

Vehicle Electrification Expo

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30th June 2022



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The Electric Vehicle Market is Growing Rapidly

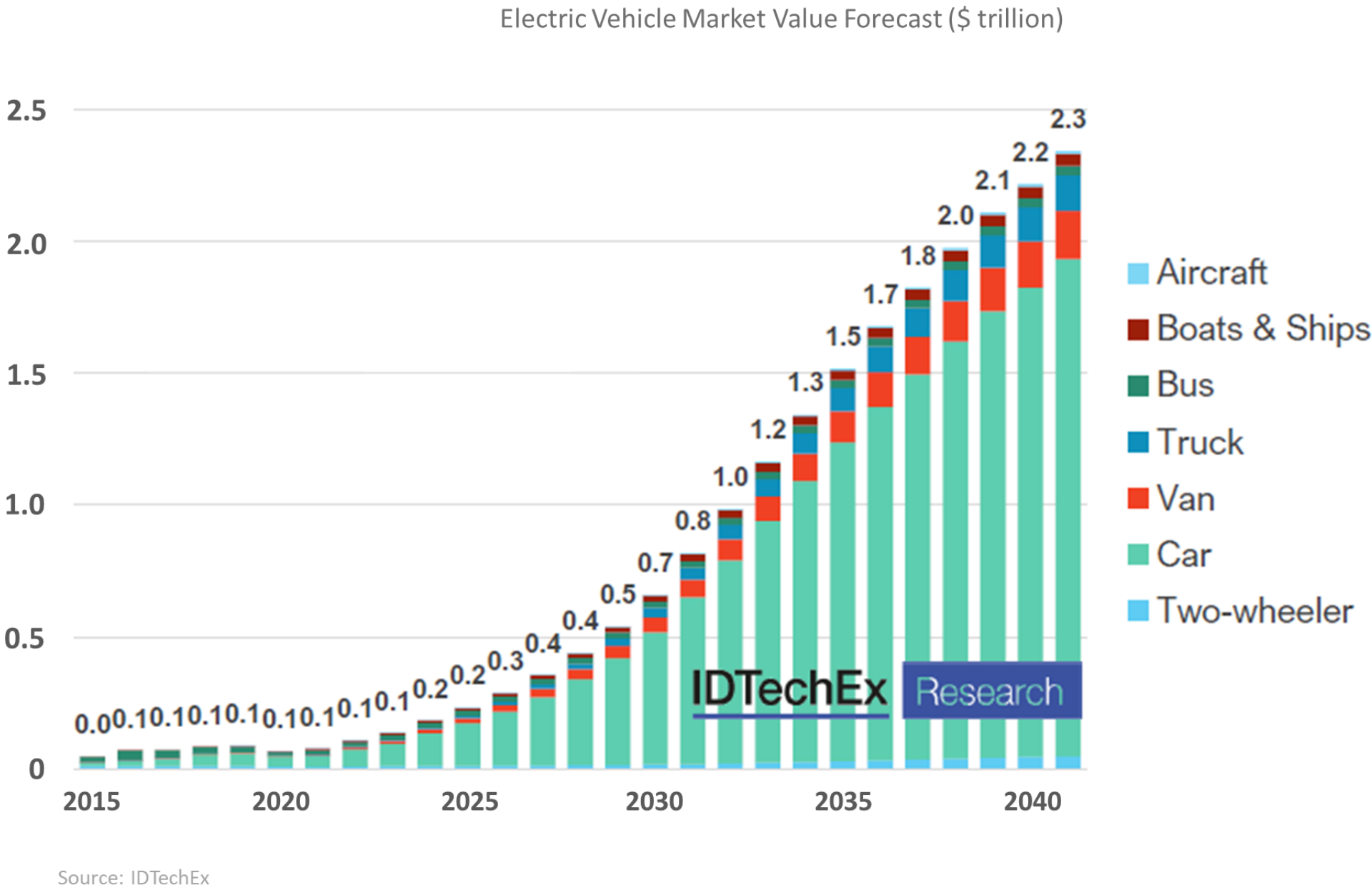
From passenger cars and two-wheelers to trucks, buses and marine

By 2041 there will be over
128 million
electric vehicles sold every year

By 2041 the global EV market will be worth over
\$2.3 trillion



This is a pivotal time across all the electric vehicle sectors.



But we have to make sure we use the right technologies

Today the best electric drivetrains rely on rare earth magnets



For every

1 tonne
of rare earths produced:



60,000m³
of waste gas that
contains
hydrochloric acid



200m³
of acid-containing
sewage water



1-1.4 tonnes
of radioactive waste

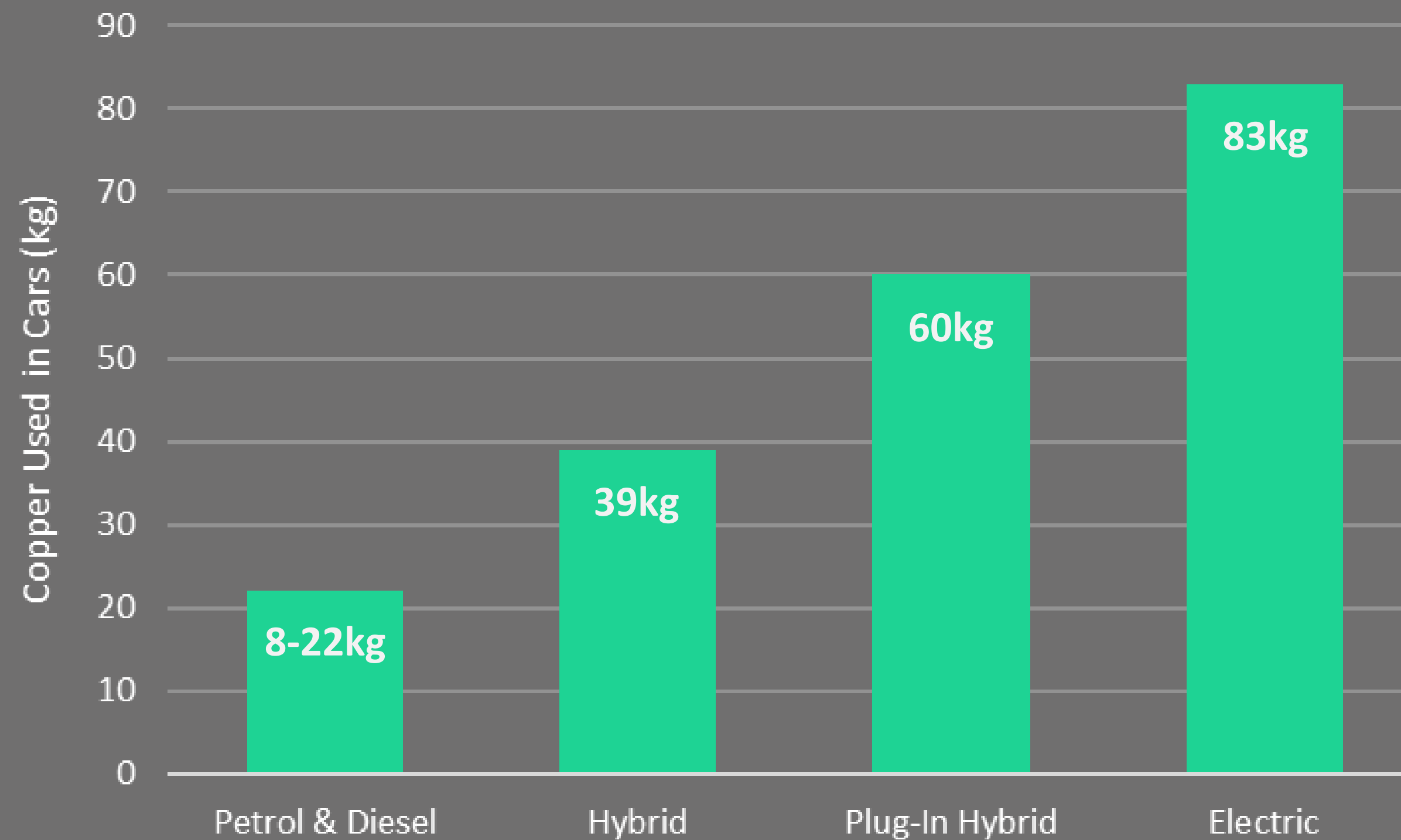


27.6 tonnes
of CO₂ equivalent
released into the
atmosphere

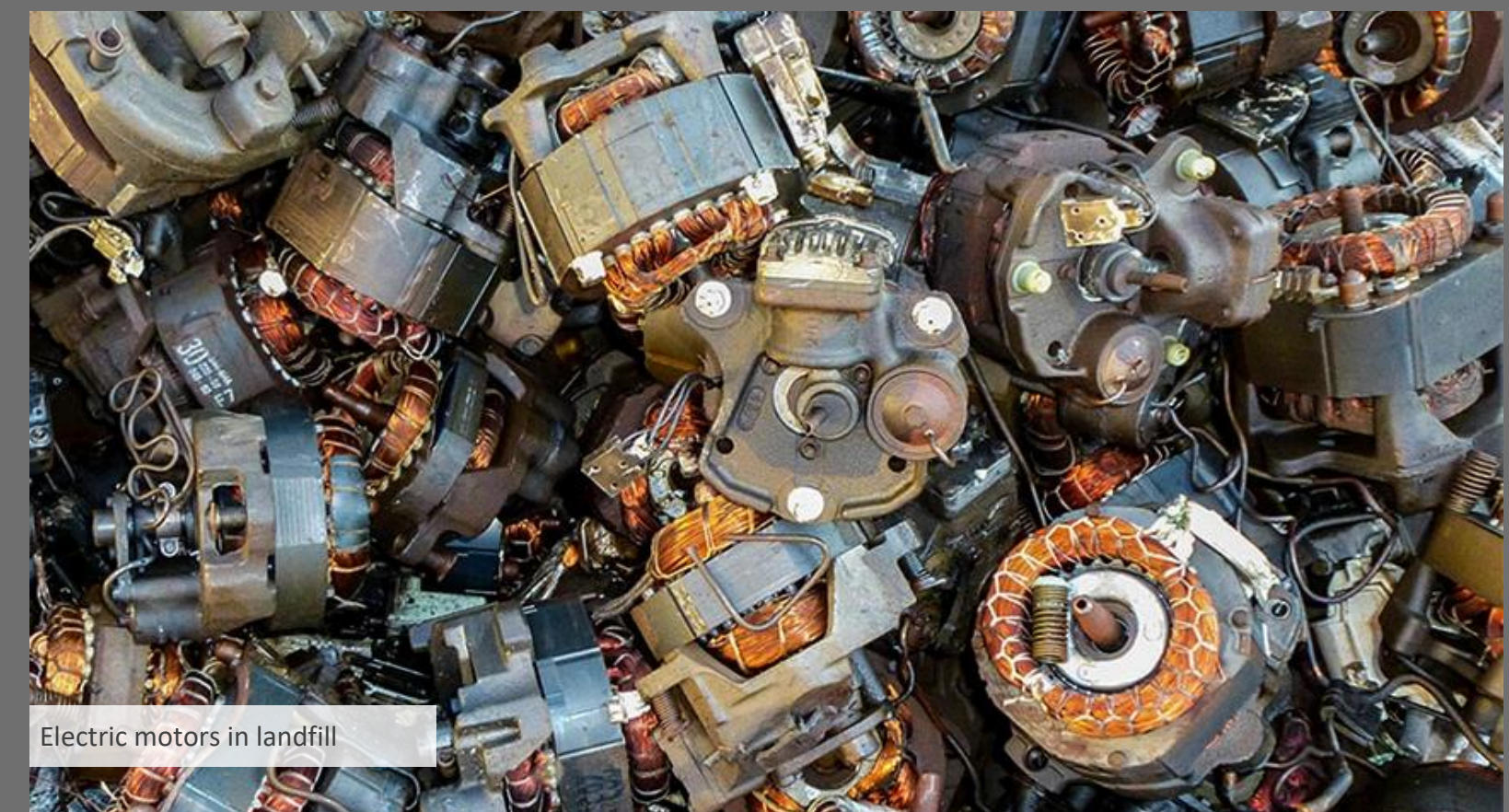
Adapted From: L. Hayes-Labruto et al. (2014), Rare Earth Pollution in Ganzhou, China Securities Journal, January 30, 2015 Rare Earths Shades of Grey, China Water Risk 2016 © China Water Risk 2016, all rights reserved

Even 'traditional' materials can become a problem

Copper is a significant material in electric vehicles, but it is difficult to recycle as part of vehicle waste



Source: CNBC



Making the right choices has the potential to change the world

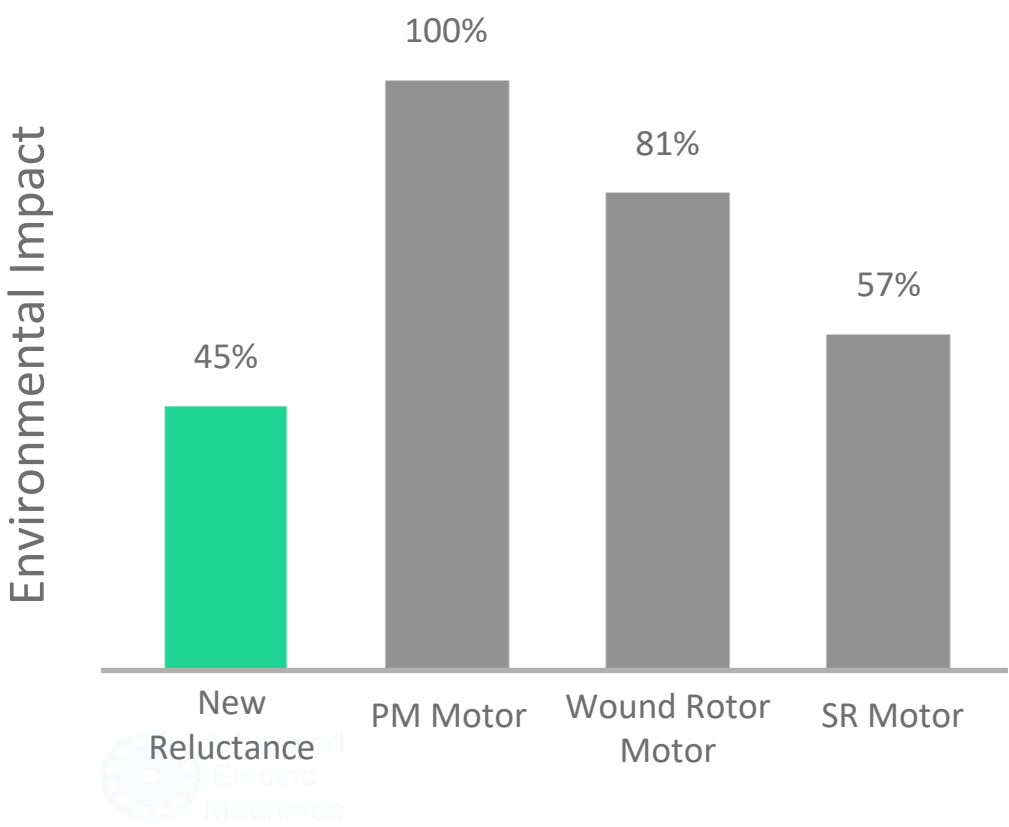
Holistic thinking from materials, through manufacturing, in-use and on to recycling is key

133M tonnes

of CO₂ equivalents saved per year compared to other motor electrification solutions available on the market today.



That is the same as removing 29,000,000 additional petrol cars from the road each year*



300k tonnes

of radioactive waste saved by eliminating the use of polluting rare earth magnets in our traction motors

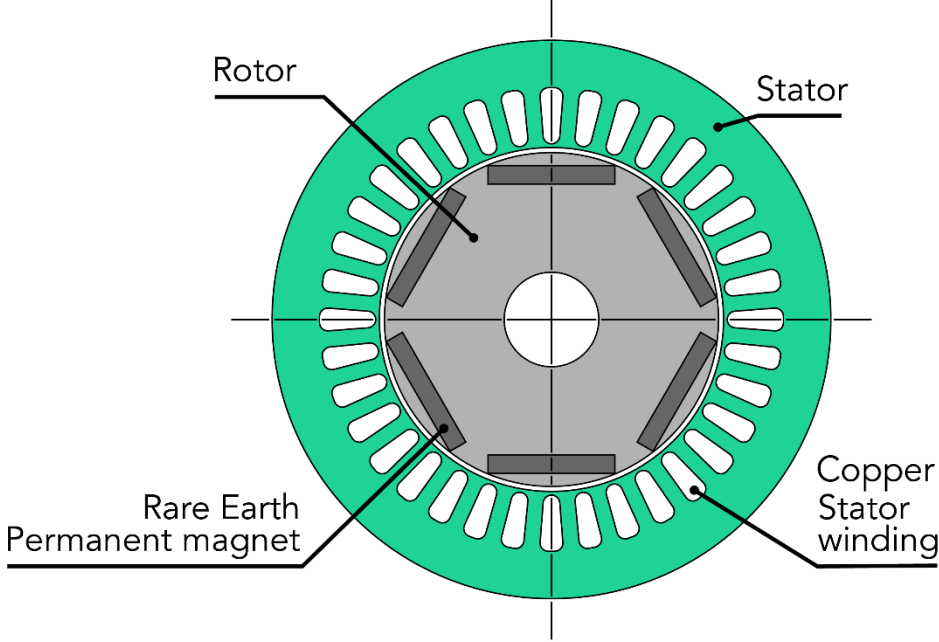
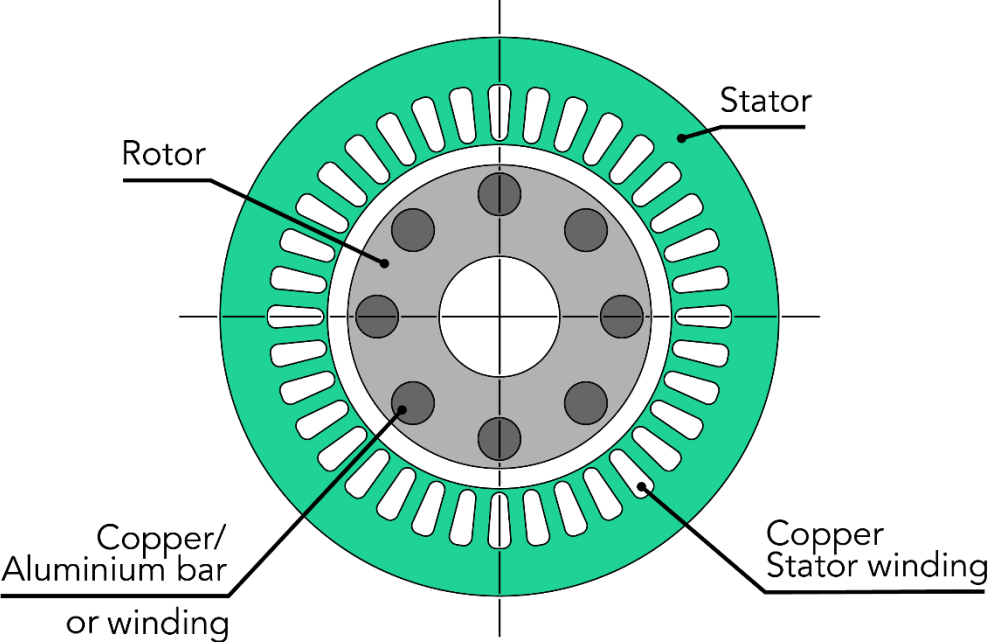
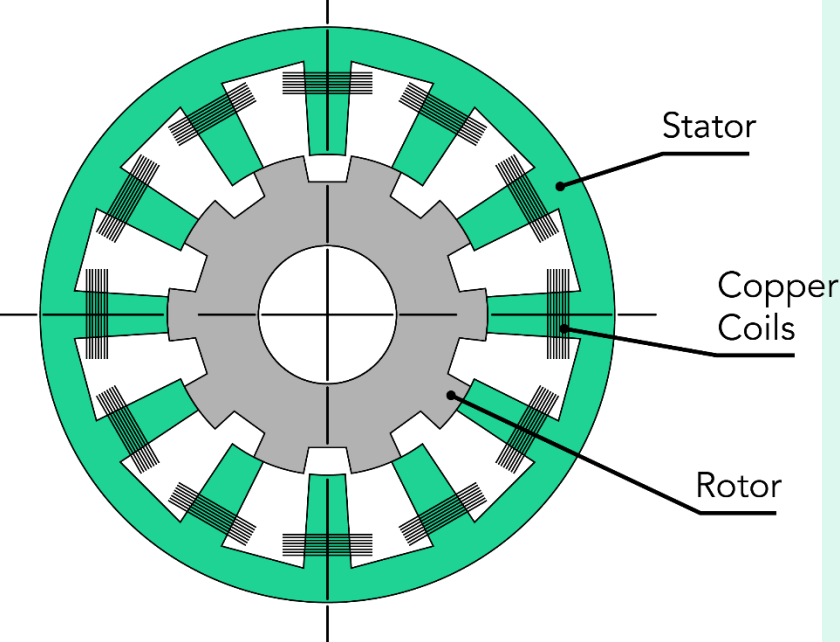
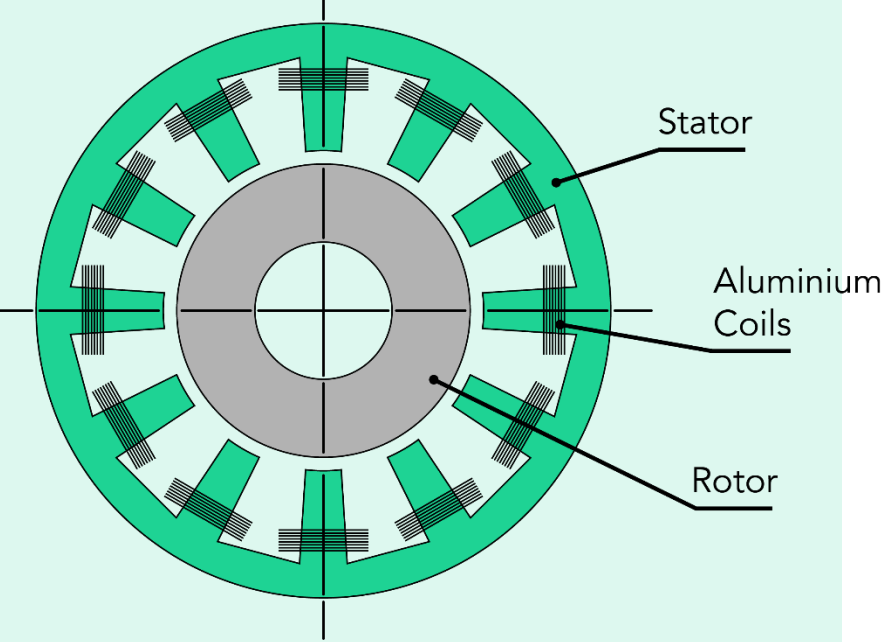
5M tonnes

less landfill per year as no rare earth metals or copper enable our motors to be fully recyclable at end of life

Source: Calculations based on IEA 'Global EV Outlook' report data
*Statistic from the US Environmental Protection Agency
Assumptions of 97 million cars produced per year, each containing 2.2kg of rare earths in the electric traction motor. 1kg of rare earths produces 30kg of CO₂ equivalent.

There are different alternatives to solving the problem

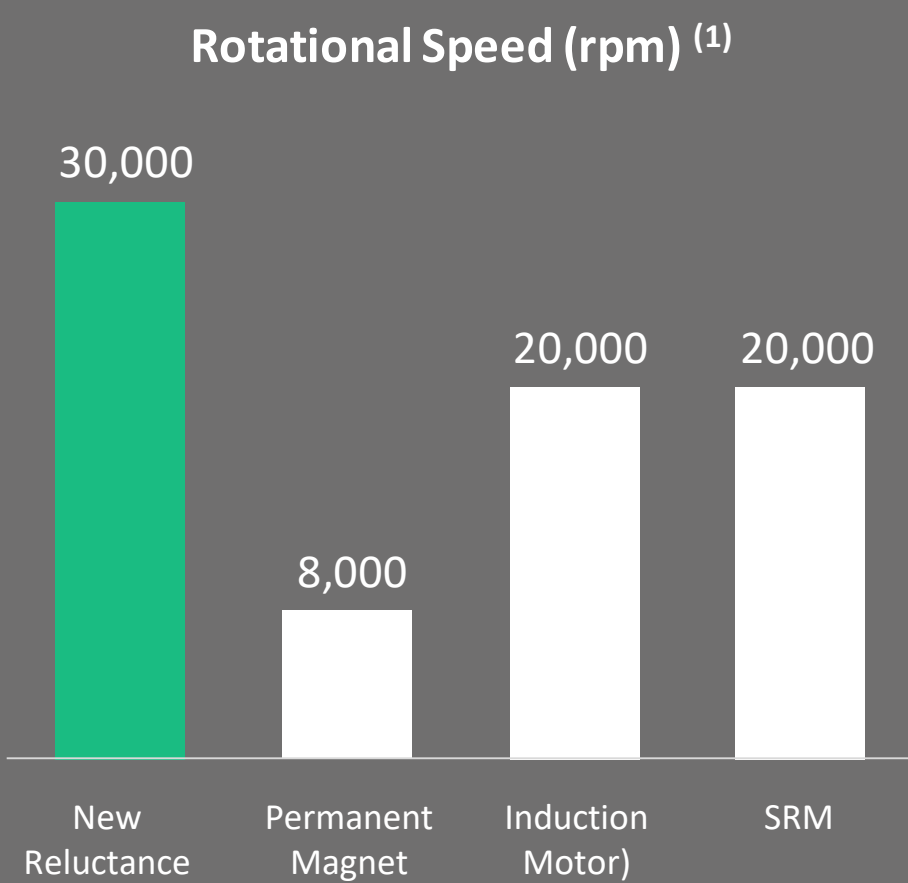
New reluctance motor designs offer a step-change improvement across the board

	Permanent Magnet Motor	Induction / Wound Field Motor	Switched Reluctance Motor	New Reluctance Motor
				
Rotational Speed	20,000rpm	18,000rpm	15,000rpm	30,000rpm (SSRD)
Efficiency	✓✓✓	✓	✓✓	✓✓✓✓
Sustainability	Rare Earths & Copper ✗✗	Copper ✗	Copper ✗	Aluminium ✓
Cost	\$ \$ \$ \$ \$	\$ \$ \$	\$ \$	\$
Use in Volume EV	Yes	Yes	No	Yes (CV)

Motors must deliver the performance demands the market has set for the next decade

While ensuring they meet the needs of multiple sectors

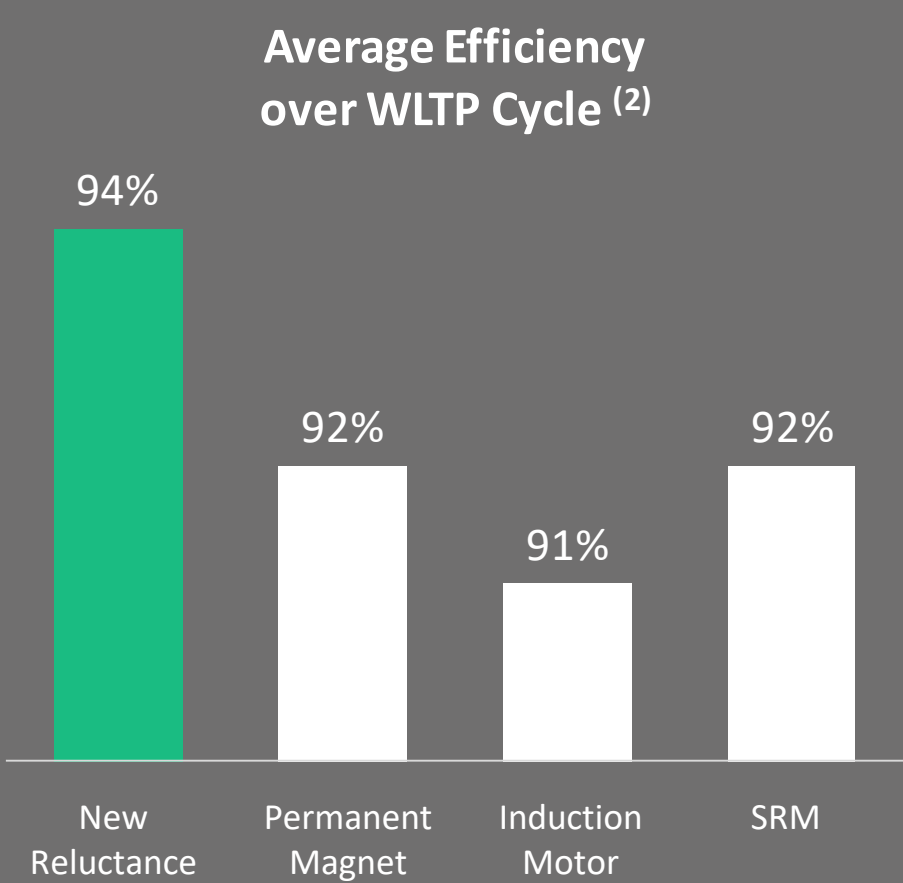
Faster



Higher Rotational Speed Means:

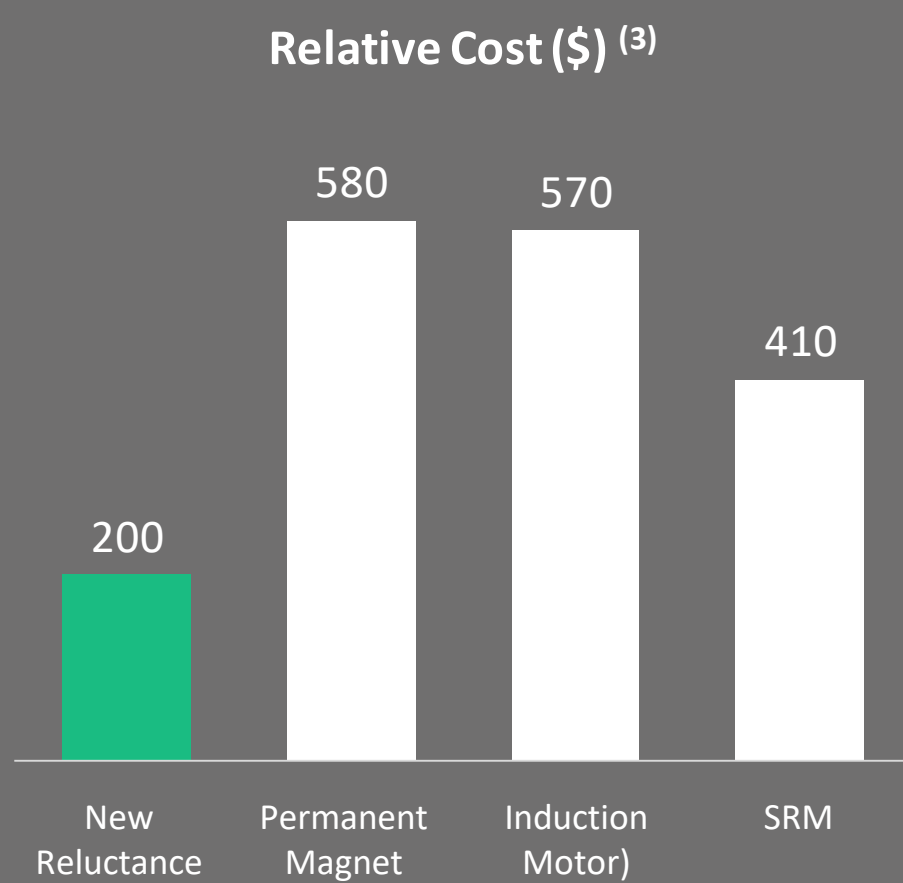
- Smaller, Lighter Motor
- Simpler, Less Expensive

Further



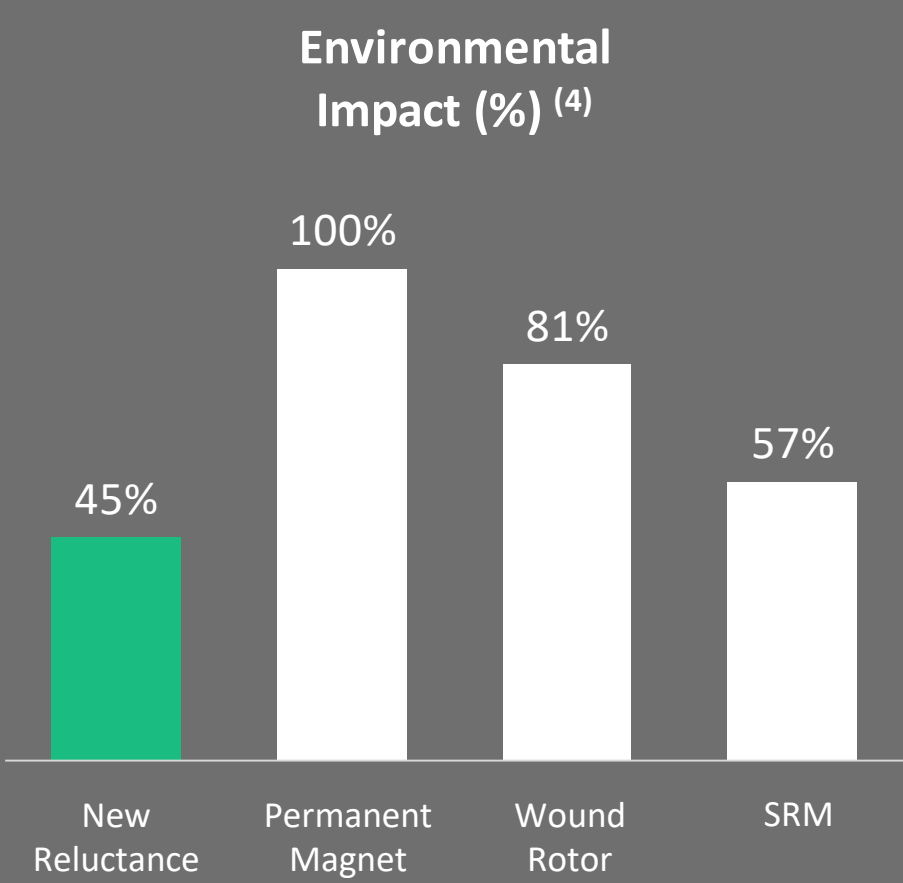
Customers report that new reluctance motors improve real world range by up to 12%

Lower Cost



New reluctance motors significantly reduce customer system costs

Greener



New reluctance motors are more sustainable than competitors

(1) AEM Internal Analysis based on competitors' published data.
(2) AEM Internal Analysis based on competitors' published data / customer feedback on their own analysis.
(3) Based on Newcastle University / Jaguar Land Rover / GKN / Sevcon / Tata Steel project findings (2016).
(4) AEM estimate based on Jaguar Land Rover Life Cycle Assessment of motor materials environmental impact.

AEMs new reluctance technology combines manufacturing and design innovation

Offering customers unparalleled benefits and class-leading efficiency



FULL MOTOR RECYCLABILITY

- Without disassembly at end of life (via steel arc furnace)
- Aluminium windings instead of copper



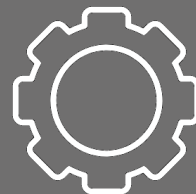
COMPRESSED COILS

- Improved power density
- Improved heat transfer capability
- Reduced packaging space



UNIQUELY WIDE SPEED RANGE

- Full vehicle speed ranges
- Simplified, single speed transmission
- Minimised transmission losses



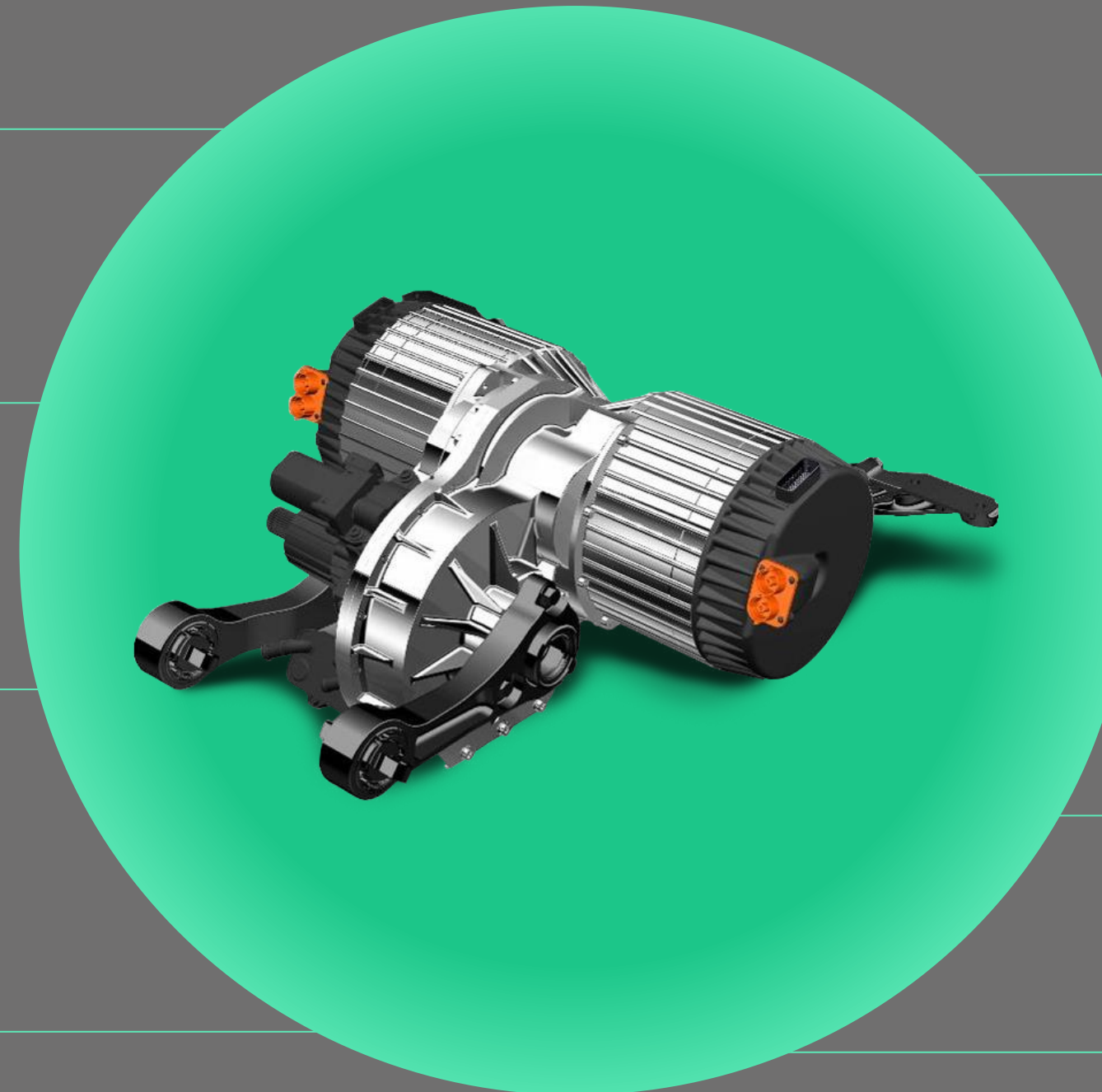
ROTORS CAN FREEWHEEL

- No electromagnetic drag losses – increases efficiency
- Improved part load efficiency with single motor operation
- Allows vehicle to coast when appropriate



NO RISK OF ROTOR DEMAGNETISATION

- No change in electromagnetic torque with temperature
- Reduced thermal management system complexity and risks



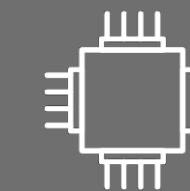
UNIQUE MOTOR CONTROL APPROACH

- Magnet-free motors using standard, off-the-shelf controllers
- Control optimised to maximise efficiency



UNIQUE ROTOR DESIGN

- More compact rotor
- Maximises torque and efficiency
- Allows for very high speeds



FULLY INTEGRATED POWER ELECTRONICS CONCEPT

- Single casing reduces material usage
- Minimises connecting power leads and communication wires



SAFE FAILURE MODES

- No magnets to cause short circuit currents or high voltages



LIGHTWEIGHT GEARS

- Unique gear design
- Low noise
- Low inertia — essential in high speed transmissions



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