

Electrified Propulsion

The Road Ahead for Manufacturing in Mobility
5 December 2019

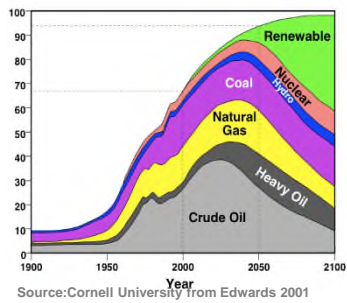
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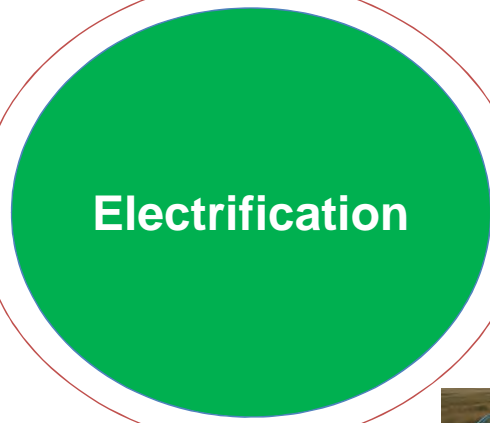
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Drivers for electrification are multiple and stable

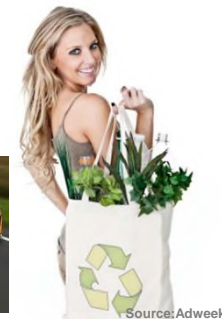
Energy Security



Climate Change & Air Quality



Industrial Opportunity



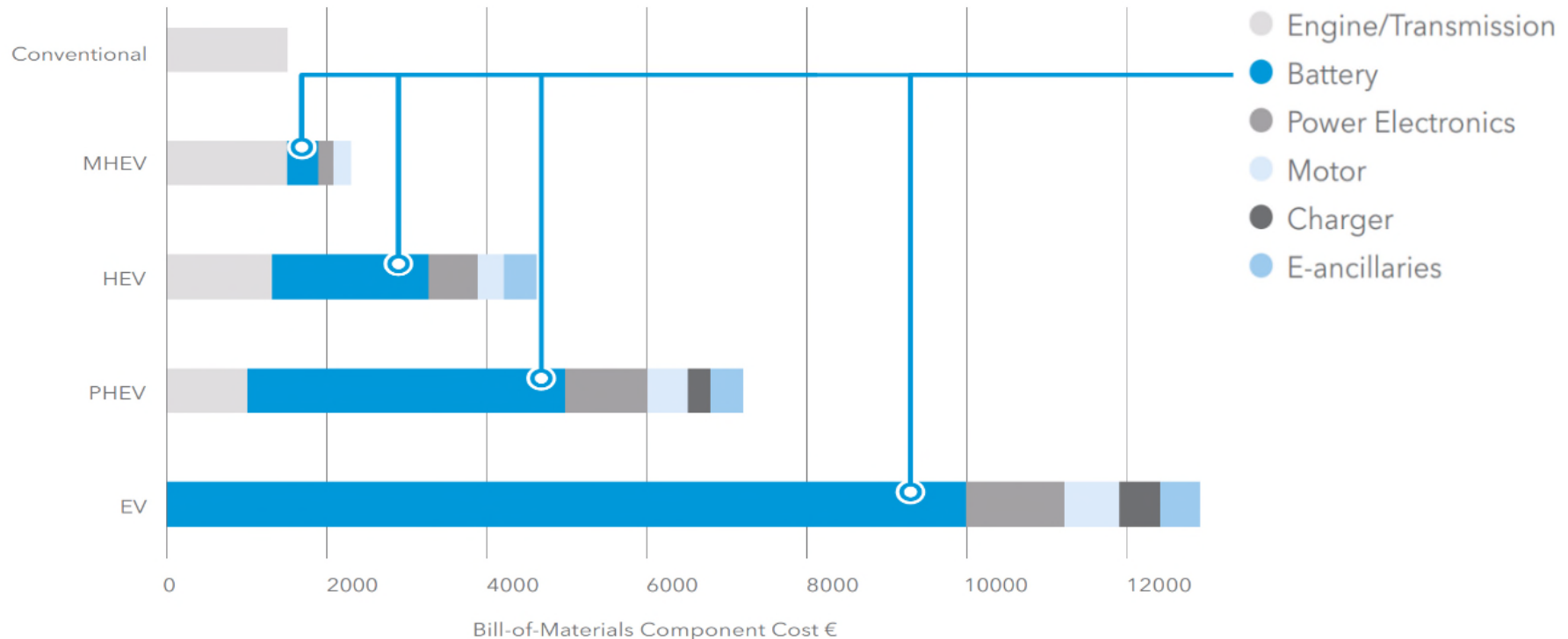
Consumer demand

Electrification is a journey with EV as the destination (for pass. cars)

| | Engine | Motor | “Battery” |
|--------------|----------------------------|---------------------------------|------------------------------|
| Conventional | 100kW Full transient | Starter motor Stop/start | 12V 3kW, 1kWh |
| Mild Hybrid | 90-100kW Full transient | 3-13kW Torque boost / re-gen | 12-48V 5-15kW, 1kWh |
| Full Hybrid | 60-80kW Less transient | 20-40kW Limited EV mode | 100-300V 20-40kW, 2kWh |
| PHEV | 40-60kW Less transient | 40-60kW Stronger EV mode | 300-600V 40-60kW, 5-20kWh |
| REEV | 30-50kW No transient | 100kW Full EV mode | 300-600V 100kW, 10-30kWh |
| EV | No Engine | 100kW Full EV mode | 300-600V 100kW, 20-60kWh |

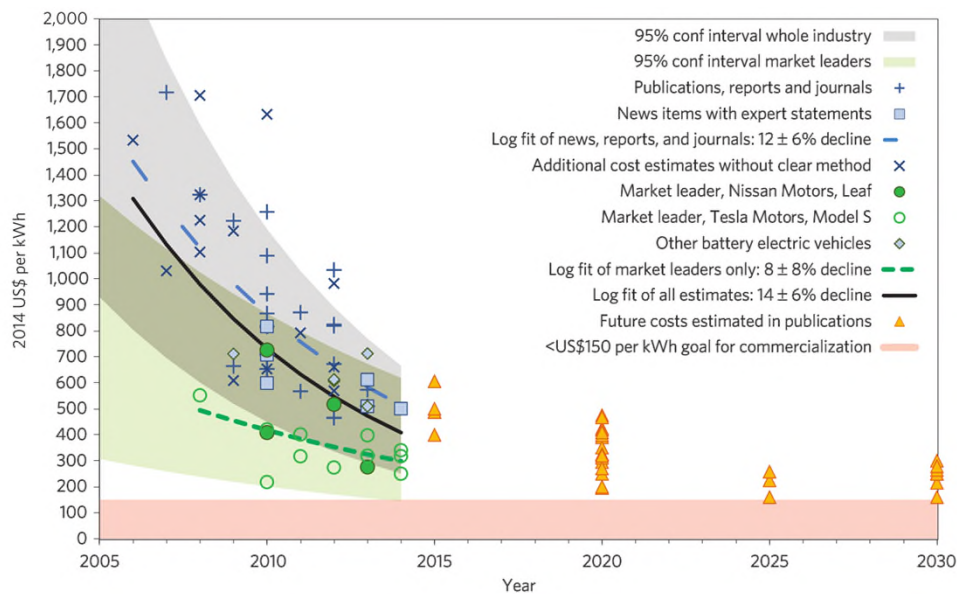
Increasing electrification brings increasing capital cost

COMPONENT COSTS FOR ELECTRIFICATION OF POWERTRAIN

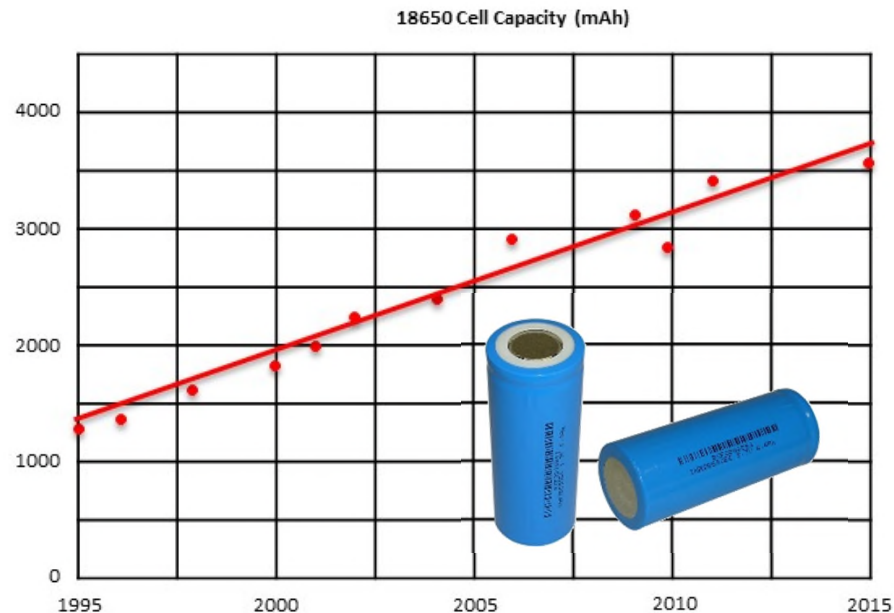


Lithium Ion batteries are improving rapidly – making EVs feasible

- ▶ Costs have fallen dramatically due to technology, production volume and market dynamics
- ▶ Pack cost fallen from \$1,000/kWh to <\$250/kWh in less than 8 years

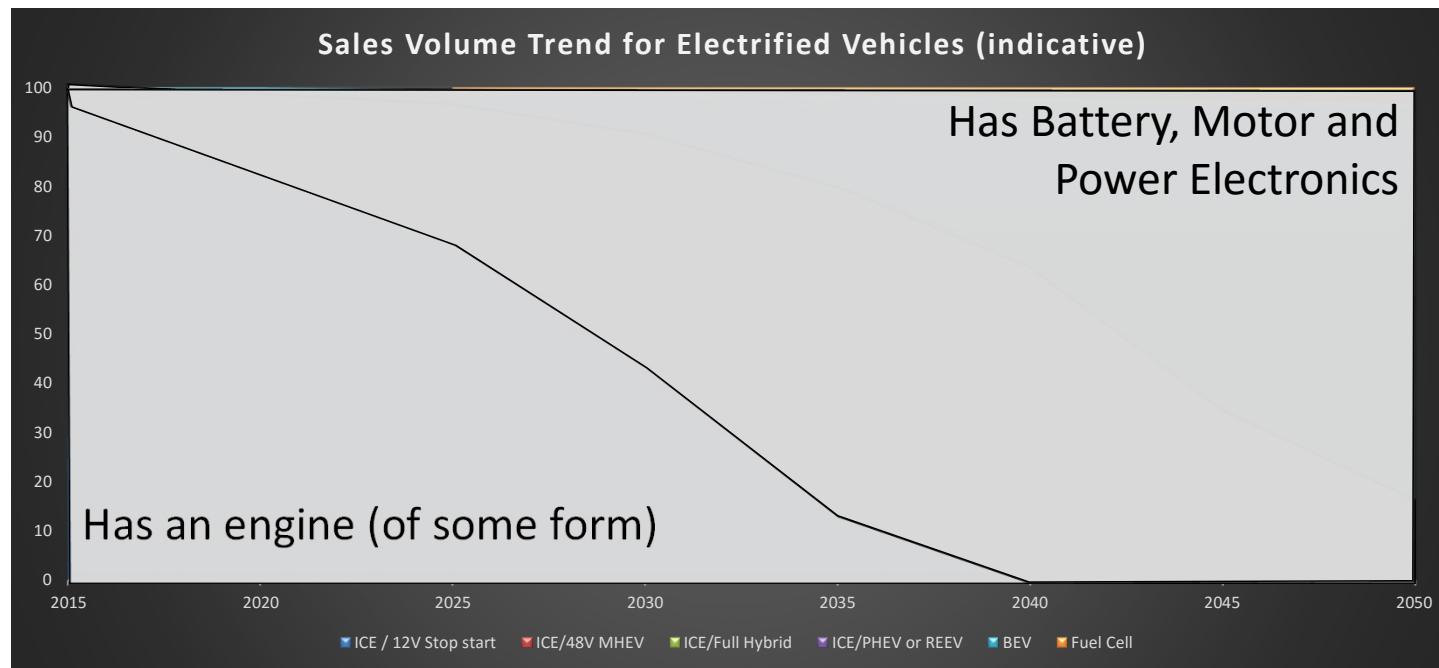


Nykqvist et al 2014



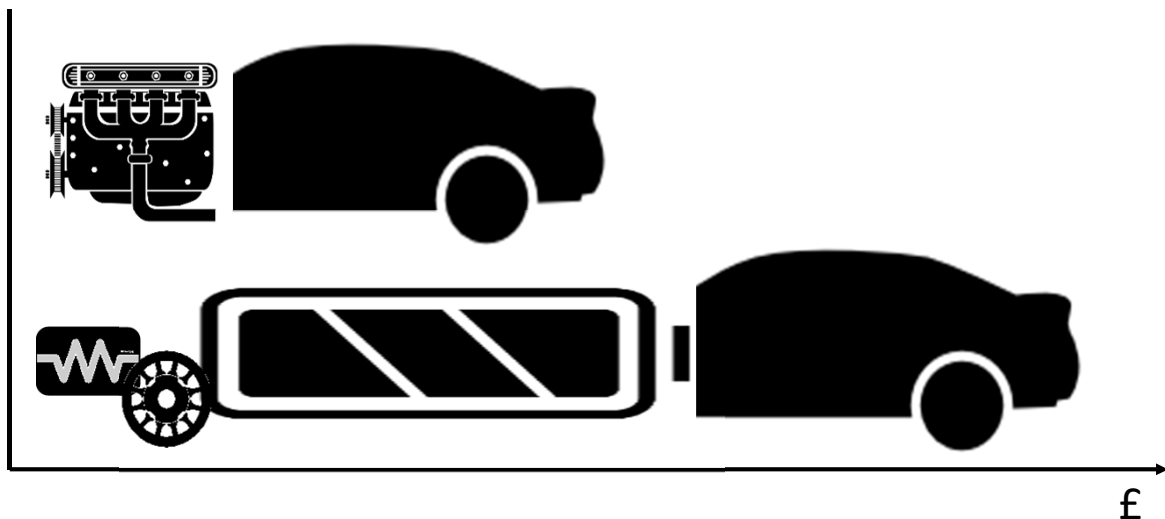
- ▶ Volumetric energy density is increasing due to better materials and cell structure
- ▶ Doubled in 15 years
- ▶ Requires continuous chemistry and materials innovation to continue

Electrification will not happen overnight....



- ▶ Market for engine components and systems still exists until at least 2035, and aftermarket until 2050
- ▶ But value will diminish
- ▶ Market for motors, power electronics and battery systems grows quickly
- ▶ **Easiest to enter market whilst small**

Electrification is a major commercial opportunity for the UK

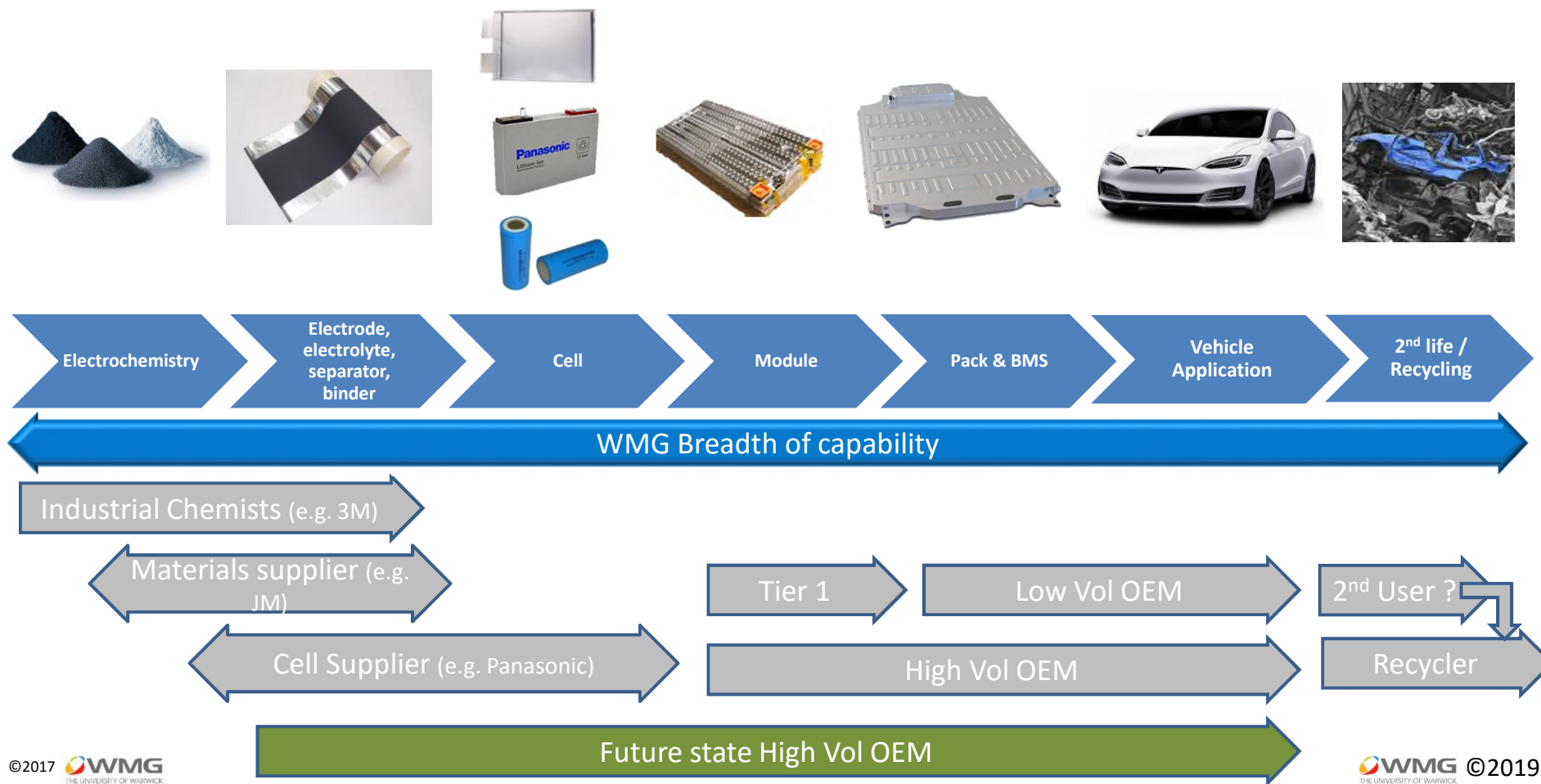


- ▶ One third of conventional vehicle cost is powertrain
- ▶ Motor and power electronics are similar in value to this
- ▶ Battery typically 5x that

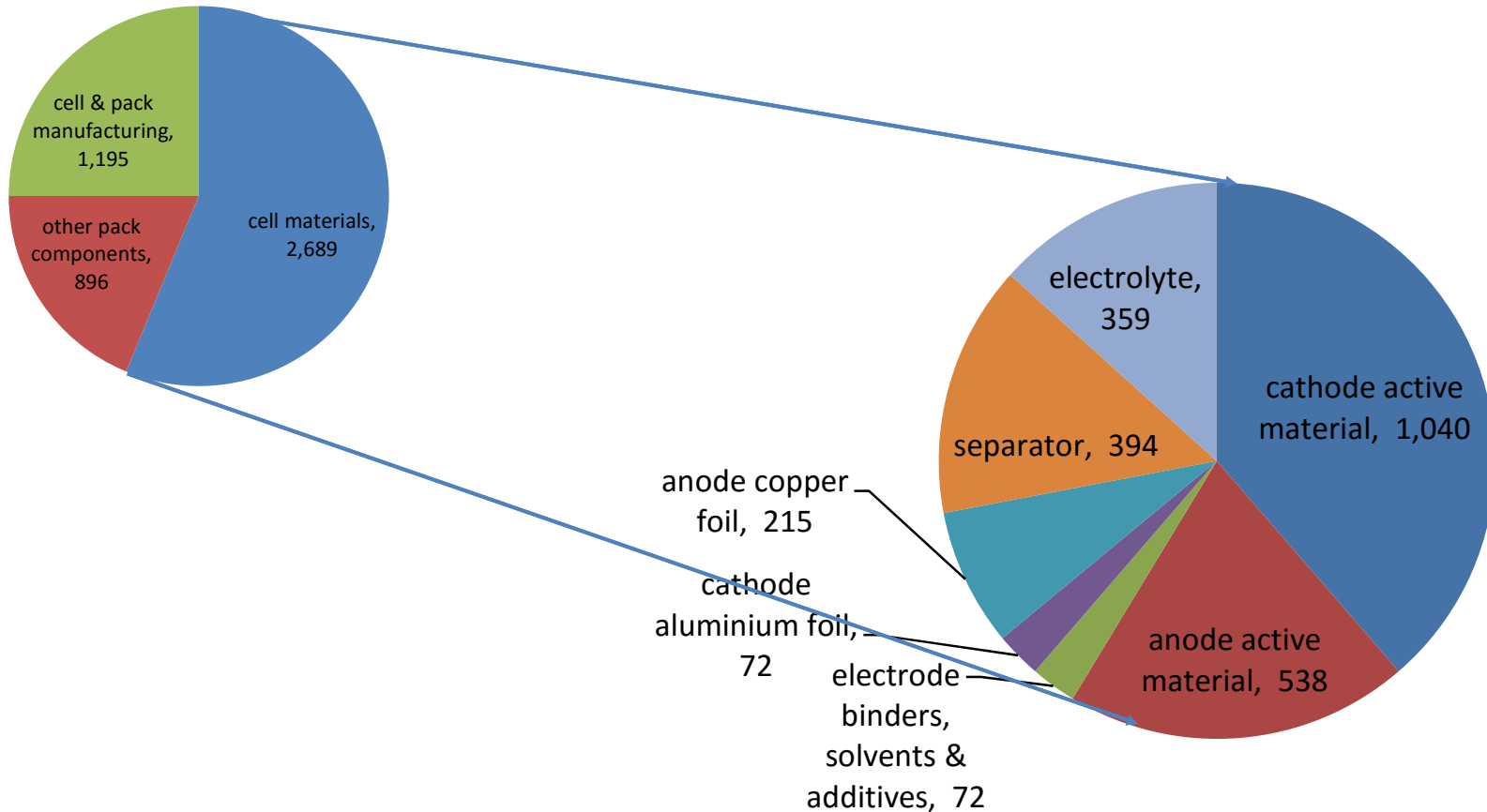
| Motors / drives | 2030 UK (\$ billion) | 2030 Global (\$ billion) |
|-----------------|----------------------|--------------------------|
| PHEV | 0.2 | 9.6 |
| BEV | 0.8 | 24.4 |
| Total | 1.0 | 33.8 |

| Batteries | 2030 UK (\$ billion) | 2030 Global (\$ billion) |
|--------------|----------------------|--------------------------|
| PHEV | 0.6 | 18 |
| BEV | 4.9 | 144 |
| Total | 5.5 | 162 |

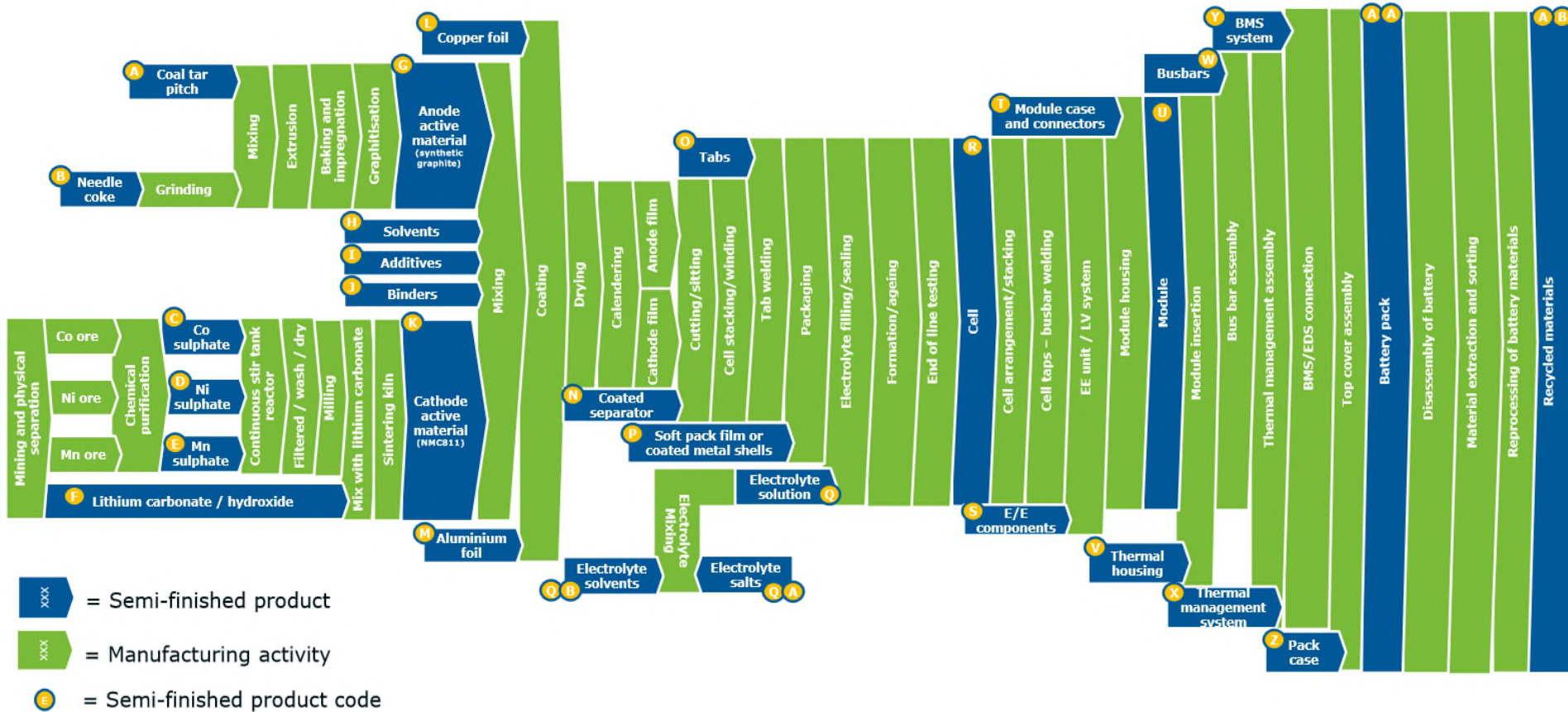
UK Supply Chain Opportunity for Batteries



Supply chain values - £M/year to supply UK in 2030

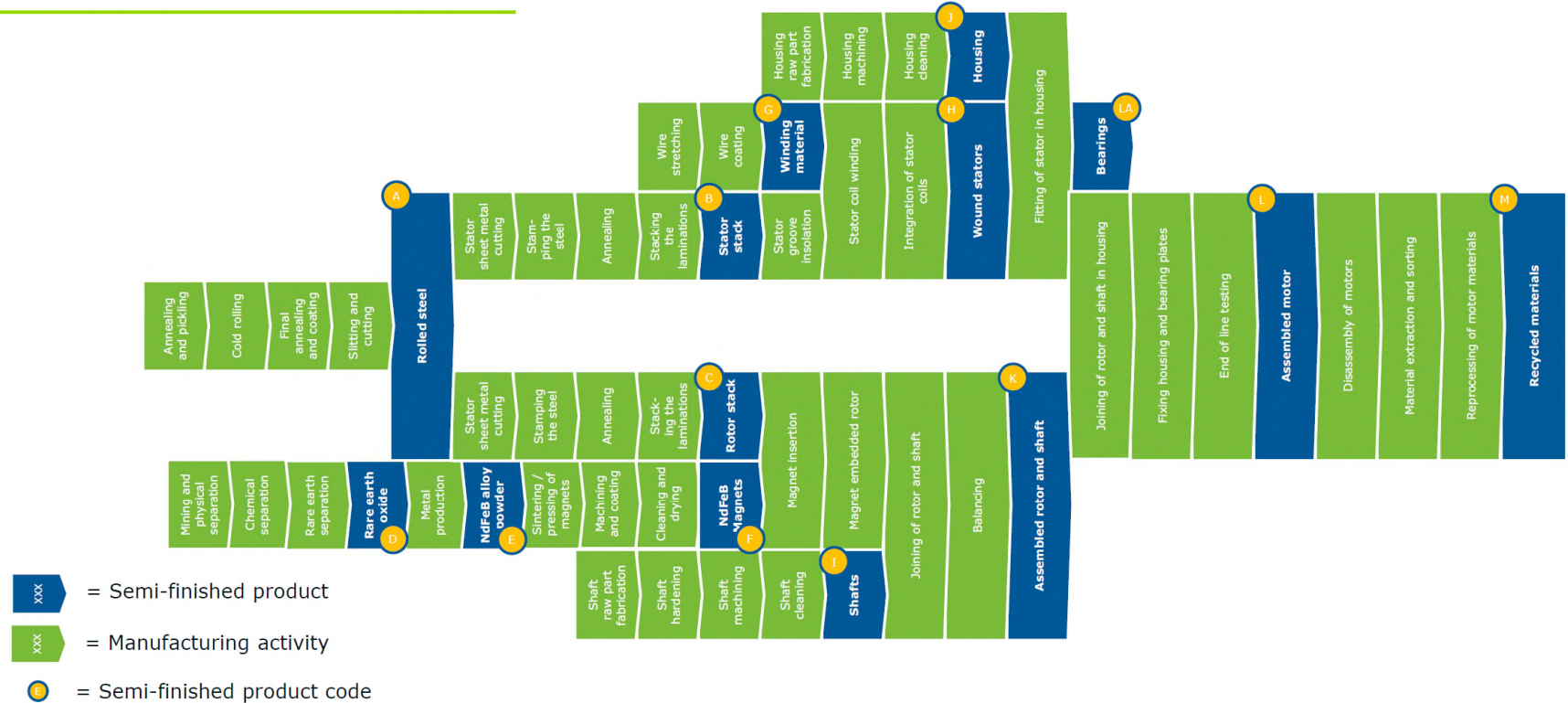


Battery Supply Chain - the whole story



E-Machine Value Chain

E-MACHINE VALUE CHAIN



Draft

Recycling – environmental necessity, economic opportunity

Conventional

Storage



Battery removal



Depollution



Airbag inflation



Vehicle recycling

ELV Directive

85% recycle/reuse
10% energy recovery



Electric

Storage



Battery removal



Depollution



Airbag inflation



Vehicle recycling

ELV Directive



Battery storage



Battery diagnosis



Battery transport



Battery recycling

Battery Directive
50% recycling

Electrification – No longer just automotive...



Thank you

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