificating and becoming responsible. What role do you think Government need to play to ensure that these critical raw materials are sourced in a responsible way?

Isobel Sheldon: If I could give a slightly more complex answer to that. It is not just a matter of getting your hands on the raw materials, because no matter where they come from—an ethical source or a non-ethical source—at the moment they come halfway around the world to be converted into finished product that comes into the front end of the battery facility. None of those conversion processes take place in the United Kingdom, even in the case of the Cornish lithium. Lithium hydroxide will get mixed into a cathode-active material process

somewhere else. So even if we do have it here, it will still travel and we have to try to resolve that problem.

We need to provide a good ecosystem and the support to develop that ecosystem to get the conversion processes here in the UK. We need to concentrate on making them more energy efficient and less polluting, so that we can get the permitting and do the right thing to get the carbon content in the supply chain down. That is one element to it. We need to get the conversion process as close to home as possible.

That opens up the possibility of doing other things. Recycling is an important one. There is no point in recycling batteries if the material you get out of them has to disappear round the world several times again. We need a conversion industry to turn the material into the products that we put into the battery facility. I think you can see a developing theme here, that we have a gap in capability that we have to fill, and we have to fill it urgently.

Coming on to ethical sourcing, consider that we have the conversion processes bolted here in the ground, and they are environmentally and taxonomy friendly, we have to start looking at the supply-chain element. We are doing a lot of work as a company, and I think other companies are working in this field, too. ESG is at the core of our business: environment, social and governance. We have to make sure we take care of our people and the environment, but also those people back in the supply chain.

It is not about things like avoiding the Democratic Republic of Congo. That is probably one of the least responsible things that we can do. The most responsible thing we can do is look for other sources but, at the same time, work with the NGOs and the local agencies on the ground. We need to work with organisations like the Fair Cobalt Alliance to make sure that we have the systems, the processes and the boots on the ground in the Congo to ensure that we are improving the health and safety of the operations there, and making sure that children are not going down the mines, that we have proper reporting and traceability systems in place. It is not going to be done overnight. It is something that is going to take some time. But simply chucking these people out of work so they cannot feed their families is not necessarily the answer.

Then we have to interrogate the supply chain for raw materials and make sure that they are doing the right thing as far as reducing the carbon content is concerned: that they are looking at sustainable activities, that they are looking at repairing the damage to the land they exploit once they have finished with those mines and those resources.

There is a tremendous amount to do, and we are interested in trying to work with the Government to try and address these things. I was with the Australian Prime Minister in London on Monday. He was saying, "Oh, yes, we have all these resources but somebody has to make up their mind to buy them." The demand is huge. We need to have a much more

strategic approach with the western nations to face off the threat that is coming from Asia, because we want to have a sticky, domestic, battery-cell-material manufacturing process here.

It is as strategically important as defence. Maybe we need a five-eyes approach with Canada, the United Kingdom, Australia, New Zealand and the US, to make sure that we have the intelligence and the monitoring in place to understand the size of the challenge. We need to collaborate as five nations to make sure that we have access to resources and can give the miners, and the countries where the mines are based, the visibility of the demand signals and the surety to invest to make sure that we have the products that we need. Sorry, that was a little bit long. I do apologise.

Professor Greenwood: I agree with everything Isobel said, so I am only going to add the delta. For most of our manufacturing industries in the UK, we are reliant on materials that are not mined in the UK. I sincerely hope that the lithium deposits in your constituency prove to be economically viable and, if they do, that will give us a high-value outlet in the UK, but there is a very large industry out there for minerals like lithium.

There are a couple of key things that we need to do. I mentioned this problem of long supply chains and the propagation of signals down those supply chains. Materials companies are at the very end of it. They are the last ones in the chain to receive a direct demand signal. From a Government-intervention perspective, it is an area where we need some significant support. I don't think it is going to be predominantly around extraction, with a few exceptions, like the one that you have mentioned.

There is a lot we can do in the UK around refining. We do have activities already. We have Vale in Wales, doing nickel refining to battery quality. We have lithium refiners in the UK. We have companies such as Phillips 66 making the petcoke, which is the precursor. Right now, as Isobel said, that gets shipped off to Asia for conversion and then goes somewhere else to get built into a battery. There is a lot that we need to do about standing up the material-conversion business and the cathode manufacturing business at the head of this. If we wait for normal market demand signals to drive it, we will miss the boat.

Q24 **Cherilyn Mackrory:** You have probably started to answer my next question, which is about whether you see supply constraints in critical raw materials holding back—so this is a yes. Are there any UK opportunities in diversifying the supply of materials? I do not want to be Cornish-centric. I want to broaden it out to everywhere else as well.

Professor Greenwood: A lot of the R&D that is going on at the moment is about minimising or eliminating the use of some of the most difficult of those materials. Matt mentioned that with our nickel, cobalt and manganese chemistries, we are gradually reducing the amount of cobalt in there. There are plenty of chemistries out there that do not use cobalt at all, and which can rely on much more abundant elements.

The UK has a particular strength around sodium-ion batteries, which are early stage. They are not yet fully industrially employed in the same way that lithium is, but it eliminates lithium from a lithium-ion battery and uses sodium in its place, which you can get from seawater or all kinds of other places. So, there is a substitution element and there is also a security of supply element and a reduction element in the meantime.

Isobel Sheldon: One of the things that is missing as far as the R&D activities are concerned pertains directly to the supply chain and the conversion processes. One thing we are really good at in the UK is dreaming up the new materials that will give us the energy density and the performance we need in the future. What we do not have is a comprehensive approach to R&D activities to improve the efficiency of these conversion processes.

As far as the R&D piece is concerned, we need to be deploying money into that, so that we get the fundamental and applied research done at the universities that will give us the new methods of making those materials that we need to be building and converting here in the UK. It is a bit of a gap at the moment. Places like Canada have a bit of a lead on us, so we need to step up to the plate and start thinking about how we can redeploy some resources in that field.

Q25 **Cherilyn Mackrory:** That is helpful, and you have answered my last question: what is industry doing to seek to diversify reliance on raw materials for batteries from limited countries with scarce resources? Matt, do you want to add anything to the conversation?

Matthew Ogg: First, on what industry is doing, driving sustainability is one of the initiatives set up that is also specific. There is a major partnership between 11 automotive manufacturers that sets out guiding principles for sourcing, for ethics. We welcome things like the Modern Slavery Act, and we think that it would be helpful for all UK-based businesses at least to be compliant with ISO standards around occupational health, around environmental management.

There is certainly a role for the Government in driving international standards, working through the UN and others to make sure that the way we comply is similar around the world. Particularly that helps to keep a level playing field as well, because one of the challenges here is always cost and that goes through in decisions.

There are some great initiatives like the Responsible Cobalt Initiative as well. That is still sourced from places like Congo but in a way that is much more traceable. There are already businesses exploring technologies like blockchain to help traceability so, although you might not be able to choose where something comes from, you will understand its provenance, and that transparency will help businesses make better decisions. Clearly that exposure and transparency is one of the key ways that we can see this through.

As you say, scarcity is huge, so it goes back to recycling and other opportunities for the UK to reuse and give a second life to some of these materials. As I said, we hope that the Cornish deposits are huge and financially viable, because that would certainly help from an ethics point of view.

Q26 **Caroline Lucas:** This follows on very neatly from where the discussion was just at, as I want to look at recycling and regulation of batteries. As you know, Professor Greenwood, the EU is currently consulting on a new batteries regulation, which will replace the existing batteries directive. In your written evidence, you argued the UK should match or exceed EU requirements. What benefits do you think that will bring, and can you see any downsides to that?

Professor Greenwood: The batteries directive as we have it at the moment simply mandates that a certain proportion of the mass of a battery is recovered. It is not particularly selective about what materials or how or why. It can be met largely by plants in Europe at the moment. Most of our waste batteries are shipped to Europe for conversion right now.

What the proposed replacement does is to look at recycling from three different perspectives. First, it requires that a much greater proportion of the battery pack's mass is recovered. Secondly, it looks at critical materials and requires that, where they are present in a battery, a certain proportion of it must be recovered during recycling. Thirdly, it looks at the manufacturing of new batteries and requires that, if you use a particular material, a certain proportion of it must come from recyclate. So, it simultaneously looks at the market for recyclate as well as the dynamics for recovery.

Given that vehicles and batteries are typically engineered, at least at a European scale, it would be perverse if we ended up in a situation where the UK regulations around recycling were significantly out of step with Europe. It would cause significant problems for car manufacturers, for the materials recovery companies and for the cell manufacturing companies to meet all of those.

The case for perhaps even considering something that goes further than Europe is that, as we do not have a lot of our own materials in the ground, the more material that we can recover from end-of-life batteries that have come from elsewhere, the easier our resource constraint becomes. Having said that, the degree to which the European Union is proposing this recycling directive goes to is relatively to close to where, as scientists, we currently see the limits as being—around 70% to 80% of the mass of the battery being recycled. I would not say there is an opportunity for us to do something that is massively more ambitious than Europe is proposing, but my view is that we should match the mechanisms that it is proposing, and if there is a case for going further we should examine that.

Q27 **Caroline Lucas:** Thank you, that was very clear. Matt, do you agree? In

particular, does the UK's own Waste Batteries and Accumulators Regulations 2009 need replacing?

Matthew Ogg: Touching on the UK regulation, 2009 already feels a long time ago. We have made great strides in what we have achieved in battery technology in the last 10 years, and that is going to accelerate going forwards. We understand there will be a review later this year, and my current understanding is that, as David said, it will be very similar to the EU; it just happens to be moving first.

We would agree with matching that. Regulatory harmony across a pan-European supply chain, and for market access and all the other elements of moving product around Europe and the UK, means that having alignment is helpful. That is going to help us with economies of scale. Certainly, the EU's proposal is ambitious. It is breaking new ground, to be honest, which is great, but certainly there are still some questions that industry wants to continue to consult on.

As David said, we are at the limits of what is possible in some of these and that is very ambitious for us to achieve. But we are watching this with interest, and our industry will continue to work closely with both the EU and the Government, because there is potential here. Having up-to-date regulations in this space is important, given the acceleration and the critical need now.

The other thing to add is that, at the moment, there are not a lot of secondary batteries out on the market. Going back to recycling, that is helpful but the critical mass that is going to be available—there will be an upswing but this goes back to recycling today. The financial viability of putting something in the ground, where there is potential but there is not yet the volume, even though we know it is expected, is again somewhere that there is a possible market failure and the Government could play a role in getting that up and running. If we are first mover, that is a competitive advantage.

Q28 **Caroline Lucas:** Isobel, could I also roll the next question into you as well? Do you have any comments to add on the question about the batteries regulation? I want to ask you about practical challenges surrounding reuse and/or recycling of batteries that are used in electric vehicles. Are there any facilities in the UK yet that are able to do that? If not, what do we need to do?

Isobel Sheldon: This rolls into the point that I was going to make. It is adding to what Matt and David have already said. The ambition is great, and I don't think anybody in the industry thinks that recycling and the need to improve the recycling picture is a bad idea at all. I see it as a feedstock for digging less out of the ground in the future.

My main concern, and probably the flag I would like to raise, is calibrating the timescales involved. As Matt has just pointed out, batteries go out into electric vehicles and they are used for 10 to 12 or more years. The batteries we are putting into the market today—do not

forget there has only been an uptick in demand over the last 18 months—are not going to be coming back until the early 2030s. Standing up a 30,000-tonne facility in 2023 is going to stand there idle for a long time waiting for this feedstock to come back, so we have to calibrate the time at which we need these regulations to bite, with the ability to get the feedstock back into the system.

This comes back to my point about the supply chain. There is no point in recovering these materials if you do not have the opportunity to put them into the conversion processes locally to get them back into battery manufacturing. If we are recycling at a large scale and we are sending these materials off around the world to be put into conversion processes, which then gets re-exported back to Europe, it makes no sense whatsoever either.

What this does is it gives us an opportunity to work on the processes that we need: recycling processes that respect taxonomy and the environment, and that are not too energy intensive and create a worse problem. If we are looking at 2027, 2028, that is probably the time that we need to be putting pilot-scale facilities in place. In the early 2030s we are going to need much larger-scale facilities to be able to take advantage of that feedstock.

That gives us an opportunity to work on the technology to make sure that we are getting the materials back in the right format that we need to put straight back into the manufacturing process. At the moment, there is a big debate: do we take it straight back to elemental metals? Do we do direct recycling and recovery of cathode materials and put that back into the manufacturing process? How do you cope with technology shift over time? These are all things that need to be factored into these decision-making matrices.

I have often said that if the electric vehicle market was easy we would have been driving around in electric vehicles for 30 years. It is quite a hard thing to do. We need to make sure that we calibrate that timescale to give us an opportunity to think this out properly, so that we do not end up in a position that we are doing more damage than creating benefit by having this recycling loop back into the manufacturing process. David's point about highlighting recyclate material rather than directly recycled batteries the whole time is very important, because we can take streams in from other industries and turn those into the converted products that we can use to manufacture battery cells. So additive, I think.

Matthew Ogg: I want to add that the CALIBRE project at the Faraday Challenge looked at cells. They do not age in a linear fashion. Replacing some of them can get the state of a battery's health back almost to 100%. Multiple times you can reuse a battery, so there is a second life and extended-life element before we get to recycling that I think we need to explore. That means also designing batteries that can be re-manufactured and repaired, and the skills in the aftermarket to do so. There is an opportunity there that should not be missed.

It is just worth noting that we agree that this is one of the areas where we are behind, but there is an opportunity. It is highly complex and if we are going to put the gigafactories in the ground, we want that whole-life element from generation of a vehicle right through. Increasingly, vehicle manufacturers are looking at whole-lifecycle carbon, total-life assessments, and this is all going to help us.

My last point was also on a trade element. We are going to need a value chain in the UK in order to trade with the rest of the world, if we are going to have a global Britain in the new trade agreements that we are agreeing. Having the ability to recycle and essentially recondition value into British origin is going to serve us when we look to be a possible commercial market going forwards to not just the EU but the rest of the world. Clearly there is a strong interest in finding growth and potential there as well.

Caroline Lucas: I am sure we are beginning to run out of time, so if you could be very fast Isobel.

Isobel Sheldon: Yes, a very quick point. Through all of this discussion we have talked about domestic demand. We have not even talked about the export opportunity from the United Kingdom, which is significant. We will have world-leading technology, we will be leading the field if we have the right support in place. The world is our oyster.

Professor Greenwood: On the recycling point, we are working with several companies looking to establish recycling facilities for batteries in the UK. The long time to get feedstock is a problem. That is unlocked by having gigafactories and battery manufacturing in the UK, because their waste products, even though there are only small percentages of them, are the most valuable form of feedstock for a recycling plant. In the early years of a small-scale recycling plant, that is something that unlocks the economics.

Right now, the critical issues for those companies are finding sites and getting the permitting that is required, particularly through the Environment Agency, because the Environment Agency is having to learn all the way through what it means to recycle batteries on a site. I would say the logistics of getting used batteries to a site are very expensive and difficult at the moment.

The actual conversion of the batteries through to the shredding and the separation is relatively known technology. The big gap is on the other end of that, which is conversion of what we call black mass—the chemical compounds—into something that Isobel wants to buy. Those kinds of hydro metallurgical processes typically require a plant of the order of £120 million or £130 million. They need quite a lot of feedstock coming through them to make economic sense. The danger that we have is that, unless we establish that in the UK, we will do all the low-value bit of the recycling in the UK and then we will ship the materials off to Europe and have to buy them back again afterwards. A focus specifically on that

hydro-met conversion phase of the recycling process will lock the value into the UK.

Caroline Lucas: Thanks. That is a very good point.

Q29 **Jerome Mayhew:** We are talking about regulations and we have been focusing on electric vehicle-type batteries, but there are also the grid-scale battery energy storage systems that we are going to need, particularly with renewables. I noticed that on 5 June there was a new report on the safety of grid-scale Li-ion battery energy storage systems, by Edmund Fordham and Wade Allison of Oxford University, which raised a red flag in terms of safety regulation for these systems. I would be interested if any of you have read that and have an opinion to express.

Professor Greenwood: I am happy to pick that up. We have a group at WMG that looks at battery safety. We set fire to batteries three times a day to understand how it happens and what goes on, so, practically speaking, we know our stuff on this.

Stationary energy applications are the applications that we worry about the least for safety. The reason I say that is because the environment in which they sit is very benign compared to a car. They are not vibrated around. They can be easily cooled and they can be placed a physical distance away from each other, so that, if you have a fire in one part of it, it does not progress to the next part. You can put fire-safety systems, sprinklers, and water control and so on around them. That is the easiest environment of all of them to control battery safety.

It is true that, if you abuse a battery to extremes, it will catch fire, and there is some but not a lot of oxygen inside the battery that propagates that. You need to get access to oxygen from the outside air to take it further. If I were to summarise, I think that, while the science behind the report is sound, the conclusions are a little alarmist and perhaps some of the mechanisms that are used by industry to control those things are not recognised in the report.

I cannot comment on the inclusion of building regulation and so on; that is not my area. What I can say is that the Health and Safety Executive that are mentioned in that report is a partner to us on much of our battery safety work, and it is far from ignorant about this. It has a very high level of knowledge on safety in battery manufacturing and use environment.

Q30 **Jerome Mayhew:** Do you think it should come under COMAH, the Control of Major Accident Hazards Regulations 2015?

Professor Greenwood: That is outside of my area of expertise. I would not like to comment on how it should be regulated, I am sorry.

Jerome Mayhew: I have pushed my luck already. Thank you very much, Chair.

Chair: Thank you, Jerome. I would like to conclude this panel by

thanking our panellists for a fascinating discussion—Isobel Sheldon from Britishvolt, Professor David Greenwood from the WMG and Matt Ogg from the SMMT. Thank you very much indeed.

We are going to move straight on to our second panel. Our first witnesses are very welcome to stay if they wish to.

Examination of Witnesses

Witnesses: Stephen Gifford, Vikki Roberts and Jeff Townsend.

Q31 **Chair:** I would like to start by inviting our second panel members to introduce themselves, starting with Stephen Gifford of the Faraday Institution, about which we have already heard a bit.

Stephen Gifford: Thanks for the introduction. Many people have mentioned us before. I am Stephen Gifford. I am the chief economist of the Faraday Institution, which has been set up for nearly three years now and has a mission to accelerate breakthroughs in electrochemical research with a view to the global race in electrification. We bring together scientists from across the UK's universities to deliver research projects, and we have about 450 researchers currently on our projects.

Vikki Roberts: I am Vikki Roberts, head of supply chain strategy for Johnson Matthey Battery Materials. We manufacturer the cathode material that gets placed into the batteries. I will be here today to talk a bit with regards to critical metals in the supply chain.

Jeff Townsend: Good afternoon, I am Jeff Townsend. I founded the Critical Minerals Association, and I am the director there. The CMA provides a body for players in the UK critical minerals sector to have their voice and advocate that we need to do more to support their industry.

Chair: Perfect. Thank you all very much for joining us today. We heard in the first panel, which I know you were all listening to, a lot about the importance not just of batteries but of the entire supply chain and the need for support for the whole supply chain. Stephen, perhaps I could ask you first, given the role you play looking across the sector, whether the Government are doing enough to stimulate an effective supply chain in this innovative area.

Stephen Gifford: I think the Government are doing lots already, but there is always more than can be done. To set the context, the amount of material needed is a large scale-up. Use is growing massively across the UK in terms of the market share. Demand globally for lithium is going to rise five times, and cobalt is going to rise three times.

What the Government can do to help with the supply chain is to help understand it better, particularly the timing and the ramp-up of the scale of the chemical supplies. Battery chemistries are evolving very quickly, and an overarching view on what that would mean is key. That is going to help immensely. Then we need to identify what the risks are, the risks to that supply chain and the bottom of that chain. The raw materials

supply chain is very lumpy and has a long lead-time, from the initial construction of a mine to getting the raw material out of the ground.

As with the oil industry, you will get massive price spikes and bottlenecks in supply. Anything the Government can do to identify early on what the risks are in that supply chain and the policy interventions is going to be very helpful. The Government can do an immense amount of work there. We need to get into the detail of identifying sites where critical minerals could be produced and processed and then, as we heard earlier, the gigafactories and getting inward investment activities.

There is a real development opportunity for the UK economy to attract a large part of the supply chain into the UK. For example, cell component manufacturers that manufacture the cathode materials, the anode materials, the electrolyte supplies, all across the supply chain, right up to the cell manufacturing with the gigafactories and the pack design and so on. It is only the raw materials that are outside the UK, with the exception hopefully of some lithium in Cornwall. There are massive opportunities, and a Government lead on this would be very welcome.

Q32 **Chair:** I will come back to critical minerals in a second. Vikki, picking up on what Stephen has said, you referred in your evidence to the Automotive Transfer Fund, which I think is a £1 billion fund that the Government have made available. Could you give us a sense as to how far that will go? What is it being invested in, and are you participating in that fund?

Vikki Roberts: There is a lot of support coming through with the funding over the next four years, and it is looking at the scale-up and the broader manufacturing activities. It does not deal with the critical metals that we have been discussing. There are a lot of complexities within a battery supply chain. We have talked about gigafactories and attracting them to the UK. When we start to look at it from a cathode-manufacturing perspective, it is a heavy drain on electricity. Like a gigafactory, you need a considerable amount of energy to manufacture.

When we have looked at this, and when you evaluate where you should establish your cathode-manufacturing facilities, you are looking at those land costs and the construction costs. As 70% to 80% of the cost of a cathode comes from its critical materials and its energy costs, there needs to be more that is pulled together to support renewable energy, access to the facilities.

Touching on what Stephen just said with regards to refining, it is critical to reducing the processing and making everything more efficient within your value chain that you have your cathode manufacturing located as close to your refining as possible, because it reduces that processing cost.

To put it into perspective—and obviously we are all eagerly keeping our eyes on Cornish lithium—if that looks at an output of 15 kilotonnes of lithium, you need three of those to produce enough material for 1 million

electric vehicles. It is not going to solve the problem, so there is more that is needed, and a focus on that refining and being able to connect the supply chain is something that the investment needs to continue in.

Q33 **Chair:** Another quick question. You are the only existing company of scale that we are talking to today. Can you give us a sense of what proportion of your company's R&D effort or CAPEX is going into investing in the supply chain for these vehicles for the future? We already heard it is going to be an enormous market.

Vikki Roberts: We currently have a pilot plant that operates out of one of our facilities in the north-east. We are about two thirds of the way through the build of our first commercial plant. That is in the region of £350 million for the equivalent of enough material for 100,000 cars.

Obviously, there are economies of scale. We have just announced a second facility that will be operating out of Finland. I am not sure that I can share the CAPEX costs of that at the moment, but if you start to look at the economies of scale you are talking billions of investment to get to that 100,000 tonnes of cathode material, which is the rough equivalent of 1 million electric vehicles.

Q34 **Chair:** Jeff, there has been a lot of talk and hope about Cornwall, but we have just heard that, even if it achieves what is hoped for, it will be only a fraction of what is required. What can you tell us about what the Government need to do to ensure adequate supply of raw materials if they are going to attract an industry into the UK?

Jeff Townsend: It is interesting. The 10-point plan is a really good set of ambitions, but it is not necessarily a plan. It does not stretch high enough upstream to the mining and the extraction. There is a lack of understanding of the importance there.

The midstream has been mentioned. Securing a midstream in the UK across electric batteries but, also, in terms of power electronics and motors is going to be absolutely vital. Not only does that gives us a location for upstream uptake to go to and give us a gateway for that, but it also allows us to close the circular economy at the other end. We need funding and support for the development of that midstream now, and it has to happen at the same time as the gigafactories are being built. Free markets do not exist in this area. You have to accept that the Government are going to have to put themselves in there to support it.

I would say that UKRI is doing an excellent job. Faraday, driving the electric revolution—which often gets missed out of the discussion—is doing great work on power electronics, and the Advanced Propulsion Centre is doing brilliant stuff. I simply think the amount of money that they have and the amounts that they are allowed to invest in individual projects, taking them from junior or R&D to its commercialisation, is something that is missing. That is important.

The final two things are: it would be very useful for the UK if we had a single body or a single Department looking at this and driving it forward. If you are involved in the critical mineral sector, you are dealing with DIT, where the mining specialists are. We have some of the best mining specialists in the world in DIT. Then they have to go to BEIS, which is talking about gigafactories, and then there is Defra in there at the environmental. We have the Cabinet Office, FCO. It is very, very complex and there is no one person driving it all. Giving visibility of who is in charge and the structure of the supply chain is going to be critical.

Q35 **Helen Hayes:** Stephen Gifford, you have been working with WMG and the High Value Manufacturing Catapult on a national electrification skills plan, which I understand will launch later this year. Could you tell the Committee a little bit about what this plan entails and whether further work from the Government is required to maximise its effectiveness?

Stephen Gifford: Our work in this area started around two years ago, when we looked at gigafactories and we came up with what the UK demand for gigafactories would be in 2040: seven gigafactories at 20 gigawatts each. We have done a detailed report breaking that down into what the skills requirements would be. This skills strategy is the next piece of work on from that.

The strategy thinks about a few things, about reskilling people and moving from the petrol and diesel industry towards an electric vehicle industry. Many of the skills will be very similar and can transfer. There will not be a gradual turnover, but it will not be an overnight requirement. The requirement will certainly be spread over three to five years, so there is time to do it if we get our act in order. There will be a need to upskill people, particularly in the high-end side and to ensure that there is a soft landing for the existing skills base. We do not want to crowd out other industries or the existing industry with a new, exciting EV industry. We want to grow the size of the pie, so it is looking both at the immediate and the future need for the skills. This is a long-term transition over many years, over a decade.

In terms of concrete things, it has a common curriculum framework, so 75% of skills will be in level 2 and level 3 technician-type roles, and it gives details of what training courses providers can provide. Then 25% is in high-end skills, more at degree and PhD level. It would also provide a standardisation so that course providers can work to a quality. It is providing a framework. That is all it is at the moment. It is very much a first step for things, and it is going to be a conversation once we have published it in the next few months that, hopefully, the Government can take on board and work in some more detail with us. Yes, it is the start of a conversation. There is some initial work done, but it is a very important strand that needs attention.

Q36 **Helen Hayes:** Are you confident that the basis of that conversation with the Government is in place and that you will see the support and the action you need?

Stephen Gifford: We have been working with a number of delivery partners—the High Value Manufacturing Catapult, Warwick Manufacturing Group, the Auto Skills Council, so all the bodies are involved. Now is the time for us to take it to the Government in the next few months, to get a shared understanding of what needs to be done next.

Q37 **Helen Hayes:** Vikki Roberts, you argued in your written evidence that the Government should set up a skills corridor with Asia to tempt talent here. Could you explain more about that? Have you raised it with the Government?

Vikki Roberts: We raised it recently in a response to the House of Lords Science and Technology Committee. There was a call for evidence on the role of batteries and fuel cells in achieving net zero. What we see is that we are behind in the technology and in the scale-up of the battery industry. When you look at Asia and you look at China, Japan and South Korea, they have been operating at significant scale for a number of years. They have a particular area of expertise in the supply chain. A lot of critical metal refining takes place, and lithium, nickel and cobalt quite often come through China and are refined there. Also, there is an accelerated scale-up from the manufacturing.

What we are trying to do here—touching on what David and Isobel were saying earlier—is that, if you have automotive companies that are starting their new platforms on electrics in 2025 or 2026, we have to scale up fast. It is a technology that we are developing. It does not mean we cannot do a step change, that we cannot bring in UK innovation, but there are opportunities there where there are skillsets that have already delivered these plants at scale and that are fully operating.

As we mentioned earlier, from a cell perspective there is a lot of scrappage, a lot of waste, that comes through the production. There are figures anywhere, on average, around 10% across the waste. That is a significant amount. If you can bring in the expertise that has already gone through the teething pains right at the beginning, on the establishment, maybe we can miss a few steps and jump ahead and get back on track. That is where we would be coming from on that.

Q38 **Helen Hayes:** What would a skills corridor look like from your perspective? Is it looking at changes to the current immigration policies, to the current visa arrangements? Is it looking at the list of skills shortages within that, at the pay requirements?

Vikki Roberts: It is definitely looking at the skills list and the availability of those skills. David was talking earlier about the re-education piece, the skills and the qualifications that we are looking to do. It does prove that there is a shortage here, so it is becoming more critical that it is raised up in the profile and that we have access to that talent.

It is incredibly difficult because it is currently an Asia-centric market. That is moving to Europe, but it is incredibly difficult to incentivise parties to come over, to come and work and support it here. Additional support that

could be offered in that sense could help to make it easier and accelerate the battery industry in the UK.

Q39 **Helen Hayes:** That is helpful. Finally, Jeff Townsend, in your written evidence you highlighted that UK universities are phasing out mining courses just when they are needed. What action do you think needs to be taken to address that trend and to make sure that the UK has appropriate, fit-for-purpose skills in mining to address current demands?

Jeff Townsend: That is a good question. When we are looking at the need for critical minerals, we are seeing an over-doubling of metals needed for the new industrial revolution. We are going to have to dig out twice as many as we currently are: an 18-times increase in lithium over the next 15 years. This all needs to be extracted. If you cannot grow it, you need to extract it. While this is happening, we need to start looking domestically at what we can do. We have some great companies doing that. We need to look internationally as well. This requires geologists and mineral engineers.

It used to be joked that, "At the bottom of every mine in the world you will find a Cornishman." That was because of Camborne School of Mines. Recently, though, Camborne School of Mines has phased out its undergraduate mining engineering provision because there are not enough students. Why is that? I think it is because of the perception of mining and the perception of extraction. When we think about extraction and mining, we think of the poor Welsh guys coming out of the pits with soot all over their faces, or we think of riots and strikes in the 1980s or we think of *Avatar*, where mining is the bad guy.

The reality is that extraction of critical minerals is the bedrock. It is the foundation of the solution to the environmental problems that we face. These are the building blocks. The first thing is changing the perception of mining, accepting that, and also changing the narrative from stakeholders, leaders and politicians about the importance of it.

It is also important that we approach partnership—it is great to hear about some of those that are already taking place—and ensuring that universities match the skills with the upstream requirements. Funding is key. If you look at postgraduate student loans, they are capped at £10,500. That does not cover a postgraduate mining course. You get no support for fieldwork. You cannot learn this off a laptop or out of a book. You need to go and do fieldwork to learn this.

If we want to go out and explore and be global leaders in exploring, finding and securing critical minerals, we need these new engineers, we need these new geologists, but right now we are reducing numbers.

Chair: I would formally like to welcome, which I should have done earlier in the first panel, Mike Pawsey, who is joining us as a guest from the BEIS Select Committee.

Q40 **Mark Pawsey:** Thank you. I have some questions on the supply of

critical raw materials, which we heard a little bit about in the last evidence session. I know we have evidence from our witnesses, and it seems to me you have concerns about dominance by some countries, some unsafe mining practices, low environmental standards. We heard about the possibility of child labour at a time when there is an explosion of demand. Jeff just spoke about an 18-fold increase in the demand for some materials. We almost seem to have a gold rush taking place. How do we prevent a wild-west scenario occurring?

Jeff, what can the Government do to regulate this sector, given that most of the suppliers are elsewhere in the world? We have just heard that Asia is the centre of this market, and the suppliers are in Africa. How can we influence standards in the provision of materials?

Jeff Townsend: I am going to have to give a slightly longer answer to this, if you can bear with me. If we look at the international market at the moment, China absolutely dominates it. China does not dominate where the minerals are extracted. That is geology, and we cannot move that. What it has done is integrate a very clever long-term strategy to secure the eventual downstream production of the electric vehicles market. It controls 75% of global battery minerals, 95% of power motor minerals and 95% of minerals needed in semiconductors.

That is not by fluke. That is a systemic strategy dating back to the 1950s. That was ramped up in 2000 with the Go Out policy, and then strengthened in 2010 with five-year plans and the national mining resource plan. China has been very clever at getting its house in order early. That was recently supported by their top legislature passing a new law that bans the export of strategic materials and advanced technology to foreign companies.

What does that mean? If we look at batteries—because that is what we are talking about, although we should be talking about magnets as well—China refines 35% of the world's nickel, 65% of the cobalt, 97% of manganese, 64% of lithium and 89% of graphite, which results in 71% of cathodes being built in China, 77% of anodes being built in China and 72% of lithium-ion cells being built in China. Ultimately, 45% of electric vehicles are built in China and south-east Asia.

What can we do to mitigate this dominance? The first thing is we have great companies. We can do stuff domestically. We are all looking at Cornish lithium, of course, because with their support and if that works, that is a strong thing. We also have other domestic critical mineral products, and that will reduce our carbon footprint. You have copper from Northern Ireland potentially, and you have tin and tungsten from the south-west.

Q41 **Mark Pawsey:** Jeff, in the greater scheme of things, are these resources going to have any impact on the dominance of China that you have just explained? Is it going to make any difference? Are there other parties that we can work with to increase availability and raise standards in the sourcing of them?

Jeff Townsend: Exactly. I am just getting on to that, Mr Pawsey. We cannot change where these are extracted, so it is important that we have companies and that we support those companies out there that are also going out and finding these products. The first thing to do is to try to reduce the amount that you ship things. By having your midstream in the UK, not only do you create a regional competitive advantage against Europe, which is our main competitor, it also creates an alternative destination for that midstream compared to China.

If you look at Canada and Australia, they would like to extract that. If you look at America, though, it is obviously very closely tied to Canada, south of the border, so partnership with Canada and Australia specifically on securing critical minerals and providing them a midstream home for their offtake would be a very sensible thing. That would allow companies that are producing cathodes, anodes and batteries the security of supply: the idea that these are going to be in country and available not for three months but for five years, 10 years. That is the first thing we can do.

The second thing we can do is we have great companies like Minviro or Circulor. Minviro is a lifecycle assessment company. Circulor does track and trace blockchain technology. These are global leaders. They are used by Volvo, Boeing and Tesla. By integrating ESG compliance through every stage we can ensure that we are giving our companies, and Canadian and Australian companies, a bit of equality in the marketspace. This is something the UK could have used G7 to do. We hope we see it at COP26. That is something we can do.

Ultimately, what we really need is to support our mining industry and get the investment in there. We are not talking about £10 million or £20 million; we are talking about hundreds of millions, if not billions, and we need to provide that equality across the international spectrum by ensuring there are global ESG standards.

Q42 **Mark Pawsey:** Vikki, Johnson Matthey is one of the biggest names in this field. What steps do you think can be taken to provide more security of supply, more stability on price and to make certain that these products are sourced ethically?

Vikki Roberts: There are quite a lot of things that can be done. From the mining perspective, from the miners that we talk to, for a long time the industry has been reliant on China and the Asian market. It is quite exciting for them to see this European market starting to explode, because it now gives them an alternative avenue.

Q43 **Mark Pawsey:** Will the European market set higher standards than perhaps the industry has been used to working to up until now?

Vikki Roberts: Yes, absolutely. As part of the proposal in the EU batteries regulation, it is now looking at bringing in requirements with regards to labelling on lifecycle analysis. If you produce your product utilising coal energy, it is going to have a negative impact. It will start with labels, but it will go on to be limits so that you will have to meet a

certain sustainability target for your product. Also, on ethical sourcing, there are standards coming in, OCD, as minimum standards and guidelines in that sense.

A few people have touched on blockchain. What blockchain will do is put more power in consumers' hands. In essence, they will be able to see the sustainability and the ethnical sourcing of their vehicle when they get to that stage. That will also start to drive it.

From a Government perspective, what we would be looking for is resource diplomacy. Post Brexit, what do we have available to us? It should be absolutely fundamental that, in every negotiation we go into, these critical metals are one of the key materials that we are trying to get hold of and bring into the UK, and processing it that way and supporting investment in the refinery. We have a long history in steel, in the metal industries. At Johnson Matthey we have a lot of experience in the refining of precious metals and we are now moving across to the refining and recycling of end-of-life batteries. There are a number of different avenues that can be taken.

Q44 **Mark Pawsey:** Stephen, do you think finding domestic sources for some of these materials is a starter, or is it all a bit pie in the sky?

Stephen Gifford: Domestic sources will be very helpful in giving a diversification of the supply chain.

Q45 **Mark Pawsey:** Are they realistic? Is there a realistic prospect of us finding them in the volumes that we might need to avoid the problems that we are facing and fighting in a world market?

Stephen Gifford: That remains to be seen. I do not have details of the exploratory mining in Cornwall that is occurring at the moment.

Just to pick up specifically on some ideas about international relationships, our Commonwealth countries have a lot of scope in terms of supply, and they host vast resources. Earlier commentators in this and the previous session talked about lithium and how it is in South America and runs through China, but 60% of global lithium is mined in Australia and that all passes through China. Australia is a huge resource for lithium. Working with Australia to develop the midstream, as we say, is going to be important.

There are probably a couple of other things to think about in terms of security of supply. Critical metals are very much like the oil industry. The UK did not need to get into securing oil because it had the North Sea oil, but stockpiling metals, bilateral relationships and agreements with other countries about how you handle resources and critical metals is going to be important. How other countries without oil stocks have managed oil. That is very important.

On the other things about cobalt in particular, the Faraday Institution is doing a lot of research in reducing the amount of cobalt. Cobalt is going to be one of the materials that is in shorter supply than other materials.

Continued funding of research into reducing cobalt is going to be very effective. We already have our project, called FutureCat and CATMAT, led by the University of Sheffield and the University of Bath, developing cathode-free electrodes.[1]

There are also things that are very closely linked to this, like developing the UK recycling industry. This is an area that requires Government support, more so than the gigafactories because we are already in a very embryonic industry. Batteries sold today will not be recycled for another 10 years, so the recycling market today is what the EV market was in 2012 or something, so there is a lot of work to be done in developing the recycling market.

If I could come on quickly to ethical considerations, it would be easy for the UK just to purchase ethically. Globally, the EV battery market in the UK will be 2% and we could easily purchase 2% that is ethically sourced, but that would defeat the object of trying to make the rest of the 98% ethically mined as well. You particularly mentioned the Democratic Republic of Congo. Only multilateral interventions are going to be effective in trying to improve the traceability of where minerals come from because everything goes through China, so it is all about multilateral engagement, a global approach.

Q46 **Mark Pawsey:** Is that engagement taking place already? Have those discussions started, or is it still a bit of a free for all?

Stephen Gifford: Absolutely, they are taking place. We are involved in the Global Battery Alliance. Other commentators here have talked about the cobalt policies as well. They are absolutely taking place. It is a 10-year issue, because the research is going to mean that cobalt in batteries is going to reduce drastically by the early to mid-2030s.

Jeff Townsend: One of the things that is important is the price of energy. If we are going to do this domestically, our energy costs have to be equal to those in Europe or globally: 15 pence per kWh versus 3 pence per kWh in Europe. We need to address that.

Q47 **Mr Robert Goodwill:** Mr Gifford, you have given us quite a lot of leads as to where the research should be going in. You dropped into the conversation that, after 10 years, you will be recycling these vehicles. In the past we have encouraged people to get new vehicles because the emission standards improve and the fuel consumption improves, but do you feel there is any merit in looking at how we can improve the lifecycle or the longevity of these vehicles, or is it that people will want to buy a new car because that is what people like to do to give themselves a bit of a boost? Can we do more in terms of the length of life of the battery, as well as the length of life of the vehicle in total?

[1] The witness has said that he intended to say "cobalt-free" here, not "cathode-free". So, the sentence should read: "We already have our project, called FutureCat and CATMAT, led by the University of Sheffield and the University of Bath, developing cobalt-free electrodes."

Stephen Gifford: Yes. The University of Birmingham is looking at recycling batteries with a target to produce 95% recycling by 2030. This is an issue that we are currently looking at.

My point was more about the recycling industry being very small at the moment because it is dealing with the batteries that were made many years ago. The recycling industry, to develop, needs Government support, whether in terms of developing pilot lines and the research needed—as earlier commentators talked about—beyond the one-year time horizon, to be three to five-year levels of research for looking at this. That was my point on that issue.

There are other technologies as well. Faraday is very much looking at next-generation battery technology to replace lithium. Solid-state batteries, for example, sodium batteries. Solid-state batteries would have higher energy density, faster charging and be safer. The incremental performance of lithium—researchers have been working on it for 10 to 20 years, so there is a massive opportunity for solid-state, for example, as well as other technologies such as sodium. That is a low-cost alternative to lithium and would be targeted towards the lower end of the EV market, maybe in developing countries as well.

Q48 **Mr Robert Goodwill:** Would that present a unique problem, given that if we set very ambitious targets for the amount of material in the batteries that could be recycled or put to alternative uses, if we change the technology in the batteries altogether, could we find that there is no market, or no massive market, for the materials in the last generation of batteries because we are now using different materials?

Stephen Gifford: There is a general point about using legislation to drive markets, which as an economist I am a little nervous about. That was very much the consensus in the first panel. This is a very innovative new market, and legislation is a very blunt instrument.

As an economist, what I would like to do is try to internalise the social and environmental costs of recycling, so that the market thinks about what they are and takes into account what they are but is then able to find the correct solution. It might be that recycling of the threshold in the batteries directive is not the optimum for the market to provide, so I would be a little nervous about doing that. Certainly, I think it is too early to say. We are in a very embryonic market, and for Government to legislate a certain threshold without knowledge of how the market matures would be a little bit adventurous.

Q49 **Mr Robert Goodwill:** Yes, I agree. I am reminded of the original end of life vehicles directive, which tended to push manufacturers back to steel. From plastic to steel was heavy, and it was easy to recycle whereas plastic was much more difficult.

Would our other two witnesses like to focus on what areas of research and development we should be putting more resource into, or is it a bit of a Betamax situation, that Governments are not very good at choosing

where to put the research and it should be left to the market?

Vikki Roberts: One of the things that is good and that we are very supportive of is the funding that has come through the Faraday Institution and the way it is being handled and processed. We would advocate for it to continue on that route, so that the right research projects are dealt with and focused on by industry experts, so they are focusing on what is coming next and how we can best develop this. There are obviously lots of different developments coming, and there are lots of things that the whole world is working on with regards to solid-state batteries. That links back into what we were talking about earlier, with skills gaps and how we could look at those sorts of things.

Where we have come at it from and what we are looking at is some opportunities that are unique to the UK, where we could focus on some of those sorts of things. So, utilising the UK's strong sectors in pharmaceutical and organic chemicals, looking for alternative organic electrolytes and focusing on some of the areas where we could also make a difference, utilising the sectors that we have a strong presence and strong expertise in already. The other thing, which Stephen was alluding to, is moving away from a lithium-ion battery. There is magnesium, aluminium.

It then comes back to the recycling point, the cost of recycling. Magnesium and aluminium are more abundant than lithium, but the value of them is different. The recycling process still has to be viable, and there has to be a cost benefit as well, to drive that industry for the recovery and the recycling of materials rather than the primary extraction. That is where we need to focus on ensuring that we are supporting. As you say, recycling is definitely going to be a key thing.

Finally, there is advanced refining technology. That is where we would like to see some additional utilisation. We are not going to be able to change the geographical location of the resources. We are not going to be able to change those, but if we can develop and offer step changes, and look at how we can be more efficient and more effective in the refining, we may be able to create an advantage. Because the rest of the industry is predominantly focusing on the cathode or the battery, the cell manufacturing and that side of things, it may be an area that has less focus in other countries and other parts of the sector, where we could maybe make some inroads.

Q50 **Mr Robert Goodwill:** Jeff, do you have any views as to where more research should be put, to give the UK that competitive advantage we just heard about?

Jeff Townsend: I think UKRI and its groups are doing a really good job there. All I would say is that I would like to see organisations like Faraday be able to invest in higher TRL levels, so taking some R&D and taking it to commercialisation quickly. Because we are in a race, I think it is absolutely necessary to take the ones that are winners now and get them up and running ahead of our regional competitors.

Q51 **Mr Robert Goodwill:** Vikki, in your written evidence you mentioned that you thought the end-of-life battery market would quickly become saturated. I suppose there are two things you can do with a battery: you can break it down to its component chemicals and make new batteries or you can stick them in these big, static battery packs to use and even out the supply. Do you have a view as to which direction we should be going? I know way back, even before Tesla was producing many cars, it was very keen to recycle its batteries by breaking them down chemically. Whereas, other manufacturers could see a battery with only 50% or 60% performance left as a resource to be used as a battery, rather than remanufacture.

Vikki Roberts: Realistically, the approach needs to be both. At the end of a vehicle's life a battery will have 70% to 80% of its capacity. It should have a use in that situation. Recycling should theoretically, from a sustainability perspective, be your last point. You should have exhausted the capacity of the battery before you start recovering and recycling. There are some challenges, though. There are no standards currently, nor any performance guarantees for second-life usage. There is a difficulty there.

The other thing in cell manufacturing is there is no consistency in the design of a cell. To be able to refurbish or reuse each cell, each manufacturer is going to require a different process and different work in order to be able to refurbish it and convert it for energy storage.

There is also a drive at the moment for the reduction of the cost of a new cell for an electric vehicle. They are looking to bring that dollar per kWh down. As that continues to decrease, the gap between the cost of a second-life and a first-life battery will start to narrow. If that becomes too narrow, and without any performance guarantees on a second life, they are unlikely to opt to take a used battery instead of a brand-new battery. There are some challenges.

We have been talking about the availability of end-of-life batteries. If you start to add a second life, that 10 to 12 years goes to 15 to 20 years before it comes back through your cycle. That is something we would have to consider and understand how it would impact. At the moment we are accelerating the number of cells that we are going to be producing, so our interpretation is that there needs to be a balance between reuse and recycle, so that the best batteries that can be reused go on for reuse. It is likely that that the reuse market will be saturated by 2030 anyway, so it is not a long-term solution.

We need to start taking some of those batteries back, because we are going to need that raw material coming back in to support. We have talked about the technology changes in batteries. The first set of batteries that will start to come back for recovery will have significantly more cobalt in them. They will be worth an awful lot more in raw materials than the batteries that are going to be produced in 2025 and

2026. We have to balance it out. From our perspective, we need both those options.

Q52 **Mr Robert Goodwill:** In his evidence in the first session, Professor Greenwood talked about the revision of the batteries directive and how some aspects of it could be skewed to favour UK or European manufacturers. Obviously, we are not members of the European Union, so we won't be pivotal in setting the parameters in that directive. However, we have manufacturers that operate both here and on the continent, so perhaps we still have a good lobbying operation in Brussels. Mr Townsend, do you have a view as to how we can skew that revision to improve the situation of UK and European manufacturers and recyclers, rather than maybe others.

Jeff Townsend: I think it is really interesting. The first thing is that if we are going to build batteries in the UK, just in terms of economies of scale, we will have to look not just at our domestic market but also at exports. Differentiating our regulations from the EU is simply not going to work for companies. They will have to be able to do them both.

Where it becomes interesting is potentially where those batteries end up at end of life. You could see a potential where the EU says that any battery made in the EU has to be returned for recycling or reuse in the EU states. That traps those batteries in the EU in terms of security of supply, and means that the UK is again having to buy new if we are not producing our own, and so on. We have to be clear on that, and we then have to have our own option here, so batteries made in the UK are kept in the UK at end of life if possible. However, that is a lot easier to say than do.

Q53 **Mr Robert Goodwill:** Yes, although we have a free trade deal with the EU, so I guess there is no barrier to the movement of the batteries. Mr Gifford, do you have a view on how we move forward on this, or do you feel it may be that technology will accelerate faster than the legislation and some of the aspects of the new directive could very quickly become out of date?

Stephen Gifford: Probably, yes. This is a fast-moving industry, one of the fastest-moving industries in the world at the moment. On the issue of harmonising or divergence, I am not sure that a case has been made for harmonisation. It does not seem to me that a gigafactory in the UK needs to have the same regulations as a gigafactory in Europe.

The trade deal allows us to diverge. What that divergence will be, whether it means different regulations for different parts of recycled material, whether you want to drive second-use or drive the recycled content, is open for debate and deep analysis. I do not see a persuasive case that we need to harmonise at the moment.

Vikki Roberts: I definitely think the controlling of the end-of-life batteries and securing that supply is an important process, as is making sure that there isn't leakage. There is a lot of good stuff in the EU battery

regulation, but they have gone at it as a belt-and-braces approach. They have gone at it from mandatory, 100% collection rates, plus the recovery and recycling efficiencies. On top of that, you have to have a minimum content of recycled material in your cathode and in your battery. It is trying to create a very tight, closed loop.

Batteries require a really significant quality of, say, nickel. You have to do a lot of recovery. If you take an end-of-life battery, it may not be very efficient to recover it to a battery-suitable nickel product that is able to go back into batteries. It may make more sense to recycle it to be utilised in a different industry or for different products in different fields. A bit more flexibility might be more efficient.

It would still have the same ultimate intent of reducing our reliance on primary raw material, but it could give us that flexibility and that advantage to support other industries within the UK by being able to access recycled material and having a more efficient and effective recycle and recovery process into different forms for different industries.

Stephen Gifford: One very quick point is that Europe is way ahead of us in terms of numbers of gigafactories. We do not want to do anything that prevents UK gigafactories being built. We already have one being built by Britishvolt. If we create the conditions where battery manufacturers think it is going to be so much easier and more flexible to do it on the continent, that is a problem. We need to be careful in this area.

Mr Robert Goodwill: I guess outside the European Union there are other levers we can pull to make our economy more efficient or better from a tax point of view. In some ways, at least some of these decisions are within our own power.

Q54 **Chair:** I will conclude with a question to each of you: are you optimistic that the UK will secure sufficient battery production capacity to enable our automotive industry to survive in the UK?

Stephen Gifford: Yes, I am very optimistic. We have all the conditions in the UK to make siting gigafactories here successful. We have a very competitive labour market. We are already the fourth or fifth biggest automotive supplier in Europe. As a colleague of yours mentioned, we have the levers in place to make a competitive tax system. We have everything in place to be successful.

We should not be complacent, though. This is a race, and the race is happening over the next two or three years. What we need in addition to that is extra things in the ecosystem, like long-term funding of research. As one of the evidence submissions said right at the start, the lithium battery was invented in Oxford, but it was not commercialised here, because the learnings were around short-termism.

If we had much more long-term vision for battery research, it would help with delivering the UK automotive industry for the future. A long-term view would also help with the transition to net zero. Many of the

assumptions in many reports assume reductions in costs and delivering performance, but they do not quite get into, "You need the technology to be invented. You need the technology to deliver this, and it is not invented yet. You need the research to do that."

Vikki Roberts: I am optimistic from a gigafactory perspective, and the battery, and that link-in directly to the automotive. There is a considerable amount of work that needs to be done to attract cathode manufacturers and further along the supply chain, in order to be cost competitive. Jeff alluded to energy prices being too high, so consistent access to renewable energy, but also that link into the raw materials. As the battery and the automotive like to be close, as a cathode we like to be close to our raw material and our refining feedstock. There is more work that needs to be done there to secure the whole supply chain in the UK.

Q55 **Chair:** Jeff, on raw materials, do you think we can achieve this?

Jeff Townsend: I am hopeful. There are 174 gigafactories being built in the world, 130 are in China. They have control at the moment. I would not say whether we can or we cannot. It is a must. We have to do what we have to do to deliver this, because that is the foundation of the 10-point plan.

Chair: It did not come up earlier, but I heard—and it may or may not be true—that Tesla, as the first mover in this sphere, has secured a very significant proportion of the currently available battery capacity. Is anyone in a position to confirm that? No. It may have been a rumour. Very good.

I would like to thank you, our second set of panellists: Stephen Gifford from the Faraday Institution, Vikki Roberts from Johnson Matthey, and Jeff Townsend from the Critical Minerals Association, for your support to our Committee this afternoon. Thank you also to Maf Smith, who is a specialist who has been helping us, to Jim Camp, who prepared the brief for the Committee, and to all Committee Members who joined us today. Thank you very much indeed.