End of Life Battery Packs in the UK: the forecasting challenge

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Contents

- The future of the automotive industry: an overview
  - CASE + CE
  - Drivers of scrappage rates
- Short-term implications and forecasts
- Long-term implications: three vehicle archetypes
  - The sub-car
  - The drone
  - The fortress
- Conclusions

Two ongoing research projects

H2020 STARS

Analysis of car sharing in the EU
Business models; market; consumer behaviour
See http://stars-h2020.eu/

EPSRC Faraday Institution ReLib Project

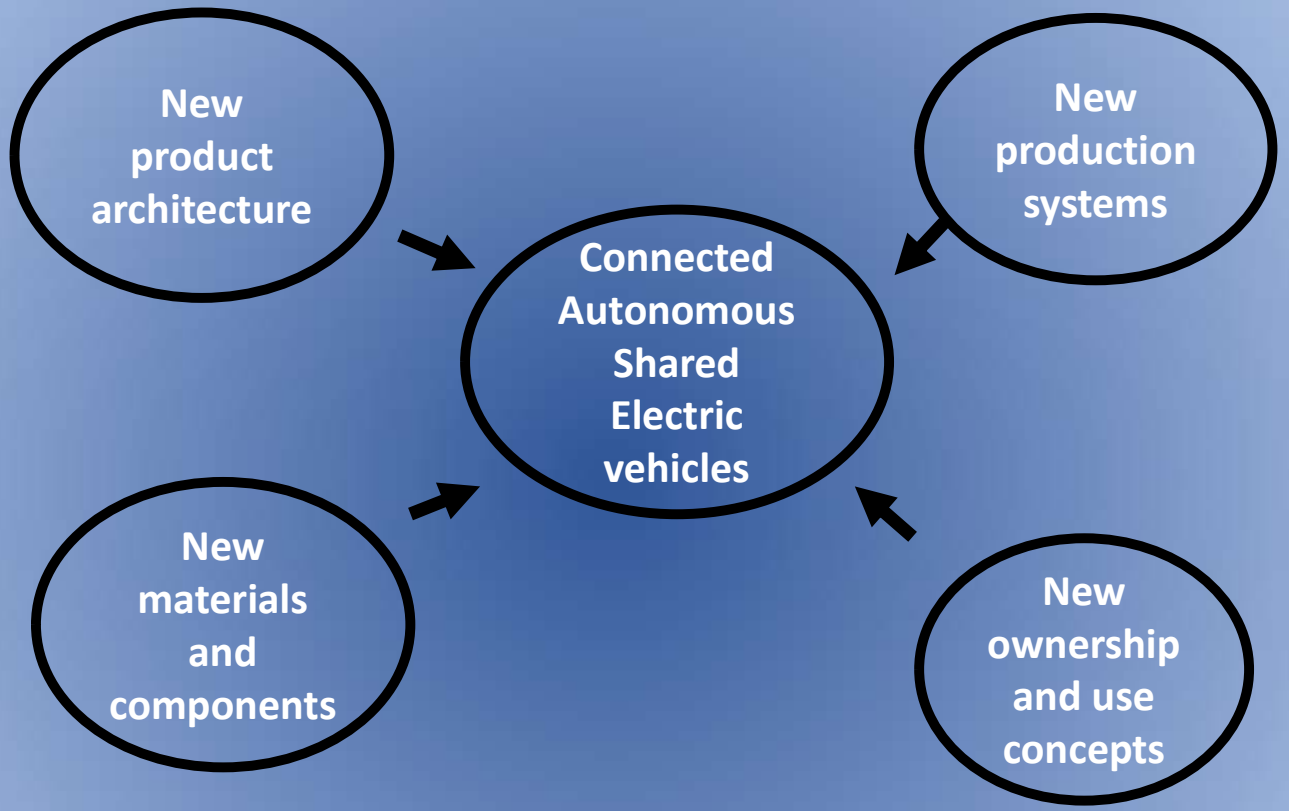
Analysis of BEV battery recycling in the UK
Disassembly; materials separation and processing; economics; business models for ELV treatment sector
See https://faraday.ac.uk/

CASE + CE

- The automotive industry is mostly concerned with CASE
  - Connected
  - Autonomous
  - Shared
  - Electric
- Leading to many new entrants, new relationships, new technologies and material applications, new product and service concepts

The impact of the COVID 19 crisis

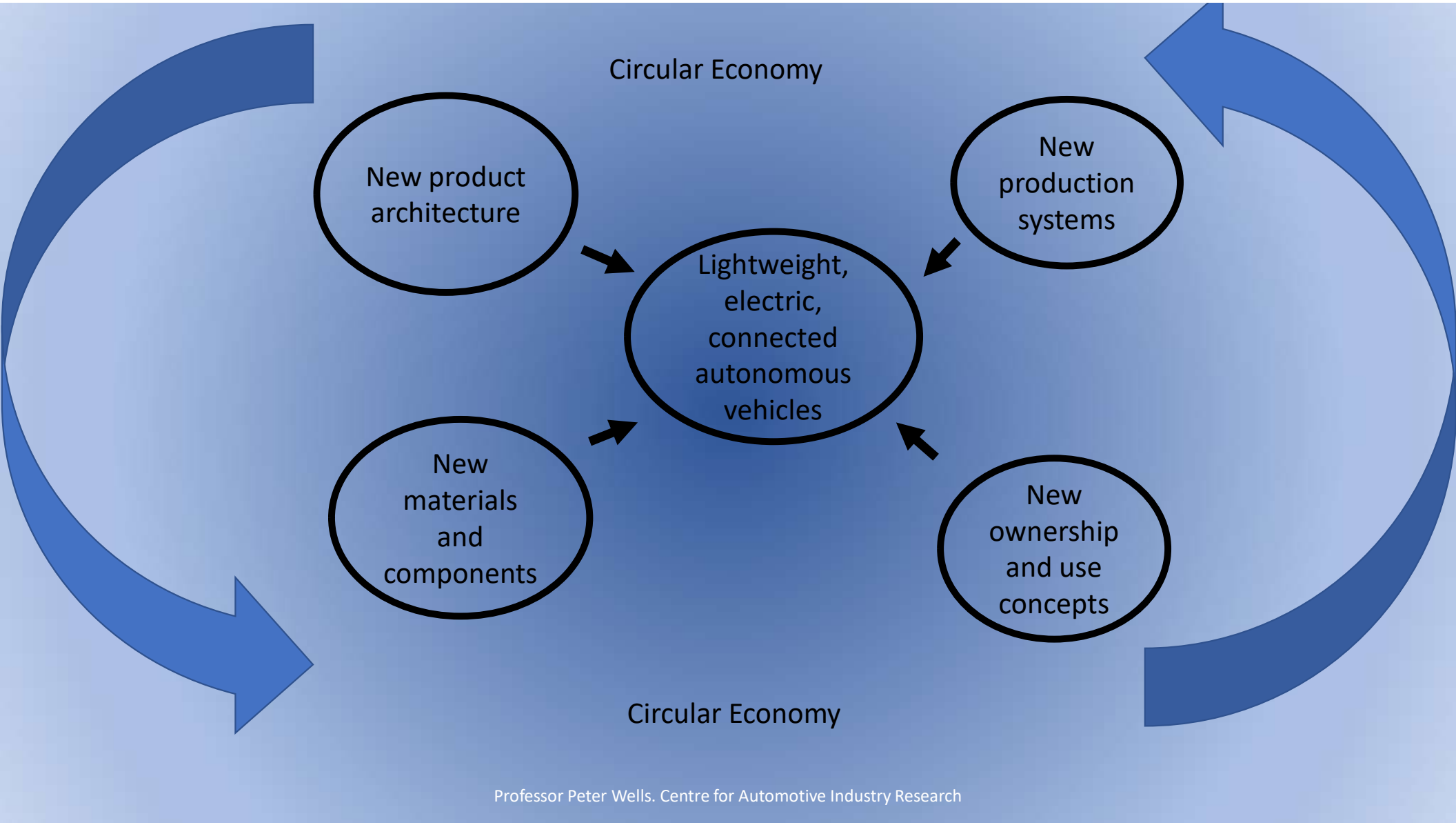
- Increased uncertainty over futures
- Probable economic uncertainty
  - Can the BEV sector support be maintained?
  - Should the mainstream industry be given more time?
  - Should any industry / company rescue package be linked to BEVs?
- Also uncertainty over behavioural change
  - Public transport, active travel, and social distancing?
  - New work and leisure travel patterns?



The CASE concept is pretty well understood…

CASE + CE

- So far, the CASE discussion has not been linked to the Circular Economy
- The assumption may be that the CE provides an external ‘shell’
  - The industry may transform inside the shell
  - No direct implications for industry or mobility practice
- BUT this assumption may not be correct
- It is important to consider how the CE will work in practice


Circular Economy
New product architecture
New production systems
Lightweight, electric, connected autonomous vehicles
New materials and components
New ownership and use concepts
Circular Economy
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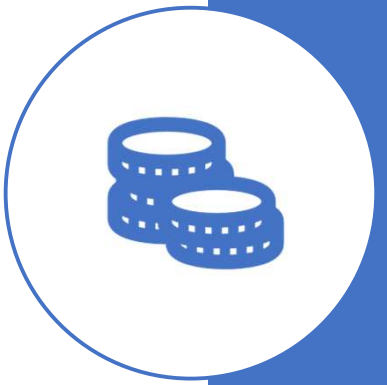
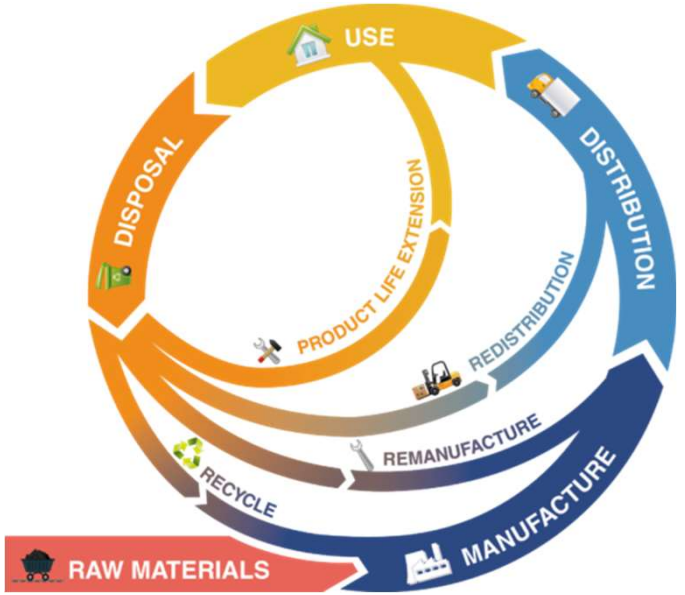
CASE + CE

- A key issue is the relationship between the waste hierarchy and the circular economy
- Directive 2008/98/EC on waste (Waste Framework Directive)
- Green economy and circular economy as defined by the European Commission
- The circular economy represents "…a development strategy that provides for the economic growth without increasing the consumption of resources and reducing the impact on the environment."



- The waste hierarchy and the circular economy may, or may not, fit together…

- Note the circular economy diagram includes the flow of new materials… so net material consumption goes up.



CASE + CE

- If we are to ‘reduce’ or ‘prevent’ the use of raw materials is this done by producing fewer cars?
- The EC definition seeks economic growth without growth in material consumption (i.e. de-coupling)
  - There is considerable doubt that such an aim can be achieved
- Or less raw material per car? Or smaller cars?
- In some respects cars are already put through ‘re-use’ practices (rather than second use) e.g. in maintenance and repair; engine remanufacturing

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Primary factors driving scrappage rates

- Temporal deterioration and write-offs
- Temporal deterioration (attrition)
  - Depreciation rates are key
  - Cost of retention versus cost of replacement / alternative
  - Cost of retention versus value of vehicle
  - Reliability and functionality changes over time
  - ANY car can in theory be kept on the road
- Write-offs may depend upon insurance industry perspective
  - Need for write-offs reducing over time?

Scrappage incentives return!

- EU and national level interest in new schemes
- Support varies widely
- French scheme most detailed so far…
  - €8 billion scheme for 1 million 'clean cars' in 5 years
  - €7,000 subsidy for new car up to €45k in value
  - Anyone who earns less than €18,000 pa, decommissions their old combustion engine and procures a new BEV can also expect a bonus of €5,000 as part of the "prime à la conversion", i.e. they receive a total of €12,000
  - Also subsidies for conversion of petrol/diesel to electric

Primary factors driving scrappage rates

- Typically the stock of cars in use has grown over time
  - New registrations exceed ELVs… UK stock up 42% in 20 years
  - Long run growth in new car registrations
  - ELV peaks may be a reflection of previous registration peaks
  - Or of the introduction of incentives to scrap vehicles
- vehicle longevity up BUT in detail this is highly variable
  - Varies by brand, model, market, and value
- How might CASE + CE change all this?

Primary factors driving scrappage rates

- Autonomous vehicles
  - = fewer impacts, less attrition?
  - = more expensive to repair if there is an impact, more write-offs?
  - = more vehicle usage, shorter lifetime, more attrition?
  - = more potential users, more sales, more vehicles in use?
  - = supportive of car sharing schemes, fewer sales, fewer vehicles in use?
  - = supportive of smaller, lighter cars, less material per car?
  - = more expensive cars, fewer sales, fewer vehicles in use?

Primary factors driving scrappage rates

- UK data
- Average age of cars in use 6.8 years (2003); 7.8 years (2015)
- Average age of car when scrapped 13.9 years (2015)
- 1.94 million vehicles in use have SORN declaration (2016)
  - About 31 million cars in use
  - **But appears to be a lot of 'leakage' of numbers**

- ACEA data
- Average age of cars in use 10.4 years (2013); 11.0 years (2016)
- Poland 17.3 years


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Make & Model	Number Registered as SORN	Total in the UK	% of Total Registered as SORN
Volkswagen Golf	60,875	1,102,638	6%
Ford Fiesta	57,612	1,523,111	4%
Vauxhall Corsa	53,873	1,244,538	4%
BMW 3 Series	50,447	705,022	7%
Vauxhall Astra	48,467	1,121,893	4%
Ford Focus	43,129	1,508,036	3%
Renault Clio	38,041	613,193	6%
Ford Escort	33,651	58,085	58%
Peugeot 206	32,769	405,686	8%
Ford Mondeo	32,715	477,127	7%

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https://www.kwik-fit.com/blog/top-uk-cars-declared-sorn-to-avoid-the-scrapyard

See https://www.howmanyleft.co.uk/about

Short-term implications

- Next five-ten years
- Accelerated scrappage rates?
  - Accelerated anti-car policies in urban areas
  - New scrappage scheme?
    - Initially impacts on reduced usage
    - Ultimately impacts on reduced ownership
  - Better capture of ELVs?
  - Diesels?
  - What about early EVs? A problem we are not prepared for…

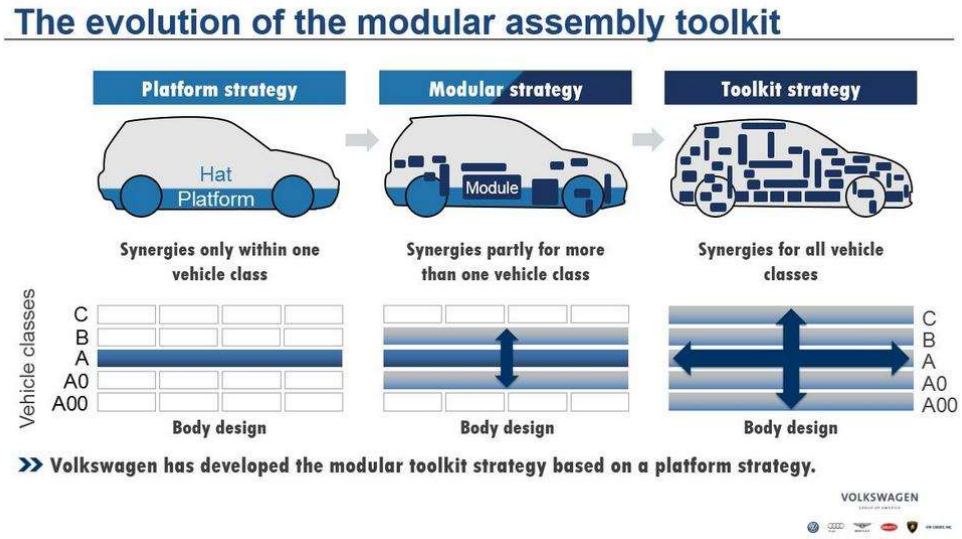
Short-term implications

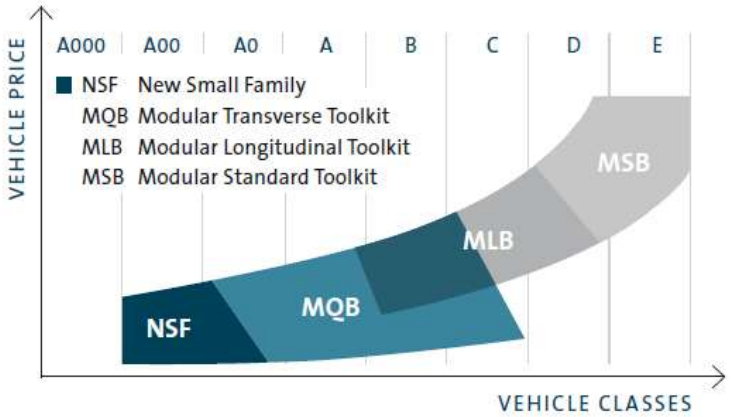
- The push into EVs is increasing material intensity
  - Audi E Tron 2,400 kg of materials for 80 kg of payload
    - 30 x payload with one occupant
    - 5 x payload with five occupants and luggage
  - Boeing 777-300ER 320,000 kg and 350 @ 80 kg passengers
    - 11.4 x payload per occupant
- The Tesla S is similar
  - A good way of moving batteries around the country, quickly

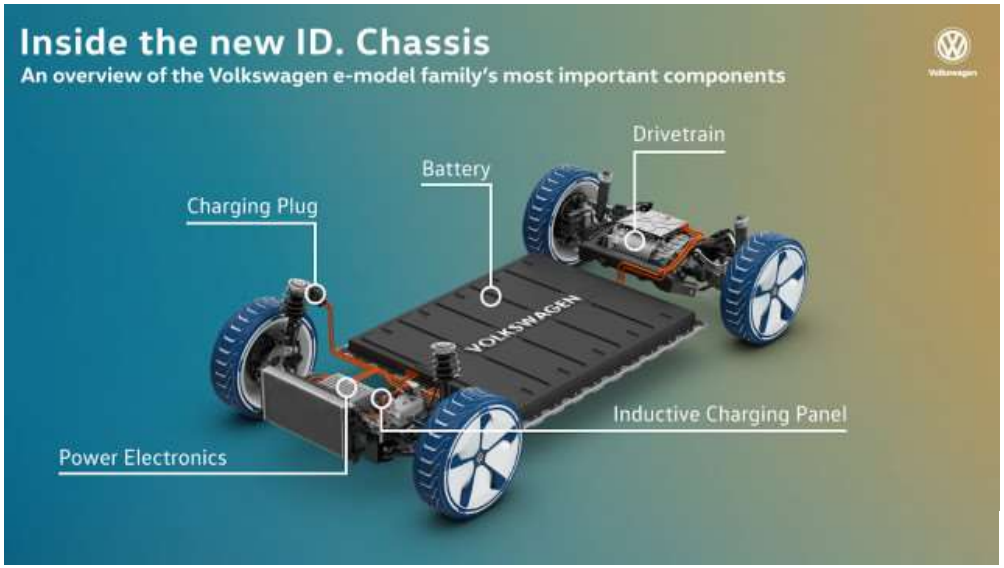

IN AE 1111

Short-term implications

- The VW Group solution…

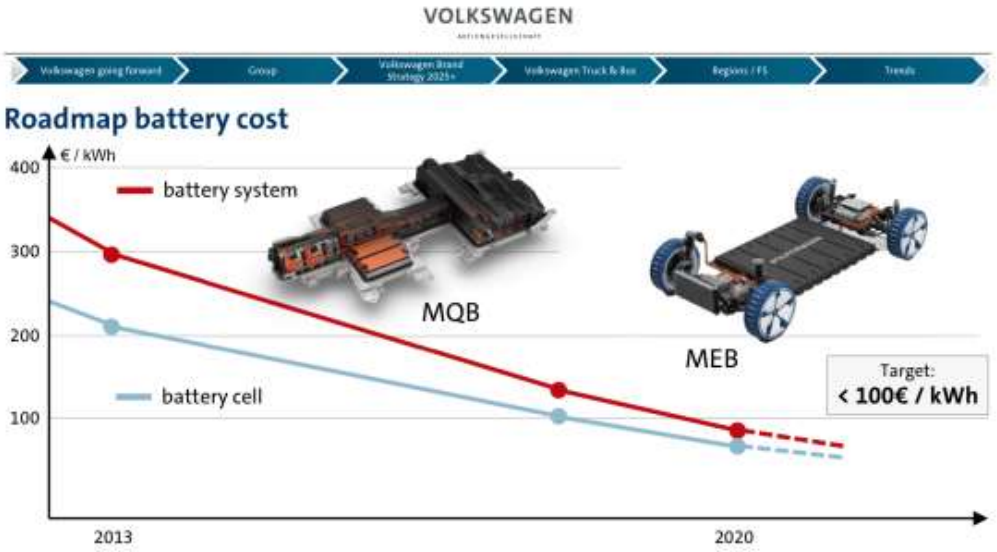






VW ID is built on the MEB (modular electric drive) matrix concept

The company is offering the concept to other vehicle manufacturers in a 'VW inside' strategy



Short term BEV battery pack scrappage rate

- To add to the ‘normal’ scrappage considerations outlined above:
- Battery packs may not last as long as the car
  - Typically 8 year warranty / 15 years lifetime use for a car
  - Not many repair / replacement options available for packs
- Rapid rate of technology change
  - Rapid fall in battery pack costs
- Second life applications of marginal significance
- Subsidies mostly aimed at new car purchases, not used
- Leads to…

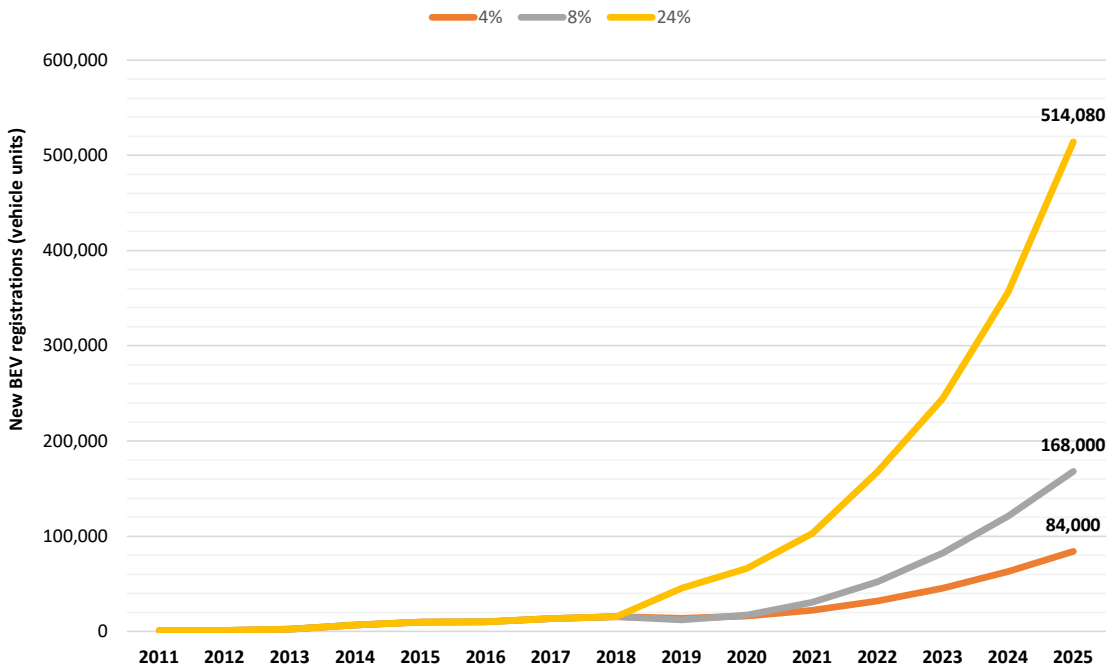
Short term BEV battery pack scrappage rate

- Two big questions:
- Why would anybody purchase an out-of-warranty BEV?
- Why would anybody replace the battery pack?
- If scrappage is a techno-economic calculus then spiralling depreciation will result in premature scrappage of BEVs and battery packs

Forecasting the rate of ELV battery packs

- First, forecast the overall new car market
- Then forecast the share of BEVs
- Then forecast the longevity of battery packs / cars
- We adopted the ‘dynamic obsolete LiB stockpile’ (xOLiB) concept
  - Forecast rate of insurance industry write offs
  - Add in replacement under warranty
  - The add in batteries beyond warranty period

Forecasting BEV registrations in the UK



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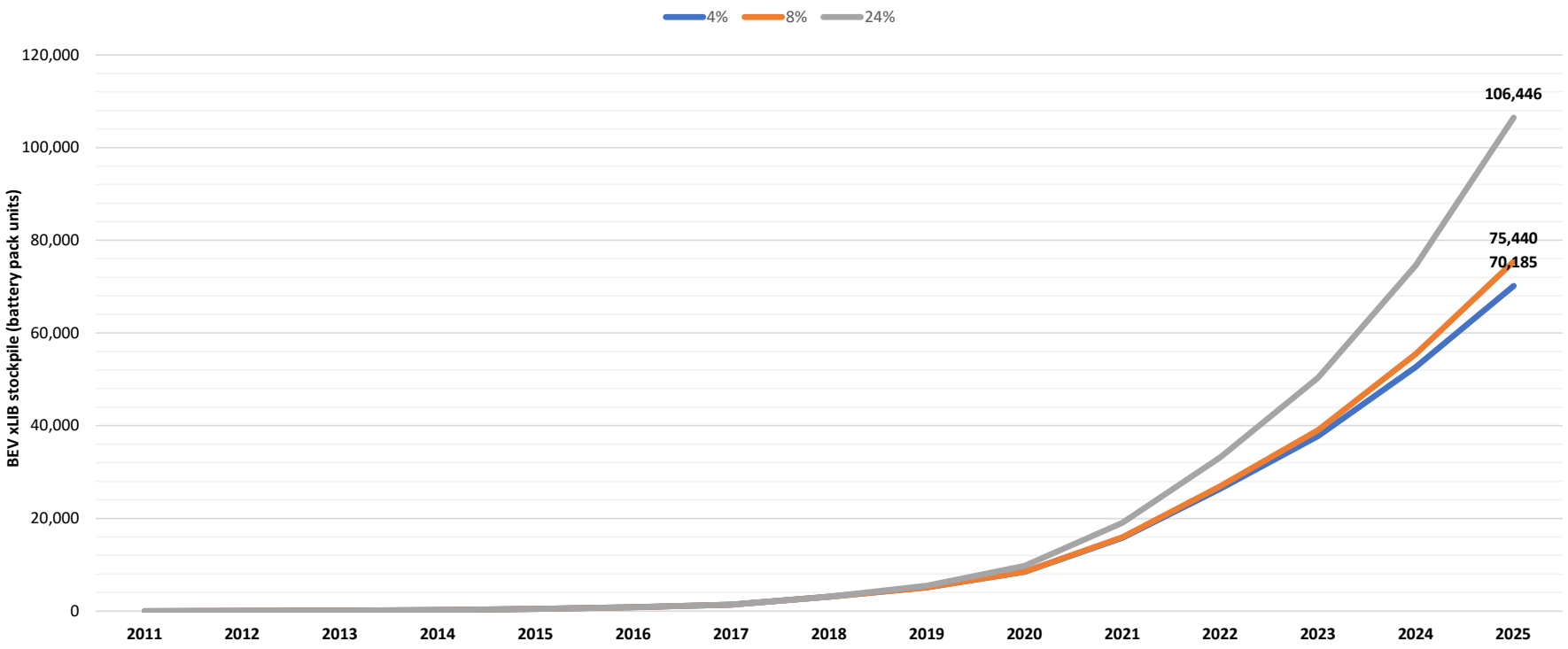
Forecast the dynamic xOLiB stockpile in the UK



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Managing the xOLiB stockpile

- The next phase of research is to investigate how this emergent stockpile will be managed!
  - Regulatory / safety issues
  - Techno-economic issues
  - Geo-political strategic issues and the circular economy
  - The competition for waste
    - Material or Product Stewardship?
    - An automotive closed loop?
    - ‘Inflating’ the circular economy

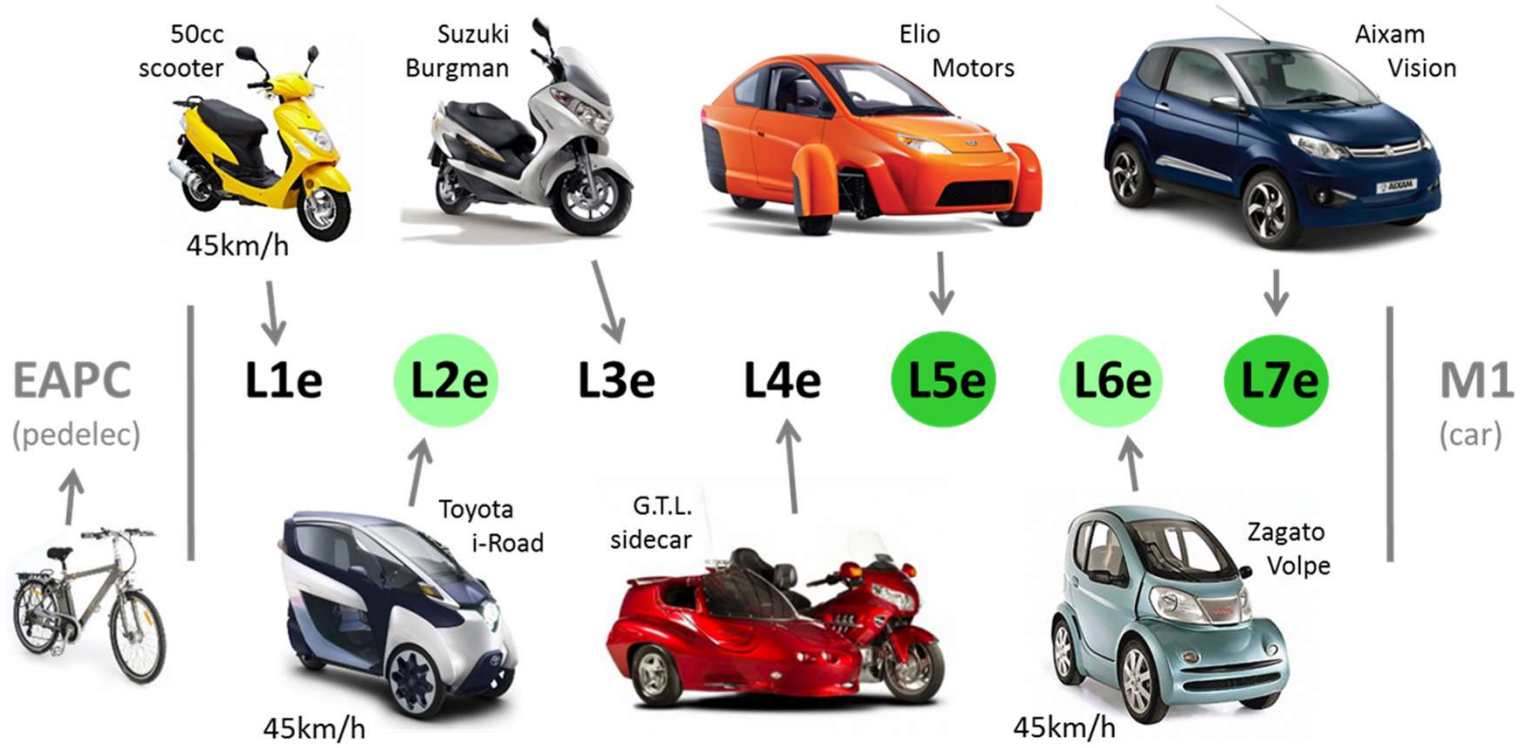
Long-term implications

- Reduced scrappage rates and volumes?
- Fewer vehicles, scrapped after a longer period of time?
- Greater rate of modular refurbishment?
  - Possible ‘build to refresh’ vehicles?
- Industry shifts from being a primary consumer of raw materials?
  - See use of aluminium in the US as a technical nutrient
- Here are three possible (and co-existing) outcomes
  - Sub-car, Drone and Fortress

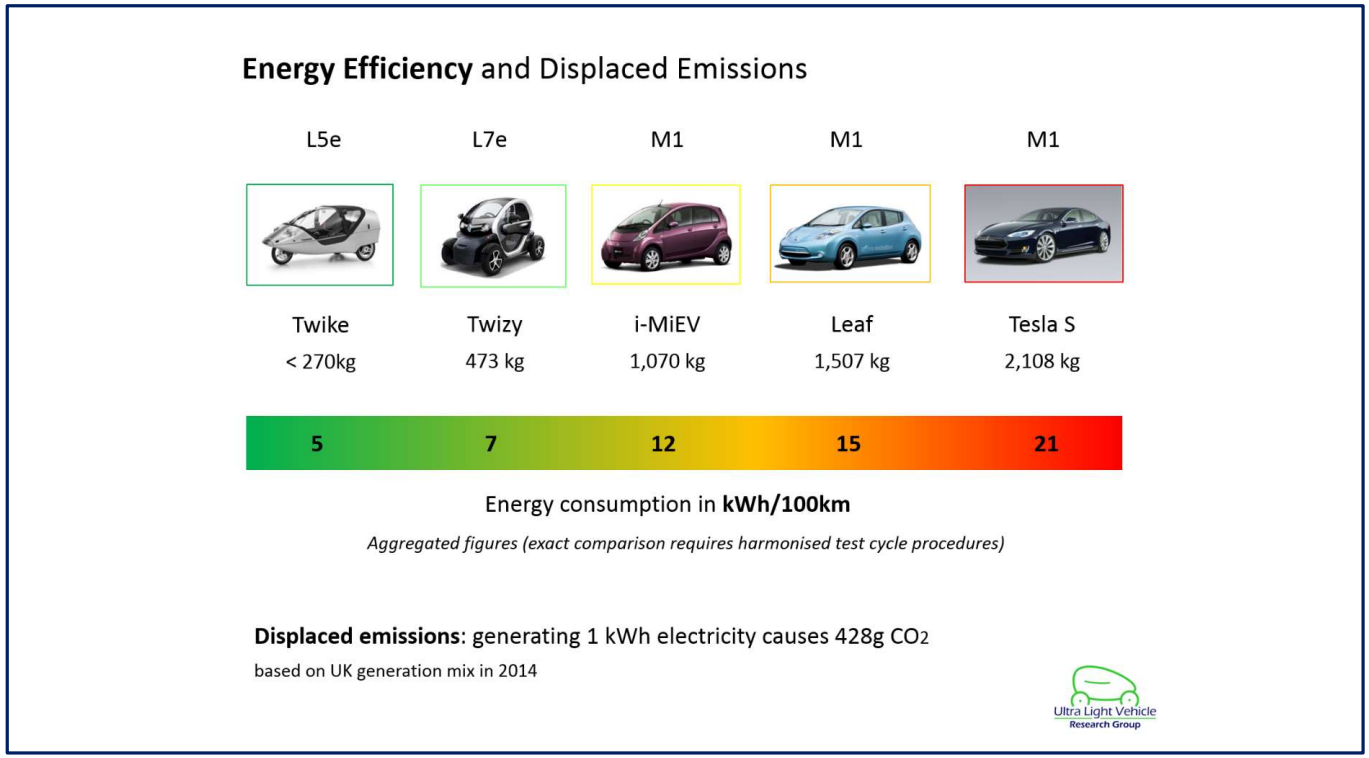
Long-term implications

- Sub-car EV
  - Maybe a medium-term growth sector
- Meets several requirements
  - Zero emissions at point of use
  - Smaller footprint, better use of parking / road space
  - Lower resource intensity per occupant
  - Lower cost of ownership
  - Suits better the shift from public transport

L Category vehicles: a diverse EU segment



Long-term implications



Long-term implications

- Sub-car can include many other things!

Long-term implications

- By 2040
- Drone
  - Utilitarian person public mobility
  - Multiple small autonomous electric vehicles in a ‘swarm’ displacing mass public transport
  - Simple, robust, repairable designs
  - Easy to recycle materials and components
  - On-demand and pay-per-use geofenced
  - Distributed charging e.g. via lampposts, self-repositioning and charging

Long-term implications

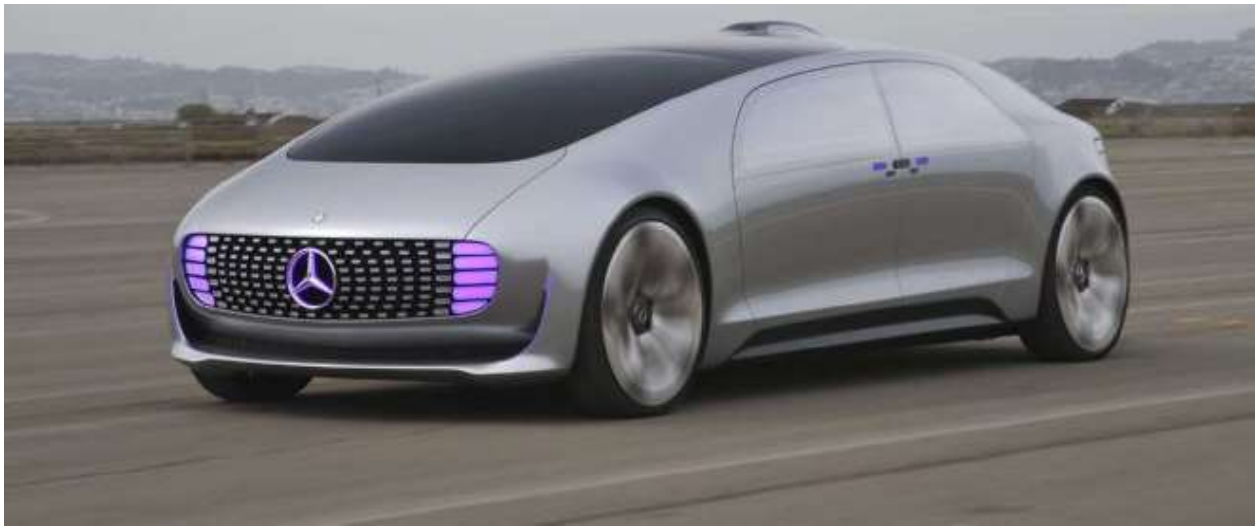
- Drone implications for automotive and recycling sector
  - The ‘milk float’ scenario!
  - Extended vehicle longevity, basic vehicles
  - Built to a purpose, not general purpose
  - Easy to recycle… but limited supply of vehicles
    - Reduced rate of write-offs
    - Greater refurbishment and retrofit
    - Dismantling (for re-use) more important than materials recycling?

Continental AG Bee

Airbus Pop.Up

Long-term implications

- By 2040
- Fortress
  - Vehicles for the plutocracy
  - Dynamic sanctuary and cocooning in luxurious setting
  - Content-rich, complex vehicles of high value
  - Customisation and personalisation offered
  - Energy efficiency a secondary consideration



Mercedes F015 Concept

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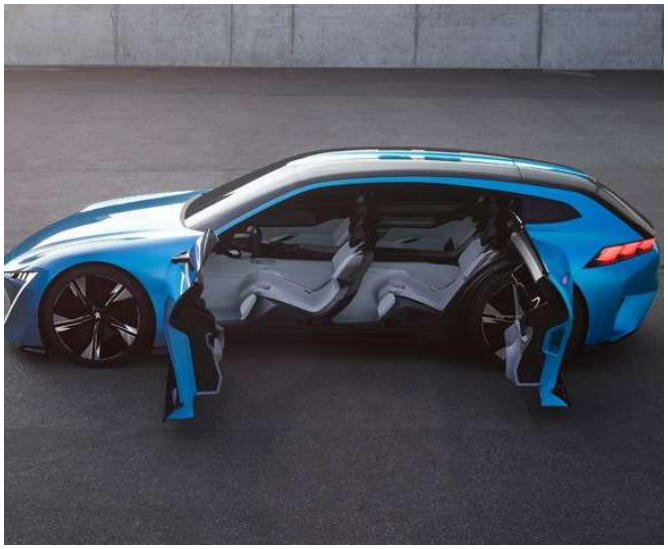

Peugeot Instinct and Legend Concepts

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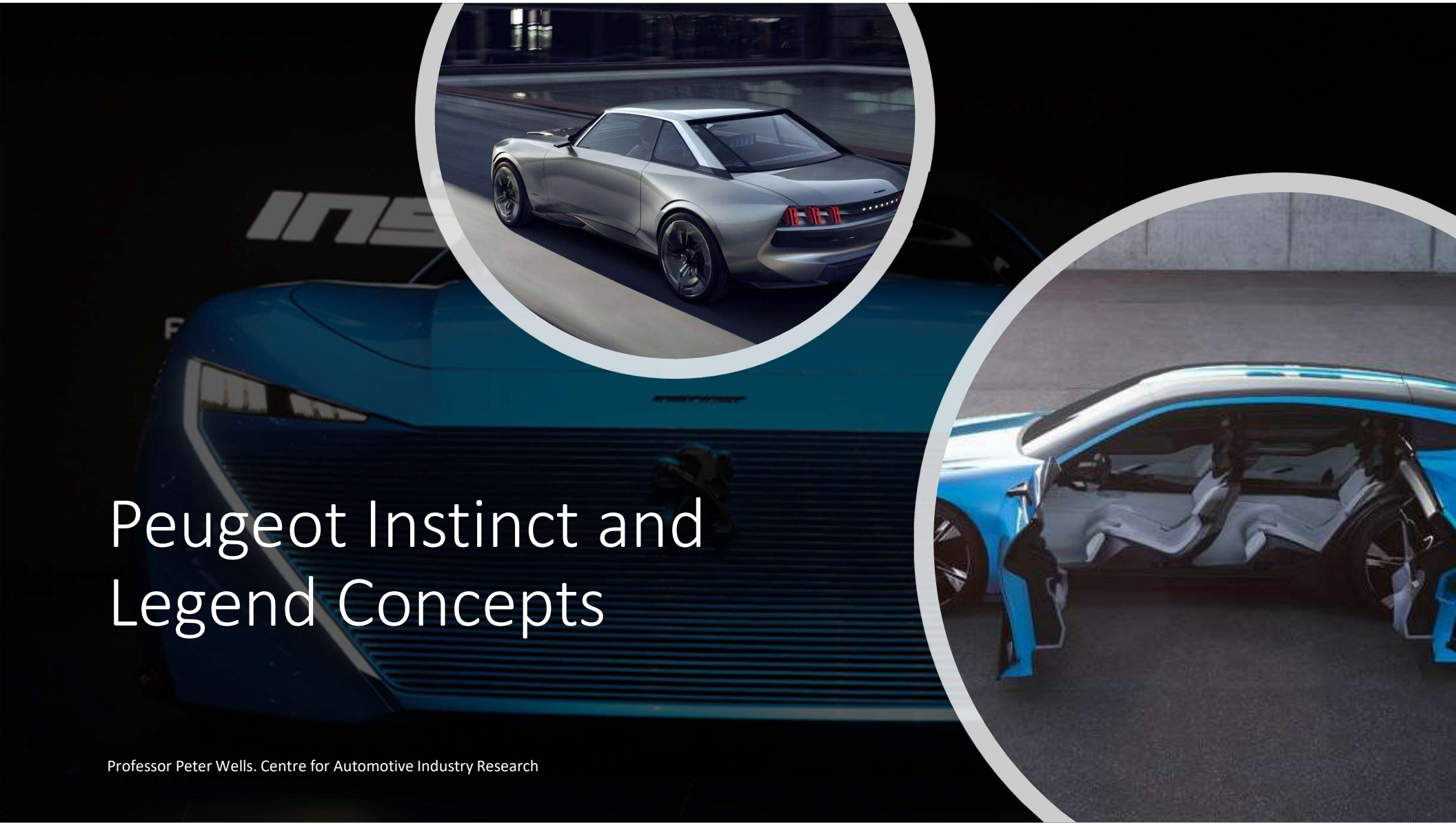

Peugeot Instinct and Legend Concepts

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Long-term implications

- Fortress implications for automotive and recycling sector
  - The Rolls Royce scenario!
  - Very extended vehicle longevity
  - Much reduced rates of attrition and write-off
  - Higher rates of retrofit
  - Much reduced rates of recycling
  - Higher cost of recycling complex, multi-material vehicles

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Conclusions

- Manufacturers to retain ownership of the battery?
  - May create value leasing circles
    - Material suppliers lease to manufacturers of components
    - Component suppliers lease to car manufacturers
- Future supply of xOLiBs difficult to forecast
- Long term is even more fragmented

Related paper

- Skeete, J.-P., Wells, P., Dong, X., Heidrich, O., and Harper, G., 2020. Beyond the EVent horizon: Battery waste, recycling, and sustainability in the United Kingdom's electric vehicle transition', **Energy Research and Social Science**, 69, Article Number 101581.