Wicked Problems PODCAST

Wicked Problems – Series 3, Episode 3:

Euan McTurk of Plug Life Consulting

Transcript

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Transcript

0:09 Toby Corballis

Welcome everyone to the third episode in our series on electric vehicles. Today I'm delighted to be joined by Doctor Euan McTurk, a consultant battery electrochemist who has been working on and driving electric vehicles since 2009. He's worked on next generation cell chemistries during his PhD at Oxford, developed ways to study how electric vehicle cells fail and how to stop them failing whilst was at Warwick Manufacturing Group, WMG, University of Warwick, and he built a state-of-the-art 200-kilowatt battery test facility in Edinburgh. So, Euan knows a bit about batteries and EVs. He also founded Plug Life Consulting, which provides technical, strategic and public outreach services to projects involving battery electrochemistry, electric vehicles, energy storage systems, and charging infrastructure.

He's also the creator of Plug Life Television, which is a YouTube channel that talks about batteries and EVs and explains the complex electrochemistry in ways that actually anyone can understand, including me... So he's very good.

He sets about busting common myths and misconceptions about electric vehicles, and today we talk a lot about that.

Enjoy the show

1:28 Toby Corballis

Euan, welcome to WICKED Problems. It's an absolute pleasure to have you here. Thank you for joining us.

1:33 Euan McTurk

Thank you for having me.

1:34 Toby Corballis

I'm really excited about this episode because I'm fascinated by the whole discussion around batteries and battery chemistry and where it's going, because there's been so much going on in that world in just the last two or three years. That alone, you know, I don't know how long you've been in that space, but it, I, I know that some of your plug life, for example, on the TV side has been going quite a while now and I've seen quite a few of your podcasts. So I know you've been looking at it for a long time. What's your take on it at the moment? I mean, it's, it's just going, I look at it and it feels like we're getting more and more, you know, capable of doing longer and longer distances on one charge to the point that it just is going to exceed anything that a petrol or diesel engine can do very soon. Is that..., am I being silly there or?

2:20 Euan McTurk

In, in theory, yeah, we, we are kind of heading towards that stage. But that said, there's the argument that “do we need for most vehicles to reach that sort of stage?” There's the argument that economically

it makes more sense to take advantage of the fact that batteries are so much more energy dense than they were only a few short years ago and use that to build a smaller, lighter, pack, which has a couple of advantages because not only is it less material, so therefore less expensive and more ethical because you've required less materials, but you've also made the vehicle lighter and you've potentially allowed that battery to go into a much smaller vehicle as well so you're looking at the likes of the Volkswagen E up being able to do comfortably in excess of 200 miles per charge with some of the chemistries that are very much on the on the horizon at the moment, you know, tantalisingly close to commercialisation. And that's what we need. We seem to be, you know, foisted... We have these big SUVs foisted upon us from all of the manufacturers at the moment and, yes, they can do two hundred and fifty, three hundred, miles per charge, but who cares, bearing in mind that these are big, ungainly, unwielding machines, unwieldy machines. Whereas, actually, a lot of people just want a small, affordable, practical car. And that's where the latest advances we're seeing in battery tech will allow those small, affordable, practical cars to broadly match the range and performance of premium electric vehicles from a couple of years ago, arguably even some of those premium EVs today. And therefore, also some of the sort of ICE ranges rather than exceeding them, but just being able to match the same kind of range as, I don't know, maybe a Fiat Panda or, that's a very old car, but you know, the sort of smaller urban ICE vehicles.

4:09 Toby Corballis

I was talking to Sam Clark the other day and he was talking about EV grazing, right? So, so rather than having to charge all the time all the way up to what 80% if you're, if you're, you know, doing battery maintenance well. You know, just plug in and do a bit of charge here and there because you don't need to be fully charged all the time. How does that affect battery life? Because if I, if I think of my mobile phone, if I keep charging it all the time I'm going to wear the battery down and, and quite a lot of people, you know – I know I'm supposed to do this thing to 80%, although I rarely do... bit naughty on that one – how's that work with the EV batteries?

4:49 Euan McTurk

So, to an extent it depends on the chemistry and it depends on the state of charge window that you're kind of grazing it between. But you know, charge grazing that, like, Sam alluded to is a valid way of getting about and it can work very effectively. It can reduce the amount of dedicated charging stops that you actually need. So, before we go on to how it affects battery health or, you know, for better or for worse, a prime example of that is: I've got an old school Tesla Model S How do you know if someone's a Tesla driver? They'll bloody tell you. Anyway, so yeah, old school Model S with a 22 kilowatt on board charger. So, you know, that will Hoover up electrons faster than just about anything else that plugs into a Type 2 AC post. So, something that would normally take hours to charge a car, this one, you know, manages to charge reasonably quickly. I drove that from Edinburgh to Oban and back. And you know, we were we were there on holiday so we were popping in for sort of 20 or 30 minutes here or there to various little tourist routes along tourist destinations along that route. Now most of those locations had a 22-kilowatt Charge Place Scotland AC post and I was able to get on those and add a meaningful amount of range in those 20 to 30 minutes. So, the entire holiday, I did not need to use a rapid charger once. I only plugged in for as long as I was going to be at that location anyway, taking photographs of something scenic or going shopping or whatever the plan was. But it was, it was very short, "grazy" stops. And I'm sure Sam would have liked it if I was stopping at a GRIDSERVE rapid charger to graze, of course, but there weren't any out that neck of the woods, but there were these, you know, these other

charge points. So, yeah, grazing is absolutely a valid way to get about. It's the, you know, the ABC acronym: Always Be Charging. But there is a limit to, you know, the sort of sensibility of that strategy. So, you know, I'd already depleted the battery a reasonable amount, I'd maybe depleted it down to say 40% and then by the time I came back to the car, it was 60% / 70% full, you know, and when it's in that kind of middling range, that's fine. You know, you can, you can shallow cycle it within that range reasonably fine. If I was charging it all the way up to 100% state of charge and then running it down to, you know, no less than 80% state of charge and then plugging it back in again and continuously doing that and that's the only way I was using that car, that's how you accelerate the degradation of the battery because well, that certainly is the case for NMC and NCA cells.

So NMC is your lithium nickel, manganese cobalt oxide. That is the most common type of battery found in electric cars. Today, we're starting to move towards lithium iron phosphate (LFP), but NMC and NCA, which are similar but different. If you routinely keep those batteries at a very high state of charge, the electrolyte that allows lithium ions to travel between the two electrodes, that liquid that allows that, it starts to degrade against the cathode because the cathode's potential, bearing in mind that the cell voltage is the potential difference between the positive electrode and the negative electrode, the cathode being positive and it being negative... So, when you've reached a very high state of charge, your cathode potential is very high, your anode potential is very low and it's that very high potential in NMC and NCA cells that crosses a threshold at which the electrolyte is no longer stable, and it starts to degrade. So, it's over a period of, you know, thousands upon thousands of, of miles that you would start to see that accelerated degradation. It's not like an instant overnight thing, but if you're constantly shallow cycling it, you're between 80% and 100% state of charge, you're probably feeding some degradation mechanisms in there as well as charging the battery. Whereas, if you're below 80% and you're doing opportunity charging or charge grazing, your longevity of the battery will be much greater. So equally, I need to run it down to 20% for health. It's not quite the same as your old Nicad batteries from back in the day where they had memory effect, which meant that even although they still had capacity left in them, that it's almost as if the cell forgot that because you only ever discharged it from 100% to say 60% and then when you tried to go lower than 60%, the voltage fell off a cliff. It's not quite like that. Lithium iron doesn't have memory effect. It also doesn't like to be discharged to too low a state of charge if you routinely go below 20% state of charge, and I mean, constantly running the thing, you know, flat basically, and then recharging it, you'll accelerate the, the degradation of, of that battery in comparison to if you run it in that kind of sweet spot, which is your 20% to 80%. But my rule of thumb for general kind of EV use is to charge to somewhere around about 80% for day-to-day use and if I need the range, charge to 100% – that's there for a reason. If you need the range, use it, but don't leave it sitting at 100% for weeks or months on end. But then when discharging it, I discharge to somewhere between 50 and 20% typically before plugging back in. I don't shallow cycle it so I'm not going from like 80% to 65% and then plugging back in unless I really need the range the next day.

So you know, it's, it's a very kind of loose interpretation of those rules, kind of 80 ish, maybe 100 if I need it and then between 50 and 20%. And by all means, if you need to go further than you know, 20% state of charge gets you. If you need to go down closer to 0, then again, it's there for a reason. But for day-to-day use, bearing in mind that the average UK round trip for commuting is about 26 miles and something like 80% of the makes and models of EV available today can do over 200 miles per charge. That's like a fortnight's worth of driving for most people. So, yeah, for day-to-day use, if you follow those, you know, very loose health tips that I've given, the battery will thank you for it.

10:50 Euan McTurk

Whereas lithium iron phosphate is definitely more robust. It doesn't mind routine charging to 100% because the cathode potential is lower, and it doesn't quite hit that same threshold where the electrolyte starts to degrade. So that's why it had, well, part of the reason why lithium iron phosphate batteries have a much longer cycle life. You know, they can be charged and discharged more often than NMC cells.

11:13 Toby Corballis

And those are the ones that are starting to come onto the market now?

11:15 Euan McTurk

Yes. So, it was Tesla that led the way in, certainly in Western markets, when they introduced the Shanghai built standard range Model 3. So that one was using CATLs LFP cells, which are very good at what they do. The Model Y standard range has those as well, but the long-range ones still use NMC and NCA I think is still used over in the States as well. But now you've got the, the standard range MG 4 Max is their standard range vans and BYD, all of their vehicles use the BYD blade lithium iron phosphate cell, which is a very good cell, which not only has long cycle life, but excellent safety as well. So yeah, we're seeing more and more LFP on the market.

11:58 Toby Corballis

So, if LFP is lithium iron phosphate is the sort of newer battery that's coming into mass production. Are there even newer technologies that we're not seeing yet, but we will see in you know, three years' time, let's say, or five years' time, that will again change the game either by giving you longer range or just by making smaller cars able to achieve the range that we need?

12:21 Euan McTurk

Absolutely. Yeah. We're going to see a great divergence in cell chemistries in electric vehicles. One of them is LMFP. So, what we've done is we've swapped out about 60% of the iron in lithium iron phosphate for manganese, which is also cheap, It's affordable, it's ethical. And what that allows you to do is increase the cathode potential back up towards NMC, which means bearing in mind that the energy contained by a cell is its capacity in ampere hours multiplied by the cells voltage, it means that you're getting back towards the energy density of NMC using incredibly cheap, ethical cobalt free, nickel free cells and the safety record of them should be similar to LFP... Should be, you know, should be pretty safe. Cycle life? It'll be interesting to see because the cathode potential has gone higher again. Are we going to see cycle lives that are more akin to NMC than LFP? That remains to be seen in the field but it is worth pointing out there are plenty of NMC equipped electric vehicles that were made in the early 2010s that are still running around on the original battery with loads of capacity left. Look at the early BMWi 3s and Renault Zoës, look at the high mileage Tesla Model Ss from 2014, 2015. So, you know, I'm not too worried about NMC's lifespan and if LMFP can exceed that, then we're laughing our way to the bank. So that's probably going to be brought out, well, rumour has it by Tesla, they were meant to do that according to the rumours with the face lifted Model 3 that's been released fairly recently but that has yet to materialise, but we suspect that they're planning to introduce that. I wouldn't be surprised if some of

the Chinese EV manufacturers or even if it's brands that we, well, that didn't used to be Chinese but are now, like Volvo, you know, Geely Group, they might start bringing out LMFP. I, wouldn't be too surprised. But that should bring down the cost of batteries even further whilst maintaining the similar kind of performance to what we would expect from the kind of higher energy density, more expensive NMC cells that we use today.

14:25 Toby Corballis

A couple of things you touched on there that I want to unpack, if I may, that I think are quite important. One of them is, well, the cost of the battery, because the cost of batteries has gone right down in the past few years to the point now where you've got people like General Motors in the, well, here in the UK, that'd be Vauxhall bringing out price parity models, right? So that it's the same price to go and buy the E version of the car as it is to buy the ICE version of the car, which makes it much more affordable. If the price keeps going down, presumably that allows them to drop the prices even further. So, the ICE vehicles start becoming more expensive and economically not as viable.

15:02 Euan McTurk

Yeah, unless there's any price gouging that takes place in our market, of course. But yeah, we are approaching that point where not only do you have price parity, but EVs do become genuinely cheaper to make than internal combustion engine vehicles. And there's not much in an electric vehicle's powertrain. You've got a motor that has a handful of moving components maximum versus hundreds in an internal combustion engine. And, you know, the batteries are a solid component. It doesn't have any moving parts, but if you can bring down the cost, which was at a cell level about $120.00 per kWh in 2022 going into 2023 and is now round about 50 to $60.00 per kWh towards the end of 2024. That price reduction has been phenomenal to watch. And it's actually to the point that it's starting to economically suppress some of the new chemistries that are waiting in the wings that we're saying, ah, we've got a cost advantage versus conventional lithium-ion. Sodium-ion is a prime example of that. But when LFP hit $50 per kWh and your sodium-ion manufacturers were saying, oh, you know, we're cheaper than lithium iron, LFP manufacturers just kind of turned around and went, "is that right? Aye." So now everyone's kind of, you know, sodium-ion's still coming, and it has a whole host of tricks up its sleeve, which, you know, I rate it very strongly as a chemistry, but it's very, this is part of the divergence I was talking about. It's not quite as energy dense as lithium iron phosphate, let alone NMC, so it's going to be used by city cars. I think Renault is probably eyeing that up. They love a good City car. French OEMs in general are quite good at making urban mobility solutions. Look at the Citroen Ami, for example, which is massively popular in Paris because it's a sensibly sized little quadracycle for getting from A to B. It's not a massive ungainly SUV. As I say there are these automotive OEMs that are eyeing up, you know, these next generation chemistries. But the cost as you've alluded to of these batteries now means that electric vehicles are so much cheaper to make. But we are going to probably not benefit fully from this in the UK or Europe, and probably not quite in the US either, because we're still building up our own home-grown supply chain, certainly in the UK and in continental Europe. I'd say that the US is ahead of us in terms of developing its own supply chains and its own, you know, EV manufacturing capability as well.

17:29

But Chinese batteries are going to be hit with import tariffs, you know, across Europe. Chinese EVs are going to be hit with import tariffs across Europe. It's likely that the UK will follow suit to an extent. And when you add on to that, the fact that Chinese manufacturers are definitely price gouging us to an extent, because some of these electric cars that are being brought in now, the price tag here might be, oh, you know, £15,000 / £16,000. It's the cheapest electric car in the UK. Yeah? Have you seen how much they sell them for in China? It's like a third of that. We're never going to reach those, those bargain bucket levels. There will always be some, you know, someone taking a cut somewhere along the line. But you know, I think back 20 years to episodes of Top Gear and Driven, if anyone remembers that, where people complained about the cost of petrol cars in the UK versus continental Europe. We are a comparatively expensive place to buy a car, but EVs will still end up cheaper than new petrol cars.

18:26 Toby Corballis

I remember a time when people would go to Europe to buy a car that they could then drive in the UK and import because they were so much cheaper. I don't think that happens anymore. The other thing I wanted to unpack slightly and I've watched a couple of your Plug Life TV shows on this, is the chemistry itself, because I think what we like to do here and Wicked Problems, we like to do a bit of myth busting every now and again, and one of the myths that I think is quite common, I see it raised a lot on places like LinkedIn or, you know, even in mainstream media articles is the ethical considerations for the battery materials. So people talk about cobalt, for example, and they it's all kids down minds or they talk about, I think there's a lot of misinformation about lithium being a rare earth mineral, which is sorry, metal, which is, I don't think it is, but these are, you know, there's myths that there's a lot of rare earth materials in batteries. What's the, what's the truth?

19:25 Euan McTurk

There are no rare earth elements in any conventional lithium-ion battery pack or sodium-ion battery pack or any of these next generation chemistries that are being considered. If there were rare earth elements in those battery packs, they would probably not be terribly economical to produce. So, yeah, that's simply not the case though... You know, these elements that we're looking at are surprisingly abundant. It's just that, you know, that's abundance at a global scale and if you look at the, you know, the concentration and ores and what have you in which they appear, it's sometimes fairly low. So therefore, you know, you do have to put a bit of effort in to extract some of those materials from those ores, so for example spodumene, which is a lithium containing ore, if I remember rightly, it's typically 1 to 2% lithium, but you know, you're not just chucking the rest of the rock away. And another good example of that is cobalt, which tends to be collocated with either nickel and/or copper in that ore that you typically find it in. So again, you're not throwing away the rest of the rock. In fact, cobalt was initially something of a by-product from copper mining before, you know, it started to gain a market in its own right. And in fact, such as the move towards more ethical materials and away from cobalt that we're predicting there's going to be a cobalt surplus by 2030 because we're more interested in the other materials in some of those rocks in generally comparatively ethical locations. But the whole thing about cobalt being all kids down mines and so on, we need to unpack that because it's a great untruth. It's a great bit of disinformation, because yes, the majority of cobalt across the world comes from the Democratic Republic of Congo. It's something like 70% of the world's cobalt annual cobalt production is from the DRC. But the vast majority of that is from open cast mines that are run by big mining giants like

Glencore. And they have to play by very strict ESG rulebooks. You know, they, they will not be allowing kids in there. They will have the strictest standards of health and safety.

21:26 Euan McTurk

I know people in the battery industry who've been to those mines and, and said they're so fed up hearing about, oh, it's all kids with Fisher Price pick axes and things. It's not. And that is abhorrent when that happens. And it does sometimes happen, but it's a tiny percentage of artisanal mining, which is a tiny percentage of Democratic Republic of Congo's output. And I remember reading a fantastic article from a, a contributor to the Fair Cobalt Alliance, which has been set up to make sure that kids are in schools, not mines, and that working conditions in artisanal mines are fair, wages are fair, etcetera, etcetera. This guy got so like... you were reading it and you could tell that he was getting wound up by this constant attack, this constant blaming of EVs and cobalt on, you know, kids being down mines and so on. And he said that's a tiny percentage of artisanal mining for all the other materials that we use around the world, like coal, for example. But that powerful spotlight of scrutiny is shone on the battery material for a green technology. It's not shone on the dirty materials that are used elsewhere.

But why does it happen? Well, DRC does not have a welfare state, and the average wage is something like $2 a day, and that's for like a teacher and so on. It's, you know, if you have a big family to look after or, heaven forbid, if you've lost your parents and you're a kid, there's nothing to fall back on. You need to try and get money somehow. And adults will do artisanal mining because it's, it genuinely earns them more money than other job opportunities. And that's why the Fair Cobalt Alliance is trying to make sure that if this must happen, that it happens safely, because it's a totally different set of, of living conditions and your financial scenario as to what we're used to in our western ivory towers. It's not a, you know, a clean cut, black and white kind of situation with the ethics. People are doing this through necessity, but by all means, you know, we should be trying to make sure that this is done as ethically as possible.

23:24 Euan McTurk

And hats off to the likes of Tesla, I think LG Chem, if I remember rightly... there's a couple of other cell manufacturers who are part of the Fair Cobalt Alliance, and Fairphone as well which is a Dutch company that makes modular upgradeable, repairable smartphones; they were one of the first whilst other companies were trying to move away from DRC for cobalt supply. They went charging straight in their headfirst and were like, “how can we make this better?” So fair play to them.

23:51 Euan McTurk

Tell you who's not a member of the Fair Cobalt Alliance? Not one oil company at all. Cobalt... it’s biggest use as a catalyst worldwide is the desulfurization of crude oil. So, if you have a lithium iron phosphate electric vehicle that has no cobalt in the battery and someone turns up next to you in a V8 Range Rover and says, “oh, what about all those kids that mine the cobalt?” Actually, as they're filling up their V8 Range Rover, they're using more cobalt than your electric car ever will.

24:21 Toby Corballis

Yes, so the Cobalt's not going straight into the car, but it's been used to -

24:25 Euan McTurk

it's been used-

24:26 Toby Corballis

To take the sulphur out of the petrol.

24:26 Euan McTurk

Yes.

24:27 Toby Corballis

So, bad practises happen, and they happen around the world in different places. What we can do is, is try and fix that within the industry that we find ourselves in, right?

24:38 Euan McTurk

Like, yeah, and there's not only trade bodies, but there's also genuinely separate markets that appear to be surfacing for comparatively ethical battery materials versus low ESG standards kind of battery materials. And on top of that, it's worth pointing out that the EU has introduced battery legislation, which has very strict ESG requirements for tracing of battery raw materials. So yeah, this, this situation is not only being worked out by, you know, the, the industry itself going, how can we make things better? It's being acted upon governmentally. And also the free market has gone, we want the ethical stuff too.

25:19 Toby Corballis

One of the things you talked about was supply chain and about the fact that we don't have that supply chain here in Europe or in the UK. When you're talking about that, are you talking about the, are you starting with the ability to actually fabricate the battery in the first place? So, we could, if you've got all the raw materials, we don't have the capacity or sorry, capability within the UK, let's say, to actually turn that into a battery. Is that the issue that we're facing mostly?

25:46 Euan McTurk

So, there are some big gigafactories under construction in the UK so we will have that capability, and we do have that capability in some areas at the moment. So, I think the first lithium iron battery factory, certainly in the UK, possibly in Europe, was the site of the sadly recently defunct AMTE Power up in Thurso, at the very north of Scotland, but that's a tiny little factory. It's nowhere near the kind of gigafactory scale of the likes of Nissan Sunderland, which is currently being upgraded to something like 22 GW hours per annum capacity. You've got Jaguar Land Rover or the, the kind of subsidiary Agratas is building a very large gigafactory in Somerset and there are rumours of another big gigafactory going into the site of Coventry Airport, and if all of that goes ahead, we will be on track for the Faraday

Institution's forecast of our basically meeting our requirement for the amount of batteries we need to produce in the UK by 2031: one hundred GW hours per annum is the estimate. But we need double that by 2040 so we do need inward investment, and we should be grateful, we should be happy, we should be cheering about it from the rooftops whenever there is that inward investment because that's creating jobs and that's creating basically the building blocks of our supply chain that we actually need. A prime example of that again is Nissan Sunderland when they started building petrol cars there; that was inward investment. That's a state-of-the-art car factory that is regarded as one of the best in the world. So, if we can have similar investment from whether it's, you know, effectively Tata, you know, JLR or whether it's, you know, one of the big Chinese cell manufacturers like CATL, BYD, Eve Energy, etcetera. If we get them interested in building gigafactories in the UK, then absolutely we should do it. And by all means, if someone wants to have a go at a homegrown exercise like British Volt again, but this time don't just hire good engineers, hire good management, then we should, we should welcome that too. We need to, we definitely need to be at least matching what the US is doing with its Inflation Reduction Act, which is a combination of, well, it's mostly carrot incentives, but there's no stick incentives in terms of import tariffs if you try and do anything outside the US and then bring it in. But there's so many tax relief efforts and so on within the Inflation Reduction Act. If you build this particular battery component or this particular cell here in the US, you will get this much of a tax break per kWh that's produced, and it's very clearly defined, and that's why there's been so much investment into the US.

28:15 Euan McTurk

We need to be doing that here because that will build up an incredibly strong economy, which, yeah, I reckon would give us good access to the European market and beyond as well.

28:25 Toby Corballis

We do a lot of consulting with companies around leadership so your point on leadership is well taken, but there's a lot of very well run companies in this country and in Europe and in the world, but where companies fail is often through a lack of, and it can be that the leadership, they may have the capability, but they haven't been taught, they haven't learnt it yet. They could acquire it, but they haven't, and nobody invested in that. And I think investment in people is actually just as important, sometimes more so, as the investment in in raw materials, so I'd take that point on board.

29:02 Toby Corballis

One of the other questions I've got for you is, I suppose one that everybody wants to understand: where the batteries go when they die?

29:11 Euan McTurk

Yeah. So, there's an excellent LinkedIn article / justified rant by Hans Eric Mellon from Circular Energy Storage who is a brilliant expert on everything to do with battery recycling, and he has rightly taken aim at this claim that only 5% of lithium iron batteries are recycled. He goes into how the source for that was spurious and it's been quoted umpteen times in the media without fact checking, etcetera. The fact is, you know, if you go for a walk on the beach you see sadly quite a lot of disposable vapes because

unfortunately some people are deplorable. I'm so glad that I believe, I don't know if the UK as a whole banned disposable vapes because they are an absolute hazard and a waste of precious resources, but Scotland is about to ban them definitely. So if it's not a UK-wide thing, then definitely catch up.

29:55 Toby Corballis

I think they're being banned from next year.

29:56 Euan McTurk

Excellent.

29:58 Toby Corballis

But for some reason we have to wait a year. I don't quite understand that.

30:02 Euan McTurk

Yeah, why not today? It's such a stupid self-defeat... Yeah, yeah. Anyway, so disposable vapes are a waste. There are, you know, I think there was recently an incident where an electric bin lorry caught fire and people thought, oh, it's the battery in the bin lorry. No, chances are it was a battery in a disposable vape in the actual rubbish hopper. It was the rubbish that caught fire. It wasn't the, you know, the lorry itself. They're just a complete hazard. But those are the ones that you struggle to recycle because idiots throw them in the bin or on the ground or what have you. If it's a mobile phone, again, it can be casually tossed into a bin. Have you ever tried chucking a Nissan Leaf into, you know, like a dumpster? It doesn't work. You certainly can't fit it in the bin under the kitchen sink. So, what happens there is because those batteries are so big and because automotive manufacturers are, are keen to try and adhere to their, their ESG requirements and so on, those, you know, those do get recycled. But actually, there have been so few that have been recycled so far because the vast majority of them are still running and that includes the, the ones from the early 2010s. They're just not dead yet. So, people, it's a bit like the fairy liquid advert with the kids being like, I really want to make a rocket out of this bottle, but it's taking forever to empty. In this case, it's like, I really want to recycle this battery so that I meet my EU battery regulation requirements of having a minimum, of like, 16% recycled cobalt in this new battery I want to make, but that one's taking ages to die. You know, it's, it's that same kind of setup. And yeah, as a result, those continue to run and run and run. We're seeing a couple of different uses for those older batteries. Some of the EVs that those batteries are in are quite powerful and some people get a bit throttle happy and wrap them around a tree, and that's when there's a fierce bidding war over the battery pack from that crash salvage car and then it ends up powering a repowered Volkswagen or Ferrari, a Volkswagen Beetle or like a Ferrari or something... electric classic cars, basically, you know, so they will take second life batteries, as they're known, and use them there.

32:02 Euan McTurk

The other thing that happens to them is they get turned into energy storage, either at a domestic scale by Power Vault or grid scale by the likes of Connected Energy, which is a, a company in the northeast,

but eventually they do get recycled through one of an increasingly efficient number of recycling techniques. One of the first recycling plants in the UK, in fact, again possibly in Europe, was in Golspie, up in the Highlands, sort of near Inverness. So again, like north of Scotland was punching above its weight back in the day that was opened, in 2004, and that was a pyrometallurgical recycling plant, so, in other words, you were just sticking it all in a furnace and, you know, blasting it with high temperatures and melting it. And you can recover the expensive materials, so cobalt and copper, but the lithium and other materials end up as a slag, so you only recover about 40% of the material.

32:50 Euan McTurk

Hydrometallurgical is the current industry standard, so it's a far less energy intensive process, but you're leaching the materials out using strong acids so there's the concern about making sure that you contain that acid and handle it responsibly, but, again, the UK is leading the way on this.

33:05 Euan McTurk

There are direct recycling techniques that you can do and, in fact, there's an episode of Plug Life Television, I believe it's called "Can electric vehicle batteries be recycled?" where I went and visited the ReLiB Project at the University of Birmingham, some incredibly talented academics, not least Professor Emma Kendrick, Doctor Rob Somerville and Doctor Anton Zoran. They have developed an advanced recycling technique where you basically take the individual electrodes out of a poach cell, like pages out of the book, stick it into an ultrasonic bath with either a no acid or a very, very, weak acid and you literally shuggle the electrode material off of the metal foil onto which it was coated, and then you basically skim that out, spruce it up with a little bit of fairy dust, and slap it into a brand new cell, and that brand new cell performs better than the original cell that it was made from when that cell was new.

33:53 Toby Corballis

I think it's another myth, but it happens to come up a lot and that is electric cars catch fire and they burn things down all the time, right? And we know that the, you know, the Luton Airport car park [fire], that was actually a diesel vehicle, but it, for a long time, everyone said, "oh, it's an electric vehicle." Or, I think there was an image I saw of a car transporter that had caught fire and all the cars were burning and people were saying it was one of the cars on there and it was an electric vehicle and it was actually quite plainly visible that the cab of the transporter had caught fire. Do they catch fire and how often, because I think it's very rare.

34:35 Euan McTurk

Well, no, you, you raised a good point. Honestly, some of the assertions that people have made about, you know, a vehicle fire being an EV fire before there's been any kind of official confirmation of this... The photographic and video evidence, as you've said, is right there. You know, you need to have an IQ of somewhere less than a house-trained Alsatian to genuinely think that that is an EV fire. You can be the most, you know, well, sorry, the least car-type person, you know, the most technophobic person and it's patiently obvious that is not an electric vehicle, and, yet, people still persist because they're lazy, particularly some of the journalists who need to, you know, actually do their job, which is investigative

research, but you know, do they catch fire? Well, I've seen various statistics on this, but they're all in agreement: electric vehicles per, you know, 100,000 on the road are considerably less likely to catch fire than a petrol or a diesel car. And I think that the most pessimistic, so in other words, you know, the greatest likelihood of catching fire is something like 20 times less than a petrol or a diesel car. Some of the statistics I've seen have said 100 times less than a petrol or a diesel car. Those statistics sometimes muddle up a few things. So, some of them, you know... not every electric car fire is started by the battery, sometimes it's an electrical fault like you would get in a petrol car, like basically a wiring harness sort of issue. Sometimes it was a neighbouring vehicle that caught fire, or a neighbouring object. There was an example, according to EV FireSafe who are fire, basically tracking and safety experts for electric vehicles – fantastic consultancy – they noted one prominent example where an entire house burned down around an EV that was parked in the garage and the battery didn't catch fire. They're very hardy things batteries. You need to generally do something incredibly stupid to get them to catch fire, and trust me, I've worked in the labs at University of Warwick's WMG (Warwick Manufacturing Group), which is just a playground of, of very expensive toys for testing batteries to destruction, and yeah, yeah, we tried. It's harder than it looks anyway. So, the point is there are some of those fires in those statistics that were nothing to do with the battery whatsoever. The battery was an innocent bystander and may not even have participated at all.

36:47 Euan McTurk

Sometimes e-bikes and e-scooters get thrown in there as well, but remember, those are sometimes notoriously badly made. If you buy something cheap off of Alibaba, you get what you pay for and that's potentially a house fire, whereas you can't just buy an electric car cheap off Alibaba or wherever and start running it on the road. It has to go through very stringent safety tests, including for the battery so that simply is not a risk. They'll all be very stringent tests and there will be an immediate recall if it turns out there is a battery issue, and we've seen that with the likes of the Hyundai Kona, with LG Chem having screwed up their pouch cell manufacturing a few years ago, folded, folded an anode tab by accident in a way that spent it could potentially catch fire. You know, those those vehicles were recalled. Likewise, the Chevy Bolt in the US was affected by the same sales packs got replaced and as an interim solution, you weren't able to charge your vehicle above I think it was like 80%. You know, they're incredibly strict about these things, whereas if it's an e-bike or an e-scooter, it's like, well, "sucks to be you hope you see the thing on the shop window about the recall." You know, there's no official means of tracking you down and going cease and desist, you know, send this back for a replacement. I'm aware I'm, I'm waffling on, but nonetheless, the odds of the actual battery self-catching fire are very slim, but when it does happen, we need to be effective at the way we tackle that fire.

38:10 Euan McTurk

And I think part of the reason why you hear the stories about EVs potentially being on fire for days, is because originally Fire Brigades for tackling EV fires that involved the battery in the same way that they would tackle a petrol or diesel car fire so they would pour water on top so it would trickle into the bonnet to extinguish an internal combustion engine fire, but the battery, of course, is hidden underneath the vehicle in an EV and it's very well protected. So, actually you want to be applying water from the underside. Otherwise it's like my socks being on fire, so I've poured a bucket of water over my head. I might be here for a while and I might get some very burnt feet and probably my trousers are going to go up as well. It's, you know, it just gets worse. So, there are new firefighting techniques that are being

developed, you know, with a focus on, you know, where is the battery? OK, let's get water there, and then how do we deliver that water more effectively? So, there's these new techniques that are being developed which effectively lands the battery with a high-pressure water jet and those have been shown in some cases, you know... there's still a bit of, of work to do to determine when it's better and when it's worse for the scenario. But there was a, a study by the Swedish Civil Contingencies Agency that the, basically the kind of fire brigade there, where they managed to put out a Nissan Leaf, I think it was a Nissan Leaf battery fire using one of these super-efficient new techniques in under 10 minutes using a third of the amount of water it would take to put out a petrol car fire. So yeah, whilst there are still safety risks, if a vehicle catches fire or if it gases off, you don't necessarily want to breathe those gases. The gases aren't necessarily as scary as... like it's not like 100% hydrogen fluoride or anything like that. It's not all HF... If you do get any HF coming anywhere near you, that's incredibly unlucky because it's so reactive that pretty much by the time it leaves the battery, it's reacted with something else around it and formed something a bit less toxic. But the point is that, you know, you want to leave the fire brigade to do what they're doing. They're trained, they've got the respirators, they've got the PPE and, of course, they've got the water to put it out. But we are so much better now, and Fire Brigades around the country are so much more informed than they were even this time last year. But it's an ongoing development to help to make fire safety even better.

40:26 Euan McTurk

But yeah, it's petrol in diesel cars that are the risk. They're the ones driving around with up to 100 litres of highly combustible fuel in them.

40:34 Toby Corballis

Which will go bang if you give it the right circumstance.

40:39 Euan McTurk

Absolutely.

40:40 Toby Corballis

If people want to learn more about the work you do, where should they go?

40:45 Euan McTurk

Yeah, so there's the YouTube channel Plug Life Television, which I started when I was a fulltime battery electrochemist. But as you can probably see by the logo in the corner, the spin out from that, Plug Life Consulting, has been keeping me very busy recently. So yeah, Plug Life Consulting you'll find on the pluglifetelevision.co.uk website; there's a section on the consultancy. And if there's any projects that you're doing, you know, if you're looking at this from a technical or a business perspective, anything to do with battery electric chemistry, electric vehicles, charging infrastructure or static energy storage, whether it's technical, strategic, public outreach, project management, all that sort of stuff. I'm just, you know, pulling together all of my experience I've had since 2009 to work on a very diverse portfolio of

projects, one of which has actually resulted in a spin-off of itself. So I now have an app called Charge Saint and that is designed to deal with icing – so, the blocking of electric vehicle charging bays by internal combustion engine vehicles – that allows you to report the incident directly to the owner of the charge point so that they'll take action to stop that happening. Again, that's available to download on Apple and Android and we're talking to some very big names in the charging industry who want to sign up and avail of that service so that we can nip icing in the bud once and for all.

42:03 Toby Corballis

Well, good luck with that. That's, that is important because it's very frustrating to turn up. I mean, one thing frustrating is that the charger doesn't work. OK, well, that's something. But if you turn up and the charger's blocked by because someone's just parked there, I don't even care that they're going to get fine, but I care that they're not there because I want to be able to use it. So it's good that you can leave that you can do that. Well, good luck with that. We'll put links below the episode so people can just click on those and come and see for themselves what's going on, maybe download the app, etcetera. So thank you. It's been an absolute pleasure talking to you. Thank you very much.

42:45 Euan McTurk

Thank you.