



HOUSE OF LORDS

Environment and Climate Change Committee

Corrected oral evidence: Electric vehicles

Wednesday 18 October 2023

10 am

Watch the meeting

Members present: Baroness Parminter (The Chair); Baroness Boycott; Baroness Bray of Coln; Lord Grantchester; Baroness Jones of Whitchurch; Lord Lilley; Lord Lucas; The Lord Bishop of Oxford; The Duke of Wellington; Lord Whitty; Baroness Young of Old Scone.

Evidence Session No. 5

Heard in Public

Questions 55 - 66

Witnesses

[I](#): Cory Reynolds, Corporate Affairs and Communications Director, Veolia UK; Ken Byng, Senior Manager, CarTakeBack; Robin Brundle, Executive Chairman, Technology Minerals plc; Dr Gavin Harper, Research Fellow, Faraday Institution, University of Birmingham.

Examination of witnesses

Cory Reynolds, Ken Byng, Robin Brundle and Dr Gavin Harper.

Q55 The Chair: Good morning and welcome to the fourth evidence session of the House of Lords Select Committee on the Environment and Climate Change's inquiry into electric vehicles. Today, we are going to look into the end-of-life disposal of EVs and recycling. We are delighted to have four witnesses here with us in the room. We have Cory Reynolds, who is the corporate affairs and communications director at Veolia UK; Robin Brundle, the executive chairman of Technology Minerals plc; Ken Byng, a senior manager at CarTakeBack; and Dr Gavin Harper, who is from the Faraday Institution and is a research fellow at the University of Birmingham. Welcome.

We have a number of questions for you; I am sure that the committee's members also have supplementaries. Let me open the proceedings by asking each of you to give us an overview of your assessment of the UK's readiness in the light of the 2035 phaseout date in terms of the required EV waste disposal facilities and, indeed, the UK's recycling capacity.

Cory Reynolds: Our view on end-of-life EV batteries is this: the current projections are for 350,000 tonnes of material to be processed by 2040 but there is not currently enough capacity in the UK to process that material. Veolia is building a battery reprocessing facility at Minworth in the West Midlands where we will have the capacity to process and discharge 5,000 tonnes of EV batteries; that separates out the black mass material and metals from the batteries. We forecast that there would need to be at least 10 times the type of facilities that we are building at Minworth to process stages 1 and 2 of battery facilities.

What we would like to see to enable that is faster and more efficient planning permissions being given for such facilities. We would also like extended producer responsibility-type legislation for batteries for their full life. We would also like batteries to have a waste code specific to batteries in order to make it easier to separate that waste out and process it in the UK.

That probably gives an overview of where our focus is. It is worth saying that batteries in general waste streams at the moment are a huge problem for the waste industry. They cause regular fires, stopping our capability to process waste. That is not just batteries; it is small electrical batteries such as those in scooters and toothbrushes—even as far as vapes. We would like a lot more, clear legislation around these issues.

Robin Brundle: Good morning. I should declare an interest, with my Technology Minerals hat on. We are what you would know as junior miners and are looking specifically for battery metals in ethical places, with assets in America, Northern Ireland, Spain and so on. With my other hat on, I am a co-founder and director of the Recyclus Group. We are the first scale lithium-ion processing plant in the Midlands, with a permit for 22,000 tonnes of processing of any chemistry of lithium-ion batteries. What that means is everything from a vape through to e-bikes, cars,

trains, fork-lift trucks and so on. We have a wider view of the other chemistries beyond just EV.

From a strategic point of view, there is work to be done on supporting the UK strategy in the sense that a circular economy already exists but most roads lead to China. For example, the black mass from battery waste that we talk about cannot yet be processed here in the UK so, by default, despite all the money we have put in and the great work in academia, our black mass material is shipped to, in most cases, South Korea or Japan. It then ends up back in China for manufacturing of batteries to be shipped around the world. As you may already know, China has the lion's share of the global supply of battery metals through its acquisitions over the past 20 years or so.

So, the circle exists, but we need either to be a disruptor or to create our own, and we need to be clear on that. The UK needs to support a policy that asks whether we are a trading nation. At the moment, we want these raw materials to come into the UK and be retained here but the current government legislation states that any battery waste is classed as green. In essence, we welcome the raw material coming in but, when it filters down through the agencies that permit that to happen, there is a difference of opinion. There are blockers in the system with that. Support, through looking at the detail of that system, would be beneficial so that we can ask, "Are we genuinely a trading nation or are we not?" Once we have made that decision, we need to be very vocal about it.

The second element of this is that we have a possible win-win situation with regard to raw materials. If you look at the legacy situation here in the UK, you will see that HMT is currently paying for around 400 mines in the UK that the UK taxpayer is picking up the annual liability for maintaining, but we are not able to do it properly. Rivers are running orange and areas of natural beauty are harmful to humans. However, we are still rubber-stamping a fee of £400 million per year through the Treasury.

You may wish to ask the Treasury for its view on how much it pays for not just those mines that are focused on battery metals but the old coal mines, because it runs into billions at that point. Those slag heaps and tailings have many of the raw materials that we need for the battery space; that is the relevance of my point—sorry, I can see the Chair grimacing. There are many resources here in the UK if only the industry could be cornerstoned by government. There is no appetite for investment in mining here in the UK. The problems and the legacy costs are challenging to tier 1s. If we are going to go back to finding our own resources, we have to find a way to have some form of amnesty on legacy clear-up in order to facilitate the extraction of raw materials. That is critical, because academia is forecasting that, through recycling, we will only ever be able to achieve a maximum of 30% of the raw materials that are required. As a result, by default, 70% has to be extracted. If you as a consumer wish to transition to EV products, you must have raw materials. We cannot create these products from thin air.

From a raw materials, strategic and trading nation point of view, we now have most of this capability. The black mass is the next blocker in the system. When you look at black mass, you see that the business model of the tier 1s such as the Glencores of this world to invest £400 million into a European hub-and-spoke scenario—where it becomes viable—is sensible. Investing £400 million here in the UK, if you leave it to captains of industry, is not viable; it therefore will not happen. Companies such as ours, where we have to prove viability, are looking at bringing in this black mass capability in the near term but only on a small modular basis. If we wish to have a narrative that we are a world leader, it will need cornerstoning to invite the tier 1s to have superinvestment in black mass treatment. Otherwise, you are back to a commercial business model.

There is more to talk through. I thank you for your time and will pass this over.

Ken Byng: Thank you for the opportunity to be here today. Obviously, batteries have been talked about, but the other part of this concerns the electric vehicles themselves. Currently, to answer the question directly, we have sufficient capacity in the industry to dismantle those vehicles for perhaps the next two to three years. However, beyond that, we expect the volume of the vehicles to rise. At the moment, it is predominantly premature end-of-life vehicles that we are seeing; they may have been damaged in an accident and written off by insurance companies, or they may be prototypes from vehicle manufacturers and that sort of thing. Obviously, I am talking about lithium-ion battery vehicles at the moment. Nickel-metal hydride batteries are a different matter, as I assume everybody believes for the purpose of this inquiry. We have been seeing those through as natural end of life for a long time.

Focusing on the lithium-ion battery vehicles and what happens once the volume starts to rise, the issue we have at the moment is that it is a small part of the network of the UK's authorised treatment facilities that dismantles these vehicles. A small number of facilities are trained to do so and have the right investment and equipment in their premises, techniques and tooling. What we need to move forward on end-of-life vehicles in our industry is growth in this area. We need more investment from the authorised treatment facilities to take account of the growing volumes that we are going to see. We also need better enforcement of the existing regulations—the End-of-Life Vehicles Regulations; I know that there is a question coming on them a little later—because we need fair enforcement to have a level playing field. When we get that, it helps the industry to grow; it encourages investment and gives confidence in it.

Where we are at is that, obviously, electric vehicles are very different from vehicles with an internal combustion engine. We will leave hybrids aside for now. In these vehicles, what we lose from a value chain perspective is the engine, the gear-box and the catalytic converter, all of which are high-value items from a conventional end-of-life vehicle. We need to realise value from the replacement components: the lithium-ion

batteries, the motors, the control gear, the control systems and all of that.

There is a lot of work going on in this area, as colleagues have mentioned. Currently, lithium-ion batteries tend to take care of themselves if they are serviceable because, with the way the regulations are written at the moment, they can be sold on. So, the people in these authorised treatment facility companies who are more business-like and more switched on leverage that; they can replace the value chains by selling those things on. However, there are also smaller authorised treatment facilities that are not in that business or at that level. What we really need, as I say, is a bit more certainty and enforcement of the regulations to encourage that confidence for investment.

There will be other issues for some authorised treatment facilities, unfortunately. Some of them are on very small sites. They work hard at sweating those assets and are efficient and effective in what they do but the issue is that, when you replace an internal combustion engine vehicle with an electric vehicle, you then have what is in itself a large vehicle. If they are damaged, they need to be sited 15 metres away from any other vehicles or anything else. The lithium-ion batteries are of a significant size. There are also requirements for their safe storage, so more space is needed on these sites. There are quite a few issues with growing what we have currently. As I say, one thing that can help with that is better enforcement of the regulations and better resources for that in order to ensure that we have level playing fields and that it is worth the investment for these companies.

There is another issue at the moment, which we as an industry are working on together with vehicle manufacturers, Defra, et cetera: the information on dismantling these vehicles that is currently available to the authorised treatment facilities. Again, under the extended producer responsibility part of the existing End-of-Life Vehicles Regulations, manufacturers have a responsibility to make sure that this information is freely available so that authorised treatment facilities can safely dismantle these vehicles and remove the batteries from them. Currently, some manufacturers are very good at that and the information is excellent and easy to follow. However, others are less so. Again, that is something that I think we need better enforcement on in future as far as the vehicles themselves are concerned.

Batteries are being covered by experts in the room so I shall not talk too much about them, other than to say that my personal take on it is this: I agree that black mass processing is a big issue for the UK at the moment and needs resolving. It needs support.

Dr Gavin Harper: I agree with Robin's assessment. One of the challenges we have is that we want a circular economy of electric vehicle batteries but have only one very small part of the circle at the moment. We do not have all the additional elements that are required to valorise that material then turn it back into useful batteries. That is a big issue.

It is important that capacity is built in lockstep with the waste arising. It is no good prematurely building lots of processing facilities and not having the material to service them. The analyst Hans Eric Melin talks about a Chinese proverb: "Too many monks and not enough porridge". The challenge at the moment, in this early stage, is that we may have lots of people wanting to shred batteries but insufficient waste arising to make those facilities viable so that they are not mothballed.

Everyone talks about black mass processing, which is the idea of taking a battery, shredding it and then producing a mixed black mass on which we can use a variety of physical separation methods to recover the active valuable material. There is another challenge there. I use this analogy: take a battery as a layered structure, then imagine a Victoria sponge. If I give you that sponge and say, "Can you separate the materials out cleanly?", what the recycling industry does at the moment is it takes that sponge and puts it in a blender. We then have to work out how to recover all the bits.

In the academic research that is going on at the moment, we are trying to look at the whole-process flow sheet—that is, not just the first stage, which concerns the question of how you initially separate the material from the battery, but taking it all the way through to recovered material. One of the challenges is that, if you mix everything together, your chemistries to drag out the certain things that you want must be very selective.

So we treat recycling as a sort of end-of-pipe challenge. We have built this capacity for shredding but, looking to the future—especially looking at some of the different batteries that will come down the line in future, where there will be less value to recover easily—we might want to look at disassembly. This means taking that sponge apart and recovering the materials cleanly, not just making a mixed black mass. Then, the subsequent chemistries that we use to turn those materials into useful battery materials become a lot simpler.

That may involve some front-end work on making batteries easier to disassemble. Look at the spectrum of batteries on the market at the moment. If you look at a Tesla Model S, you can imagine it as 8,000 little Swiss rolls put together; it is very difficult to disassemble. If you look at a Chinese BYD cell-to-pack design, you will see that it has big, flat batteries that could be very easy to disassemble so that it is easy to recover the material cleanly. It is about having the right quantity of capacity available; it is also about having the right type of capacity available.

- Q56 **Baroness Boycott:** I do not quite know who would answer this, but I want to ask something more about extended producer responsibility. How far does that responsibility go if you sign up to it? You started on it, Cory. Are producers meant to take it right through to the recycling of the black mass that you were just talking about and getting the various elements of the car to the right place so that they are no longer damaging or are in a state where they could be used again? What does it actually mean when you sign up for this?

Cory Reynolds: In an ideal world, we would like to see the introduction of a take-back scheme for waste industrial lithium-ion batteries.

Baroness Boycott: Take back?

Cory Reynolds: As in you can take them back to where you got them from. That would be on the part of the manufacturers and the producer of that material; they would be responsible for the whole life of the battery, including its recyclability. That is one of the things that would really encourage eco-design and better design for recyclability, as Gavin just said, and being able to separate components out easily. It would also encourage the potential for reusability. In EV, for example, the battery in end-of-life vehicles might still have 50%, 60% or 70% of its capacity but, rather than taking it apart, it could be reused for storage or other things in a properly administered scheme. On EPR measures for EV batteries, to answer your question, we think that it should cover the whole life of the battery, whether that goes to reuse, to potential repair or to recycling.

Robin Brundle: I have three or four points to add to what has been said. To pick up on this point, let us drill down the producer responsibility to a product. When we first had mobile phones, you could disconnect the battery from them, change the battery and send the battery somewhere, to have value in a chain of some description. Today, you cannot do that; they are specifically glued into products to make them waterproof and so on. I believe that there is a challenge for producers to look at this. We know that, from a laptop, we can get the glass, plastic and circuit board, but we cannot easily get the battery; we have to go into a shredding scenario to do that. That is one example.

Another example is end-of-life batteries. This is a really fast-moving environment, and I urge caution around it, Yesterday, Warwick University declared that it feels that putting EV cells back into second life is not now the correct thing to do because the materials in those older batteries, once processed, would now make five new batteries. Therefore, is it effective to have something that is operating at between, say, 50% and 80% of its efficiency, where those raw materials, with the way that manufacturing has improved already, could produce five new ones? I am not saying that is right; I am just saying that that is the narrative.

The other aspect is to consider the insurance voice. The experience is of poor-quality repairs being done in the marketplace, to the point where the insurance industry, I believe, is considering a "Do not fix" for any car that they are responsible for at end-of-life, be it an insurance write-off or whatever. I suggest that you seek opinion from the insurance world as well, because it is finding it volatile to take repaired products into the marketplace.

There is a third piece about consumer responsibility, because we are not recycling enough effectively. There is a piece to say, what can we do? Producers have to pay money into compliance schemes; could a compliance scheme fund a fourth bin collection for local councils, for example, that specifically focuses on electric toothbrushes or vapes or

whatever, so that we actually capture more of this material? Our forecast is that, this year, there will be 83,000 tonnes of material, and we will, in the next few months, process around 8,300 tonnes. We could get all that material just from waste vapes. They are all going to landfill.

Look at the legislation as well. There is a very fast win here. At the moment, we in the UK perceive batteries in the whole. If you take lead acid handheld device batteries, they represent 4% of the UK's pot of batteries this year. However, in evidence for the producer to say they have recycled, they represent 78% of the evidence. That fundamentally means that most lithium-ion is being either stored, incinerated, landfilled or exported. We do not have a process. By splitting those batteries by type, you could get the raw materials from lithium, with a very fast win, with an acceleration of the battery regulations 2009.

Baroness Boycott: Would it become a government responsibility to say that everybody has to sign up to the extended producer responsibility?

Robin Brundle: No. It needs to be driven by government to form the legislation to make it a responsibility. From what I am reading, I believe that, in our trade discussions with Europe and the US on a minerals strategy, there is common ground among nations that producer responsibility is the first part of the chain, along with assisting consumers to be more responsible.

The Chair: EPR has been around for quite some time and a lot of countries on the continent, particularly France, have extended producer responsibility. On your point, Robin, we have asked for evidence and have received it from insurance companies.

Ken Byng: To clarify, extended producer responsibility already exists in this country, under the Waste Batteries and Accumulators Regulations. A lot of manufacturers take this seriously, to go back to what I said earlier. Currently, a minimum of 50% of a battery needs to be recycled, and that extends to the producer. How it is enforced is a different matter, as is how much it happens in reality, but the regulation is there currently. That is being reviewed. The EU has already put its proposals forward for its review, and we will follow soon.

The Chair: It is clearly an issue we will pick up with Defra.

Q57 **Baroness Young of Old Scone:** My question could be asked under any of the questions that we are talking about, but it might as well come sooner rather than later. This is an incredibly complicated process, and we have umpteen government departments involved: the Department for Business and Trade; the Office for Zero Emission Vehicles; the Department for Energy Security and Net Zero; Defra and/or the Environment Agency; local authorities; the Department for Transport, because of the producers—and so it goes on. Is there somewhere where this is all being masterminded?

Robin Brundle: Welcome to our world.

Baroness Young of Old Scone: Is there any mechanism for masterminding it?

Dr Gavin Harper: We put together a policy commission, Securing Technology-Critical Metals for Britain, chaired by Sir John Beddington. One of our recommendations was that, because of the cross-departmental nature of lots of the challenges around critical materials, there was some need for co-ordination. We now have the Critical Minerals Intelligence Centre, and I think that it is a really good platform. We are looking at batteries here, but there are other challenges around other technology-critical metals used in electric vehicles, such as rare earth magnets, which have their own recycling challenges, et cetera. It is important that we look at the specific issues relevant to critical material under that organisation.

Baroness Young of Old Scone: Is the Beddington group a government group?

Dr Gavin Harper: No. It was convened by the University of Birmingham. Sir John was previously a government Chief Scientific Adviser. We brought together industry, academia and a whole range of experts.

Baroness Young of Old Scone: So there is not actually a government co-ordinated process, and you have had to invent your own.

Dr Gavin Harper: It was our suggestion. On the basis of that, the Critical Materials Intelligence Centre was set up, as well as a whole range of other initiatives.

Robin Brundle: I would say that pretty exhausting lobbying is where it has been in history. I personally recommend—and I apologise that I do not know the correct mechanism—some form of effective Select Committee-type mechanism that is ongoing, because, as you can see, this is such a fast-moving environment. Forward-roll 12 months and you will be facing a whole different set of circumstances; if you legislate now, you will be behind the curve still. This needs something that is lithe and has additional agility.

This is what other nations that are getting ahead of us have done: they have said that they understand the risk of these materials, and so sought to control harm to humans; beyond that, they have opened up legislation and, with their EU money, sought to create competitive tension to bring in and welcome tier 1, serious players. We are behind that curve.

Last week, in London, we had the mining and metals convention. The narrative was very much that the upward pressure on the supply of copper in three years' time will be a big problem. We have an amazing history of mining for copper. We should be looking not only at being a disruptor and playing catch-up here but at whether we have the ability to look forward and say, "If we were to cornerstone mining here in the UK to make it more appealing to the investment sector, could we get ahead of the curve?" It needs commerce and politicians, and a rounded

approach, but it also needs energy delivered from the top. Back to you for that one.

- Q58 **Lord Lucas:** I liked Dr Harper's cake analogy. Taking black mass and smelting it, and getting a mixed metal and ash with lots of lithium in it—this is relatively simple chemistry—takes me back to my A-level chemistry. It does not matter what the design of the battery is; it all goes through the same process. Is that not much easier than trying to design a machine that can deal with 96 different varieties of cake?

Dr Gavin Harper: There is easy and then there is what would look good in terms of recycling/recovery efficiency rates. There is a whole spectrum of different recycling technologies. There is pyrometallurgy, as you say, which is smelting everything down; there is hydrometallurgy; then there is the concept in the future of direct recycling.

There are two things to bear in mind here. One is the value of the materials contained within the battery in their raw form. I think of it as a game of snakes and ladders: you start with raw material at the bottom, your finished battery is at the top and every roll of the dice is a processing step that takes you up. Pyrometallurgy takes you a long way back down the board; you are taking that material back to a very basic form where you have to invest lots of energy to take it back up to a finished battery. Hydrometallurgy takes you slightly less far down the board, but direct recycling enables you to keep not only the material itself but the value that is embodied in all those processing steps in order to turn those raw materials into finished ones.

If you have batteries that are very nickel or cobalt rich, you can put them into a pyrometallurgical process and recover the value out of the nickel and cobalt. Looking to the future, though, we are seeing more and more people pivot towards lithium-iron phosphate, or LFP, batteries; LMFP batteries also look very promising. These batteries do not have a lot of intrinsic value in the raw materials—people in the industry talk about them as “rust and fertiliser batteries”—so you do not have the value there in terms of nickel and cobalt to recover via these more traditional processes. The only way that you could really recover the value in a meaningful way is to keep that cathode material as near as possible to its finished form and perhaps rejuvenate that material. Shredding it up and mixing it together makes it very difficult to do that and recover any meaningful value.

In speaking to recyclers around the world, I have heard some of them saying that their processes will tolerate 5% of that LFP material through their process without affecting their profitability too much. If we start seeing the market share of LFP increase significantly, which I believe it will because it is a cheap material that is not reliant on critical materials in the same way as some of these cobalt-rich and nickel-rich formulations—it is the lithium that is the main challenge there—then we as a recycling industry will have a challenge if we have built lots of plants to shred batteries that cannot then produce waste that can easily be valorised.

The Chair: I think Robin and Cory want to come in. Be brief, please, because we have a number of other questions that we need to get on to.

Cory Reynolds: Following Gavin's discussion there, I want to make a point about lithium-ion batteries, the waste code and the health and safety aspect of this. Lithium-ion batteries are assigned a non-hazardous EWC code at the moment, the same as other non-hazardous batteries and accumulators that do not contain lead, cadmium or mercury. We strongly believe that lithium-ion batteries should have their own hazardous EWC codes; that would not just help in the reporting and management of the risks around the management of lithium-ion batteries but ensure that recycling is undertaken by responsible operators, given the hazardous chemicals that we are discussing in those batteries and, as previously mentioned, the serious risk of fires that we all experience on a far too regular basis.

Robin Brundle: I want to come in on the chemistry. You are quite right: first, throughout history, the automotive industry levels chemistry for commercial reasons and volume to bring pricing down. We have not yet seen the auto industry level so, to Gavin's point, when it does so, it would be great to persuade it to make the cake so that we have a common technology across the globe for the automotive industry as far as is commercially possible.

Secondly, the reason why the black mass currently goes out to Asia is that they have a process that enables them to split the black mass and recover around 80% of the lithium—previously, it was 60%. In Europe and the US, they are washing away the lithium at the start of the process, leaving only the remaining three salts. Warwick University has developed a process that we are working on, along with a car company, where we can extract the lithium from our black mass to a 99.8% quality, enabling enough to go back to be cradle-to-cradle material so that it can go back into a battery. The challenge is not cradle to grave; it is cradle to cradle, which is what we are trying to deliver. That work is here in the UK. We have got it; we have invested in the academia and they are brilliant. We just have to upscale the TRL level and it is on its way.

Q59 **Lord Lilley:** We have been told that 85% or 84% of the cars sold in the UK are manufactured abroad. How does that affect things? If we lay down rules about how cars are produced and so on, to what extent will British rules determine how BMW, China or Kia in Korea make their batteries and cars? To the extent that we recycle them, will we be recycling foreign batteries to redirect the materials to Nissan, Jaguar and Toyota here, or will we then have to export the materials to the countries that made the cars originally from which the batteries that we have processed have come? Lastly, this is a slightly different question: I gather from what you have said that there is no point recycling unless we have some primary lithium-manufacturing capacity here. Is that correct?

Dr Gavin Harper: The automotive industry is going to be the major consumer of lithium-ion batteries but it is important not to neglect the fact that lithium-ion batteries will find other applications in our energy

transition. Think about support for the grid and enabling greater penetration of renewable assets into the grid: there will be opportunities to build lithium-ion batteries for energy storage. There are reasons why we should be making lithium-ion batteries in the UK that extend beyond just automotive applications.

There is the possibility of developing the lithium-ion battery industry in the UK independently of the automotive industry but we need to think about what vehicles we are manufacturing in the UK. The types of vehicles will in part determine the types of batteries that are required for them. For example, if you are building luxury vehicles where people want very long ranges because that is the segment of consumer, those batteries are still going to have high levels of cobalt and nickel because you need them to deliver volumetric and gravimetric energy density. Lithium-ion phosphate material will go into your more budget and standard cars. So it is a case of matching the recovered material to the type of vehicle that it is going into and aligning that end-of-life process as well as the manufacturing process.

Robin Brundle: The automotive space is self-governing here in the sense that there is legislation in place—currently under challenge in the EU—saying that, within a certain timeframe, 55% of the car has to be manufactured locally. In our case, they are talking about Europe and the UK. So, by default, there have to be enough minerals in the system to be able to achieve that because, in this modern powertrain situation, the battery is more than half the weight of the car. It is already a challenge if there are not enough raw materials to build the batteries at plants here in the UK. That is where the pressure point is. Where are the raw materials coming from? China, predominantly. China has the circle; that is what we are trying to break. The US is also saying, “Unless you’ve got this 55% local content, you cannot sell your products in the USA”. So there is global automotive control.

The industry may also do a throwback to the 1970s and 1980s where Japan suddenly brought in its kaizen production processes and said, “We’re going to storm the world”. Europe then said, “Actually, we will give you only 10% market share. It is up to you how you divvy it out between the Japanese car companies”. We may end up going back down that path because the Chinese have a really fast start in the auto space. I am sure that all those discussions are going on in the political arena.

Ken Byng: The extended producer responsibility also includes importers. If you have cars and batteries that are manufactured abroad, both sets of regulations still mean that the importer or manufacturer who brings the vehicle in bears the same responsibility. They still have to make sure that that vehicle and that battery are properly treated and recycled at their end of life.

Q60 **Baroness Bray of Coln:** Looking to the consumer in all this, it sounds like pretty grim news for them. In your opinion, how much of the news you are bringing us today impacts on their decision whether to buy one of these vehicles?

Ken Byng: That is a really interesting question. Currently, at a vehicle's end of life, the market tends to take care of it. The extended producer responsibility regulations are in place to make sure that, even if scrap prices drop through the floor, that vehicle would still be able to be taken back free of charge from the consumer for responsible recycling. It is exactly the same with batteries. Obviously, with lithium-ion batteries, there is a cost implication to them being recycled anyway. As I said earlier, some of them can be resold if they are fit for resale, so that is that part of it. My personal view is that I am not sure a lot of consumers think that far ahead, necessarily, when they are buying a vehicle. I could be wrong, but that is my perception.

There is an issue at the moment with the education of the general public and consumers. Some parts of the media, as we all know, are trying to discredit electric vehicles and lithium-ion batteries. They are trying to give the impression that they are not recyclable and are being stockpiled here, there and everywhere; clearly, that is not true, we know this. They can all be dealt with and recycled—we know we have issues with black mass at the end of the day. My view is that we need a joint education campaign between industry, government and all those different parts of the equation to educate the public so that they understand that, actually, that vehicle can be recycled, that it is very important that the battery can be recycled and, if it is, it can then go towards manufacturing a new battery in the UK. That is my view, if that helps.

Robin Brundle: The two key blockers for consumers right now are range anxiety and cost, but we are seeing the prices of electric vehicles tumbling in their thousands periodically. This is as the new technologies are setting to level and as the batteries are becoming more voluminous—volume drives cost. When we get to next year, I believe that the European car manufacturers will be far more competitive in range anxiety and suddenly there will be products on the market that will be able to be compared with fossil fuels on their distance of travel, while using your wipers and your heater—and some are claiming that the charging mechanisms for the new types of batteries take under 15 minutes. Suddenly that becomes a much more compelling consumer proposition and if the prices continue to tumble because of competition, which is a natural process, then, frankly we start to align with more volume of the products coming through.

I do not think we should dismiss hybrid hydrogen fuel cells, but please bear in mind that they carry lithium-ion batteries to transition the energy from the hydrogen through a battery, through motors, on to the vehicle. So, there are still lithium batteries involved, but much less in density and volume. They are the two key blockers. The minute you can say to a family, "You can do 500 miles on the range of the battery and it will charge in under 15 minutes", we are in a different world. That does not help the early adopters.

Cory Reynolds: With the current waste battery regulations that we have heard about, producers and consumers can take the battery back at end

of life. However, as Ken alluded to, it is not widely communicated or publicised by battery producers and car manufacturers, and that has to change. This might be due to the fact that there is a cost associated with electric vehicle battery recycling; that may be one of the barriers we need to look at, as well as how we bring that down. That also pushes across to what we are seeing in terms of second-hand batteries being purchased on the internet and used in an unregulated way, in vehicle conversions and DIY energy storage projects. Reuse is important, but the industry needs better regulation and the rules around recycling batteries need to be much better enforced, with proper waste codes and properly regulated EPR.

Baroness Bray of Coln: What are we talking about in terms of the lifetime of a vehicle? You say you do not think people are necessarily that bothered when they buy a new car about how long it is likely to serve them, but I would say that a lot of people do think about whether it is a car they are going to be able to drive for the next 15 years. At the moment, you are saying, yes, they can, but only with a large cost half way through, when they are going to have to have the battery looked at.

Ken Byng: I think it is fair to say that when electric vehicles, particularly battery electric vehicles, first came on to the market in the UK, the EU, et cetera, the general thinking was that the batteries would be good for about eight years. They have far outlasted that and have proven to be very resilient and to last a lot longer, particularly in the UK, because we do not have the extremes of temperature or the length of travel that you might have in other markets. If anything, it is that side of it: people realise that an electric vehicle will last them just as long as a conventional vehicle. However, as I said earlier, the issue is that in some parts of the media, some of the articles that are written are very misleading and wrong. That will have a bit of an impact.

The European Union has already put its proposal forward on the Waste Batteries and Accumulators Regulations rewrite. It is hoping to address a lot of the holes that are there at the moment, particularly with things like second life and the sorts of things we have talked about. In the UK, we have just started the review of our regulations. Current thinking is that we will align, hopefully, with the EU regulations. There are probably some areas where we can actually improve them, but certainly that process is ongoing, so the hope is that a lot of these issues will be addressed. Certainly, Defra is working with industry in the consultation process to try to cover a lot of those areas.

Q61 **Baroness Bray of Coln:** I have a final question. Will it ever be—or in the near future at least, any time soon—that the battery will not have to be completely taken to bits and put back together again? Will there be a new type of battery where you just have to slot a few extra bits and pieces in and it is ready to go?

Ken Byng: Currently in the UK, I would say that that market is nascent. In other markets, in the Netherlands in particular, Sweden and other places, they are way ahead of us with all that. There are second-life

applications, which tend to take the form of a portable energy bank to replace the mini-generator that people might have used at one time. Some companies are manufacturing huge units that can be used on construction sites, instead of the big, old generators: they are charged and then delivered to site and, once they are depleted, they are collected and replaced with another one by the companies that manufacture them. They are manufactured through batteries at the end of their first life, quite often.

That is happening at the moment, as are things like home energy storage systems, but in the UK, as I said, we are behind the curve. There are some companies that are doing that, but only at quite small scale. I have personal experience of this, because we try to leverage that sort of second-life use where possible; for example, if you have batteries that have failed and they are warranty claims. Somebody may have had an alarm on their vehicle, they have driven it back to the dealer, the dealer has had a look and said, "Right, we will just replace the battery". When the battery is off the vehicle, and once we assess it, strip it down and test it and cycle it, it is actually okay for second-life use. So, it is not an end-of-life battery.

Notwithstanding all the discussion that has gone on before, that Robin raised, about what the right thing to do is with the battery, my belief is that second life is a viable option. Part of the reason it has not flourished is that the current Waste Batteries and Accumulators Regulations do not allow for that and do not cover it. That is because, back when they were written many years ago, it was not an issue: we had not really got lithium-ion batteries in vehicles. Again, the EU has tried to close that gap and to put in place mechanisms so that these second-life uses are regulated properly. If we can shadow that in the UK, it gives the industry confidence to invest in this sort of second-life application.

The other thing is that, as was alluded to earlier, battery chemistries and technologies are changing all the time. In order to have volume products for second-life markets, we need a lot of the same or similar battery modules and that sort of thing. There are a lot of issues around that but it is certainly possible in the UK. I hope the regulation will support that and we will see further activity in that area.

The Chair: Looking at the time, I am going to have to close this question down because we are not going to get through everything. I know Baroness Young wants to ask a quick question.

Baroness Young of Old Scone: It has been answered.

The Chair: Okay, we will move on. If there is something you want to raise within another point, please do.

Q62 **Lord Whitty:** The big question here has been answered: you do not find the current regulations effective. Could you be more explicit about what about the regulations needs to improve? The EU proposals are moving in the right direction but are they good enough, and are they likely to be

adopted by all types of car producers—the Japanese and the Koreans have similar regulations—or is it more a question of enforcement?

I am not even clear who is supposed to enforce these. When I was a transport Minister, we had responsibility—which we did not exercise very well—over the quality of breakers' yards. It has improved a bit since, but does this come under the Department for Transport, one of the transport agencies or Defra itself? Who is actually supposed to enforce the regulations that we have? What are the key elements of an improvement in the regulations, and has the EU at least got something right in this respect?

Cory Reynolds: I can respond on the EWC codes. That is a Defra matter. We would like to see lithium-ion batteries have a specific hazardous waste code under that legislation, and for that to be enforced.

Lord Whitty: Enforced by whom?

Cory Reynolds: The Environment Agency.

Lord Whitty: With whom?

Cory Reynolds: With Defra behind it.

Lord Whitty: A related matter is whether this is enforced more effectively in other countries than here. You have talked about Sweden and the Netherlands having a better quality of recyclable or reusable batteries. Is the legislation and its enforcement better anywhere in the world than it is here?

Robin Brundle: I support exactly what is being said about Defra and the EA. I caveat that, in the sense that we are not throwing daggers at the EA; in our opinion, it does a great job. It is short of resources, frankly, for a number of historical reasons that you will be familiar with.

Secondly, it is difficult to enforce something if there is nowhere for that enforcement to go and resolve the issue. In the case of lithium-ion batteries, until we went live with our facility the EA had nowhere to demand that people take those batteries other than landfill, which is less than desirable. Now that we are live, and there is this capability in the UK, we ask that the EA be given additional resource to police that. I shall give you one example: material arriving at our site today was actually stored first in early 2021. So all this pent-up demand is sitting around the UK, as potential fire hazards, and it needs to move now. You cannot criticise if there is no exit, but there is now an exit.

The Waste Batteries and Accumulators Regulations 2009 are a solid, robust document but it now needs teeth to deliver it and empower the agencies that are responsible—there is more than one department responsible in some of these examples. To your point, those battery regulations have given us—rightly or wrongly, after Brexit—the freedom to exercise. One example is that Europe classes the batteries as hazardous waste. We currently welcome them as green waste, so that we

can get the raw material in, which goes to my point about whether or not we are a trading nation. The slight problem there is that the Environment Agency believes it to be hazardous waste, and permitting is the responsibility of that agency. Right now, you can have all this work done by academia but they themselves take 18 months to get a permit from the EA, not through the fault of the people but, in our opinion, from a lack of resource.

Lord Lilley: Who are “they”?

Robin Brundle: The EA is responsible for the permitting but the personnel within the agency are currently taking 18 months even to vary a permit. You can have all the investment in academia you like, but then, even if academia itself wishes to transition up the technology readiness level, they have to wait to get the same permit that commerce does. We have had plant sitting idle for nearly two years waiting for permitting, so this capability has been sitting in the wings. There are no individual people responsible, but the organisation is underresourced.

My direct answer is that our legislation is agile and seems to be on the money—and it seems to be live, so people are changing it as circumstances change—but we need to resource those who are going to accelerate the ability to do something with it, otherwise we are always going to be followers.

Lord Whitty: I know things have improved significantly but, traditionally, the industry has not been, shall we say, the most obviously regulated industry. If there is a lack of resources in the agency that is primarily responsible, is there a case for having a different agency or a different system of enforcement?

Robin Brundle: I would support that. As a piece of thinking, I as a businessman struggle to understand this: we fund academia to learn how to do it properly and we then put in place an agency to regulate them, but the agency has to learn all the stuff that academia has already been through. Why would we not engage academia and fund it to support the permitting, licensing and the knowledge transfer? There is a much greater knowledge transfer because they have done all the early-stage work. In our knowledge transfer with Birmingham and Warwick, the sharing of knowledge has accelerated both academia and commerce. That is fantastic—so why would that not be allowed to influence, for example, the Environment Agency in order to help it?

Q63 **Baroness Young of Old Scone:** I should declare an interest—as should Lord Whitty, in his case as a board member in the dim and distant past—as chief executive of the Environment Agency. Is it not true to say that most academic institutions would run a mile from the prospect of becoming a regulator for a system that is very dispersed among a whole load of operators and is very fast-moving? It is simply not their job. Regulators should regulate, not academics. Dr Harper, where do you stand?

Dr Gavin Harper: Even applying for the process of permitting as an institution has been a significant challenge and taken up bandwidth, overheads and time that people would rather have spent elsewhere, so I tend to agree with that view.

I would like to pick up on a couple of the previous points. Of course there are licensed routes for vehicle disposal, but there are also people who unscrupulously dispose of vehicles, and that burden then falls on the local authority. One of my grave concerns is that, if we should get to a point where the cost to consumers of disposing of vehicles becomes too high, we have to remember that the consumer who owns a vehicle at the end of its life is probably very different from the consumer who bought it in the first place. The uses cascade down. If we were to see an uptick in unlicensed vehicle disposal, such as burnt-out cars by the side of roads, that burden would disproportionately fall on local authorities to deal with, and that would impact their budget lines.

You talked about swapping batteries out. The Chinese firm NIO has batteries that are hot-swappable, so they can be taken in and out of the vehicle.

Baroness Bray of Coln: As in Israel, funnily enough, a few years ago.

Dr Gavin Harper: Yes, the Better Place project. There was talk about that as well. That is a different model that has not really taken root in the UK, but the fact that you can get the batteries in and out of the vehicles will potentially impact their recyclability and is something that should be explored further.

Talking about battery life and longevity, the Dahn Group in Canada has talked about the idea of million-mile batteries. How many million-mile cars do you see? The potential is that battery life could outlast vehicles as traditionally conceived—that is, your seats and the interior will wear out before the battery does. There is the question of how to valorise and extract the best use out of the battery because, on the one hand, there are the materials but, on the other, there is the energy that you have input into manufacturing that battery in the first place.

The challenge with second-life applications—taking that battery out and putting it into a different application—is the fact that the product is regulated, certified and type approved as a battery for a car; it is not type approved as a battery for a house, a factory or whatever. So there is the concept of “vehicle to grid” whereby you can plug a car into a grid and have a bidirectional power transfer. It might be good if we wear the batteries out while they are in the car, get the best use out of them then recycle them, rather than looking at taking a product that is designed for one application and transplanting it into another.

Ken Byng: In answer to Gavin, hopefully we will not get to the point again where cars are abandoned because of the End-of-Life Vehicles Regulations.

I shall answer another question because I have personal experience here since we, as CarTakeBack, work in other markets, not just the UK. The end-of-life vehicle directive is an EU directive, as I am sure you know, which is then transcribed into regulations in the different member states. That happened in the UK when we were a member state. What they are now doing with the new review is that it is going to be a regulation. It will not be a directive because there were a lot of differences in the way different markets and countries implemented the directive.

I shall answer a couple of other questions briefly. It gets confusing between different departments that have to enforce different parts of the regulations. To take the ELV regulations again, Defra is responsible for making sure that vehicle manufacturers and authorised treatment facilities report targets and recycle the vehicles to the right percentages but then the Environment Agency is responsible for visiting all the authorised treatment facilities, policing that, making sure that they are doing what they should be and closing down illegal sites, so there is a bit of a gap there.

I echo what Robin said: although there are a couple of other facilities in the UK that can process batteries and black mass, there are definitely issues with permitting at the moment. As Robin said, in the case of both Defra and the EA, any issues are not necessarily down to the regulations, in my opinion. Although the Waste Batteries and Accumulators Regulations need changing and updating, the issue is enforcement. That is a resource issue with both sets of regulations.

Q64 Baroness Jones of Whitchurch: I want to move on to the issue of how much of the battery can be recycled. We have already begun to explore all this; I have learned an enormous amount so far in the first hour about black mass, how it is shredded and so on. I want to explore this a bit more. Your Victoria sandwich example was very helpful but what is it in a battery that wears out? In other words, is it the critical minerals in it that are burning out in some way? I know nothing about batteries so bear with me. If you start off with the battery, what stops it from going on for ever and doing a million miles or whatever? Is it the rare minerals that we will eventually lose if a battery runs for long enough?

Dr Gavin Harper: To try and simplify it as far as possible, you are taking an anode material and a cathode material, which is a mixture of different metals. It is the structure of those metals that allows the lithium ions to intercalate and deintercalate across the membrane. So a range of different degradation mechanisms take place within that battery. It is not that the materials are being consumed; it is that the structure you created initially starts to degrade over time. The idea of direct recycling is that you could take those materials, in whatever structure they are left in, and rejuvenate that structure rather than taking those metals that are still there back to a raw material in order to reintegrate them into a fresh structure.

Baroness Jones of Whitchurch: Okay; that is helpful. That was my first question. You at Faraday are doing research on this. Your challenge

is that you will make the content of batteries 95% recyclable, which seems like a reasonable challenge. How far down that road are you now? We have learned about the progress of the science. Can you update us on where you have to go to and where you think you will be in the next 12 months?

Dr Gavin Harper: The challenge is that everyone can recycle the high-value bits of the battery—the nickel and the cobalt; that is where the value is—but we want to look at how to valorise and recycle the whole battery. There are lots of different challenges there in terms of recovery, such as anode material and being able to get value from that. At the moment, if you put the stuff in the battery that is not particularly valuable—such as the separator material and the plastics—into a pyrometallurgical process, people say that they are recycling high percentage figures of the battery but a lot of those plastics are actually being burned to produce energy in that process, so it is dubious to say that that is being recycled well. For a truly circular economy, we want to keep those materials in as high-value a state as possible in order to be able to recycle them properly, not just recover the energy.

There are elements of the process where key technology enables us to, for example, delaminate material cleanly in order to put it into recycling processes. We have work on using AI and robotics to disassemble batteries and cleanly separate those materials, rather than just shredding them up and mixing them all together. So there is a suite of keystone technologies; our challenge now is to scale them up and demonstrate them at higher technology readiness levels to show industry that this is a viable alternative solution to shredding.

Some of that work is going on at the Tyseley Energy Park in Birmingham, where the Birmingham Energy Institute has a massive demonstrator site for a range of alternative technologies. There is work there where robotic disassembly cells are able to take a battery apart and disassemble it to lead to the recovery of higher-value materials. So we are on a journey to scale up that technology readiness level and get it closer to industry for when the real volumes start coming through. At the moment, we are dealing with fairly trifling volumes of batteries coming through the system but we anticipate that, by the 2035 target, there will be much larger volumes. You have to imagine that, as those volumes of waste start to scale, so do the volumes of chemical reagents that will be needed to do all that end-of-life processing and hydrometallurgy. If you have inefficient processes requiring a lot of chemical input to extract not a lot of material and you then start scaling that by the volume of waste, those volumes could become colossal. So, the more efficiently we can do that, the more efficient we can make the chemistries and, when those volumes start to come, hopefully we can deal with them in as efficient a way as possible in terms of both energy and materials input.

Baroness Jones of Whitchurch: It sounds like you are quite a long way towards your 95% target. From what you are saying, you might hit it before the 2035 deadline.

Dr Gavin Harper: If we look at some groups around the world, the ReLiB project at the University of Birmingham is the UK's largest project on recycling and reuse; in the US, we work with colleagues at the Argonne National Laboratory on the ReCell project, which is a similar counterpart; and there is work going on at CSIRO in Australia. Internationally, there is a well-integrated community looking at all the challenges around battery recycling. We are all working on different parts of the puzzle; as a scientific community, we collaborate really well. Everyone is working on a different bit. By the time the target comes, I think there will be new solutions to battery recycling that differ significantly from current industry practice.

There is always going to be a case for shredding some batteries. Take vehicles that have been involved in a crash: you do not want to disassemble that with a robot. Also, there is not going to be any value in disassembling the small batteries that are used in small consumer electronic devices. However, for larger batteries used in energy storage and in large electric vehicles, we are going to see a lot of evolution in recycling technologies, and perhaps in battery design to enable recycling.

By 2035, the landscape may look significantly different from how it looks now, and that will be aided by a lot of technologies that are in the lab at universities around the world at the moment.

Robin Brundle: On recycling, I would like to give you some comfort. The process we have in the UK has been designed in the UK, built in the UK and run by a UK company, and academia are describing it as world-leading, so we have an edge on recycling. The second thing to say is that 100% of every lithium-ion battery that goes into the process is separated and collected. At the moment, we are at the high end of 99% of reuse in some form—arguably, some may have to go to energy—but, by the end of this quarter we believe that we will be at absolutely zero to landfill. So we are doing something, even with the liquid in them, called electrolyte—we are able to recover that as well. Be reassured that UK recycling is in good health, in that sense.

Cory Reynolds: To add to both of the points around battery design, at the moment, the aluminium casings around batteries, which are welded together, and some of the foam around the batteries, make it very difficult to dismantle and reuse or recycle those. Design for recyclability is really important going forward to organisations such as ours, because we need the manufacturers to think about how those batteries are going to be dismantled and recycled, and how those components can be reused in the future.

Baroness Jones of Whitchurch: Are they always going to be a fire risk? Are they always going to be flammable, or is part of your design going to address that? We have heard that they cannot be stored near each other and all those issues—could we have fireproof batteries in the future?

Dr Gavin Harper: Different types of cathode chemistry have different safety risks. I mentioned earlier the lithium iron phosphate batteries that are considered particularly cost-effective but are also intrinsically safe in their energy density compared to the high-cobalt and high-nickel batteries. That is one reason we might see the prevalence of this particular LFP chemistry, which is starting to be used on vehicles with lower range, but currently there is lots of improvement work happening, because it uses less critical materials. That chemistry presents a real challenge to the recycling industry to recover any value at the end of life, because it is lithium, rust and fertiliser; there is not lots of value in there unless that material can be kept in its finished form and rejuvenated.

Robin Brundle: I would also say, in my very simplistic way, that the industry appears to be moving towards something called solid-state. What does that mean? At the moment, we have liquid in the lithium-ion batteries, and that liquid is where, fundamentally, the explosion element of the battery is at its worst. Solid-state, in my simplistic view, is literally taking that liquid away and creating a chemistry environment without the liquid, which then takes away elements of the fire triangle and explosion chemistries. We welcome the move to solid-state, because we believe it will be so much safer for us all. However, we can still recycle those batteries, and they genuinely will have value in the circular cradle-to-cradle economy.

Q65 **Lord Bruce of Bennachie:** Thank you very much for a fascinating morning. This is a very complicated area and it is changing very fast. Like Lady Bray, I am thinking about the consumers. They are looking on and saying, "What are we going to do here?" You have the early adopters, who you say may be the losers and not the winners in some cases, and the people who are not yet ready to adopt. You have all these considerations.

First of all, most people buy second-hand cars. They are going to come along and say, "I am buying a car, and it is six or seven years old, what am I buying? What is the state of the battery?" The battery is half the car—I buy a car and a year later there is a battery problem. How is the industry going to cope with that and give assurances? Is there a danger that you would scrap the car, even though the car might have, in its own condition, several years of useful life, as long as it has several years of useful battery.

I know you are saying that the battery is ultimately going to last a lot longer, but, at the moment, in the current state of the market, it seems to me that consumers are inevitably going to be wary. With a fossil fuel car, you wait until either the mileage is high or the gear-box or engine is going to fail, and that is usually terminal—end of life, end of car. People are not sure, with an electric car, what the comparator is.

That feeds into the business rebooting the battery, and then that becomes the point at which the trade can say, "We can sell you this car. It is seven years old but the battery is rebooted and, in normal circumstances, it is good for another few years."

At the moment, it all seems to be a bit up in the air and consumers are likely to be rather resistant. They really do not know how to calculate the value of buying a car, what they should pay for it and what they should get out of it. How do you address all that?

Ken Byng: I would like to answer that one—as much as I can, anyway. Ultimately, that is a question for the manufacturers, and I know the manufacturers have been here. Certainly, there is work going on at the moment with various manufacturers, and there are manufacturers in the UK who are looking at whether batteries can be repaired. That comes back to a question that was asked earlier. If they can be repaired, how do you recertify them to go back into a vehicle?

Again, because everything is moving so quickly with the different battery chemistries and the technology in the vehicles, for an electric vehicle that is 10 years old, the likelihood is that that battery will not be manufactured anymore—certainly not in the same format that it was in that vehicle originally. There is potentially a market there for remanufactured batteries, but again, the Waste Batteries and Accumulators Regulations as they are written do not cover any of that. That is something that is being looked at, and needs to be looked at.

It is possible, exactly as you say, that people may then be able to buy used vehicles with a reconditioned battery. Different manufacturers give different warranties with the batteries and with the vehicles, so some are quite aware of this and aware of consumer reluctance.

As part of the Waste Batteries and Accumulators Regulations review that has happened in the EU, and its proposals, things such as battery passports are coming along. What that means is that, for the life of a battery, whoever comes into contact with it, whether they be a vehicle manufacturer, a main dealer or an independent dealer—or even, at the end of life potentially, an authorised treatment facility—they should have some way of interrogating the vehicle and battery to find out what the life of that battery has involved and the condition of the battery at that point. We are not there yet. As was mentioned earlier, once these regulations come into being they will affect vehicles that are manufactured down the line. We have a lot that are on the road already.

It is an interesting question. You are absolutely right that it is a challenge, but there are measures being taken to address those concerns—and they will have to, otherwise consumers will not be interested, even though they are being pushed in that direction anyway.

Robin Brundle: The genesis of the problem for the auto space is that, when the calculations were done, the average UK driver drives 82 miles per day, and the average battery life is about 250 miles. The industry thought that that would be enough and underestimated the comparison with fossil fuel.

What has that done? It means that those who are genuinely doing the average of 82 miles per day will become the natural users of the used

products as they fall in price. I think the natural flow of the ownership profile will continue, but the pressure point will be that we know already that the replacement cost of the battery pack is well north of £10,000 on average—well north. Will those people be able to get insurance, or will that car come prematurely to end-of-life because of a lack of insurance? If an insurer has a car valued at £8,000 and is responsible for a cost north of £10,000 for a battery, let us say, it is just not likely to happen. That will be the pressure point: when the battery should fail, even if it is prematurely, the car will then be prematurely finished.

But, when it comes to the natural circle of life of the car ownership profile, I genuinely believe there will be a limited market to cities, where the 82 miles is perhaps relevant. From next year, as I said, there are products coming on to the market with a range of 400, 500 or 600 miles.

Ken Byng: To add to Robin's comments, there is a lot of work going on between the insurance industry and the end-of-life vehicle industry, looking at these green parts. It is win-win for the insurance companies with conventional vehicles, because obviously that brings the cost down. As long as those parts can be certified as suitable and equal to replacement original manufactured parts, then it certainly makes sense for the industry. There is work going on regarding lithium-ion batteries as well. It is possible that that work might extend, in which case it might resolve this issue with the insurance companies. However, Robin is right that a lot of insurance companies out there are getting nervous about insuring electric vehicles, and that is an issue that needs to be overcome—because they are going to be around, aren't they?

Q66 **Lord Whitty:** I have a question about the structure of the world automotive industry. My understanding has always been that the western world, at least, is dominated by huge international companies that manufacture all over the place. Even though the battery may be 50% of the value of the final electric car, surely they must specify what kind of battery they are going to incorporate. If you got Ford, Tesla and three or four of the other companies around the table to specify what sort of battery we are going to have, surely we could get all these improvements put in. A lot of responsibility lies on the final assemblers as well as on government regulation. Surely the power in the land is the automotive producers.

Dr Gavin Harper: What is really positive is that we have seen a lot of aggregation and agglomeration in the automotive industry. Volkswagen, Seat and Škoda are part of one big group, and Stellantis is part of another big group. With electric vehicles posing such a big challenge for that industry to transition to, with enormous R&D costs and so on, they have clustered around a smaller number of platforms and designs as groups of manufacturers, so to some degree that process is happening already.

Part of the challenge is that manufacturers have enormous sunk costs invested in the first generation of electric vehicles. They just want to extract some value out of the R&D work that has been done, so there is

lots of reluctance around doing evolution for design for recycling and so on. What will probably drive that is competitive pressures from China and the Chinese vehicle manufacturers, which we think are much further ahead in their thinking on some of the design elements of electric vehicles, especially around the cell-to-pack concept.

To pick up on one of Ken's points, something that is worth flagging up and being mindful of is that, when a car is scrapped at the end of life, not all batteries are going to be recycled; lots of them will be sold into secondary markets to be reused, remanufactured and so on. We are seeing a big informal trade in electric vehicle parts. If you look at the online auction sites, you see that you can buy electric vehicle modules and battery packs. A lot of people are doing incredibly ingenious things with these, such as building home power storage systems and taking old classic cars where the engines have gone and converting them into electric vehicles. There is a degree to which this reuse of second-hand vehicle parts has always gone on—for example, there has always been a kit car industry—and that is great, but we need to think carefully about how safety is managed in the context of those regulations. Obviously, people building their own cars has gone on for a long time and we manage that safety appropriately within current regulatory frameworks, but it is worth giving some thought to how the context will change with electric vehicles.

The Chair: Just in case anyone is thinking of doing a spin-off of "The Repair Shop", it needs to be regulated properly.

Robin Brundle: To support Lord Whitty's thinking, this morning on Radio 4 the boss man of Stellantis declared that they now feel that they are able to take the commercial fight to compete with the Chinese products. So, to your point, the settling down of costs is very much happening around us in the way the automotive companies achieve it.

Lord Whitty: The Government are bunging quite a lot of money at manufacture—it is Bridgwater. Are the specifications for that going to be the right ones?

Ken Byng: Briefly, in answer to Robin's point, it is absolutely right that there is this thriving industry at the moment. The big concern is obviously over lithium-ion batteries, which are being sold on online auction platforms and over the counter to members of the general public. I could tell you some horror stories, but I will not. Currently, that is not against the law, with the way that the Waste Batteries and Accumulators Regulations are written. I keep talking about it, I know, but we hope that, with the review of the Waste Batteries and Accumulators Regulations, we can build in some sort of mechanism that regulates that, rather than the free-for-all that there is at the moment.

The Chair: Does anybody want to come in on the Bridgwater point?

Lord Lilley: Once you have built a battery plant making one type of battery, can it be repurposed to make one of these solid-state batteries,

for example? Or are we putting all our money into something which may turn out to be a lollipop? I do not know. The other thing is a purely technical point: you said 82 miles a day, which is 30,000 miles a year. I thought the average car use was 11,000 miles a year.

Robin Brundle: To answer that last point first, that is a stat that the industry uses to say that the average journey is no longer than 82 miles in any one go, not that we all do it. In other words, why did they choose 250 miles as a range? It was because their indicators were that nobody really went any further than 82 miles, and they underestimated the fossil fuel comparison.

Lord Lilley: That was a minor point, comparatively.

Robin Brundle: On your question about solid-state, if you imagine an automotive production line, it has a chassis, going along with a certain body shell, coming out of it today; they stop for the summer break; it comes back on the same production line with another body shell of a different size, shape and scale on it. It is about tooling and jigging and understanding the chemistry. Once the facility is built, as a taxpayer, I would personally have no hesitation in saying, "Money well invested", because it should be agile enough as a building to accommodate more than one product through the same type of evolution.

Dr Gavin Harper: To pick up on the earlier comment, one of the challenges, speaking to colleagues at Birmingham Law School, is around when a battery actually become a waste. When is it still a product that can then be sold into a second life, and when is it classed as a waste? There is a really thorny definitional issue here.

On your point about investing in a factory, the question is how much of the factory can then be repurposed. Is it just a shed and you have to change all of the equipment inside? There is so much variety as far as lithium-ion batteries go. Think about the form—the actual shape of the battery. Are you making little can batteries or big, flat, long batteries? These are apples and oranges in terms of the type of batteries and the way in which they are made. Then there is all the investment in the actual chemistry that goes into the battery. Certainly, there will be investment in things that could be reused if things change, but there will also be things that would potentially be outmoded.

There is also a sort of technological lock-in: if you invest in a certain set of stuff and you have a certain set of tools and a certain set of skills, your natural inclination is to keep using the same thing and doing the same thing. I think it is really important that we have some scrutiny at this point, to ask whether we are going to be making things that will then be able to be reused at the end of life, or are we making things that are going to create a bit of a challenge down the line?

Cory Reynolds: That is where the extended producer responsibility can make a big difference.

Dr Gavin Harper: For sure. To pick up your point about disassemble ability and design for recycling, we have done lots of work and know that the glues and adhesives in batteries are absolutely terrible. Trying to get things unstuck is really difficult. It is about thinking through some of those processes, whether it is smart adhesives or mechanical fixings: what can we do to make batteries that can be taken apart easily at the end of life?

The Chair: I think we are out of time. I thank all four of you for your contributions today, for educating us on quite a complex issue and doing so in a way that those of us who find this more challenging than others were at least able to follow. Thank you for that; we appreciate your thoughts.