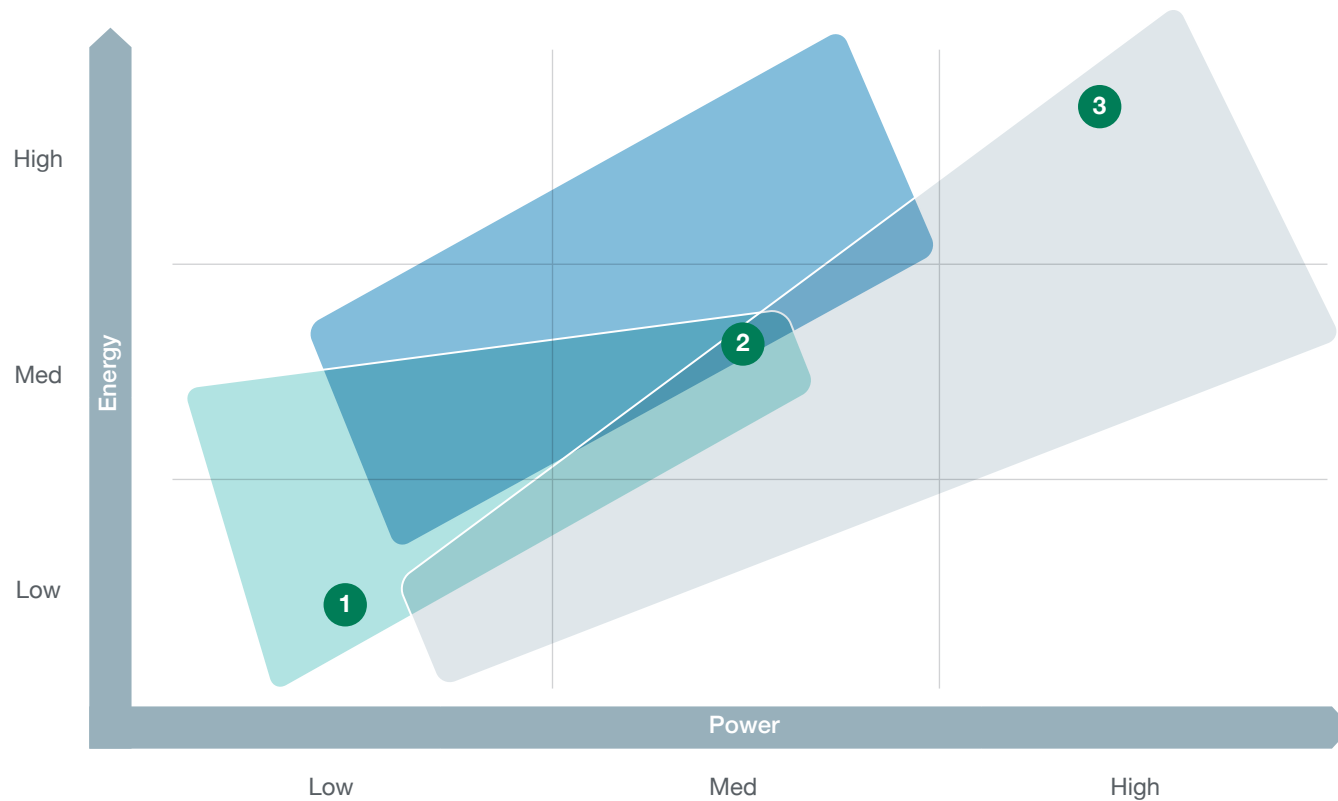




Energy-power spectrum across applications

Propulsion systems are tailored to specific power and energy demands, based on their use case and duty cycle. The graph below presents an outline of principle mass-market products.



Light Duty Vehicles <3.5T Buses and coaches Heavy Goods >3.5t and Off-highway Vehicles

The 2020 roadmap provides values for (1) Cost effective, high volume indicators.

Values for (2) Power dense, high performance and (3) High power, ultra-high efficiency applications will be developed with industry in due course.

- 1 Cost effective, high volume orientated:**
Achieving economies of scale at a low cost is paramount for these products. Applications include high volume passenger car and delivery vans (majority 400V).
- 2 Power dense, high performance orientated**
High power densities are required with cost a less decisive factor. Applications include performance passenger cars, buses and some medium duty vehicles (800V prevalent).
- 3 High power, ultra high efficiency orientated**
High power densities and reliability are needed for these applications but efficiency is key to maximise energy use. Applications include 44 tonne trucks and large, off-highway vehicles (700-1,200V).

**Technology indicators for cost effective, high volume applications**

Technology indicators that industry is likely to achieve in a mass-market competitive environment. All the cost and performance metrics are ambitious, but relate to the same technology.

		2020	2025	2035
Electric Machine Indicators	Cost (\$/kW)	6	4.8	3.3
	Volumetric Power Density (kW/l)	8	25	30
	Gravimetric Power Density (kW/kg)	4	8	10
	WLTP Average Efficiency	93%	95%	97%

The below table represents the indicator specifications used for the roadmap. These are for reference only, and do not reflect a target spec.

Electric Machine Indicators Spec	2020	2025	2035
Peak Power	100kW	100kW	100kW
Continuous Power	50kW	50kW	70kW
Input voltage (nominal)	400V	400V	800V
Output current (max)	450A rms	450A rms	225A rms
Coolant inlet temperature	65°C	65°C	65°C
Production volume	>100k	>100k	>200k

Notes:

- The electric machine indicators above refer to **1 Cost effective, high volume** applications. See page 1 for other indicators which present other product applications.
- The cost indicator represents the price an OEM would be expected to pay for a cost effective, high volume electric machine.
- All masses and volumes include the active electromagnetic components of the motor, the shaft, casing and any heatsinks. They should not include the mass of any cooling fluid, external radiator or fluid pump. Electrical filters and power electronic components should not be included.
- Continuous power and torque should be sustainable for at least 15 minutes.
- Power is Net Power, as defined in ECE R85.
- WLTP Average efficiency refers to powertrain efficiency. This should be read as the motor, inverter and the transmission achieve the indicated efficiency value for 2025 and 2035.



This roadmap represents a snapshot-in-time view of the global automotive industry propulsion technology forecast for mass market adoption. Specific application-tailored technologies will vary from region to region.



Dark bar: Technology is in a mass market application. Significant innovation is expected in this time frame



Transition: Transitions do not mean a phase out from market but a change of R&D emphasis



Dotted line bar: Market Mature – technology has reached maturity. Likely to remain in mass market until it fades out where it's superseded

