Light Duty Vehicle <3.5t Roadmap 2020

Narrative Report

February 2021 | Version 1.0

automotive council UK

ADVANCED PROPULSION CENTRE UK

Overview: Light duty vehicle propulsion is under pressure and transition is inevitable

External pressures are stronger than ever

The automotive sector faces tightening regulation on multiple fronts, whilst at the same time consumers are changing their relationship with mobility. In the backdrop, there are significant pressures to reduce global carbon emissions to net zero by 2050. Transport is responsible for nearly 30% of the EU's total GhG emissions; almost 73% if this is from light duty vehicles (passenger cars and light trucks). Urban pollution and congestion add further pressures, bringing tailpipe regulations, mandates for ZEV sales, city restrictions, consumer environmentalism, life cycle manufacturing demands and more.

Global uncertainties remain

Vehicle and energy companies are responding with new vehicle types and propulsion options. Despite the global nature of the LDV sector (comprising cars and vans), the regulation and fleet demands vary by region, country and city. The recent UK Government's decision to end the sale of petrol and diesel engine vehicles by 2030* (hybrids by 2035) was unknown at the time of publishing the UK Automotive Council roadmaps and added uncertainty to the inputs collated but possible eventualities were factored in.

A race of three technologies

Battery electric vehicles are key to zero-tailpipe emission vehicles. New thermal propulsion technologies and emerging fuel cells can each play a role in addressing road transport's air quality and CO_2 imperatives and can deliver net-zero objectives. These technologies vary in maturity, cost and related infrastructure. The traditional automotive industry and its supply chains benefit from commonality and scale, so a focussed approach will benefit. None of these technologies are mutually exclusive, with ICE hybridisation and fuel cells co-dependent on advancing battery technologies. The roadmap, informed by a wide industry consultation, charts the journey of these three propulsion technologies and routes to mass market adoption.

* Announced by UK Prime Minister Boris Johnson on 18th Nov 2020

A full glossary is provided at the end of this report

Foreword and Acknowledgements

The APC would like to acknowledge the extensive support provided by industry and academia in development and publishing this roadmap.

We are grateful to the Automotive Council for entrusting us with the product and technology roadmaps refresh and their continued support.

This work has received significant support from BEIS (Department for Business, Energy and Industrial Strategy).

Graham Hoare
Chair of the
Automotive Council

The automotive sector began 2020 preparing for a uniquely disruptive decade. Stringent CO_2 and air quality legislation regulation has underscored a shift in powertrain development with promising alternatives emerging. The coming decade is no different with key technologies such as autonomy, connectivity and electrification enabling an ambitious net zero transport systems by 2050. To realise this vision and maintain the automotive sectors sustained growth, our industry must continuously innovate so vehicles are both environmentally benign and cater for the world's changing mobility habits.

Since 2009, the Automotive Council has ensured the UK remains at the forefront of automotive technology development and production. Our product and technology roadmaps are an informative resource that are used globally as strategic documents. The updated 2020 product roadmaps are no different and mark a significant improvement from 2017. Developed through a robust industry consensus process, the updated product roadmaps offer a fresh way of charting the development of future vehicle innovations. By putting mobility at the heart of the update process, we were able to define powertrain development trajectories for light duty vehicles, better integrate heavy duty vehicles and off-highway vehicles as well as show a clear direction for the future of the bus and coach sector.

While organisations may take a different view on some topics, the roadmap's consensus driven approach and detailed analysis of trends make this document a must read for those working in low carbon mobility. The Automotive Council looks forward to continuing working with UK Government, academia and industry to ensure that the barriers to adopting new vehicle and powertrain architectures can be addressed and capitalised upon to provide sustainable benefits to us all.

Neville Jackson
Chair of the Automotive Council
R&D Workstream

Since they were first published in 2009, the Automotive Council's roadmaps have been instrumental in signposting the most likely evolving technology paths to deliver a de-fossilised and more sustainable future vehicle parc.

With almost 30% of all greenhouse gases in the EU coming from the transport sector, the industry is mobilising an ambitious plan to rapidly accelerate the development of zero-tailpipe and net-zero carbon propulsion technologies. This plan also requires the development of sustainable, renewable and clean energy sources and the infrastructure to deliver this in accessible form to consumers and operators, including that required for off-road and construction vehicles.

Battery electric technology has developed at a promising pace, with signs of significant early market share uptakes in most geographies. The technology selection for heavy duty and off-highway vehicles remains challenging with long distance transport, high-power demands and viable business cases to consider. The bus and coach sector is well on its way to expanding its fleets of battery electric and fuel cell vehicles to meet mass mobility needs although more needs to be done to make these vehicles affordable.

By using powertrain power ratings and energy sources to map the demand of each vehicle type, the 2020 roadmaps communicate competing technologies that can deliver the sector's long-term zero tailpipe and net-zero carbon ambitions.

The UK has an important and long-standing role to play in the automotive supply chain as it competes in an increasingly challenging international market. Our aim with these roadmaps is to show that the Auto Industry has a largely common, logical and well planned vision in developing propulsion technology towards a greener future.

Executive Summary

Urban Mobility

Batteries play a strong role, with ICE hybrids in the near term and potentially fuel cells longer term.

Urban mobility has a lower power and energy demand for most applications. Battery electric vehicles are well-suited for this, whilst ICE vehicles diminish in demand over the coming decade. Enhanced battery energy density and faster charging are expected to improve BEV applicability for drivers unable to recharge at home or work, and for MaaS.

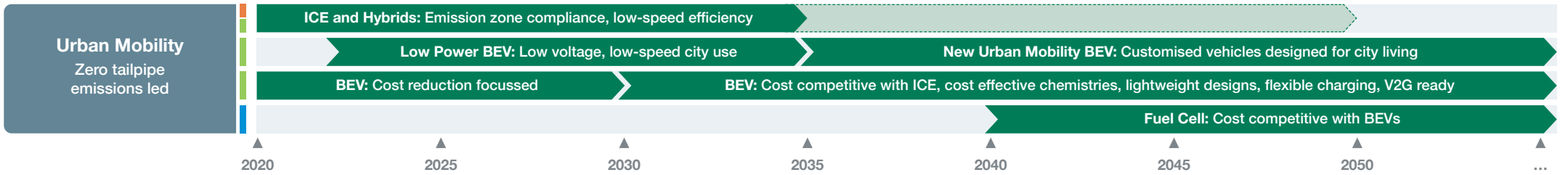
Depending on the development and evolution of cost-competitive FCEVs, these may feature in the urban mobility segment, providing greater autonomy and faster filling than equivalent BEVs. A suitable hydrogen infrastructure and customer confidence for this technology will determine adoption in the long term.

Urban Mobility
Zero tailpipe emissions led

Typically Low Power

High Volume Compact Passenger Car

Small Urban BEVs



Long Range Mobility

ICE hybrids endure in some markets, batteries become established but may not compete with fuel cells longer term.

Long range mobility brings greater power and energy requirements. New ICE propulsion systems, developed specifically for net-zero carbon fuels and/or electric-only mode operation in cities, can continue to offer a viable solution but depend on local jurisdiction decisions. BEVs are already available in this segment and technology advances are expected to increase their appeal in terms of cost and usability. This will require fast charging to be widely available beyond cities. However, batteries may not meet the needs of LDVs that require long range without significant cost and weight increase from today's equivalents. FCEVs are expected to provide range parity with ICEs in the medium term and compete on a total cost basis with BEV and ICE vehicles in the longer term. Like fast charging infrastructure, hydrogen refuelling will be a prerequisite.

Long Range Mobility
Net-zero* emissions led

Typically Medium Power

< 3.5t Vans

High Volume Passenger Car

High Power and Performance

ICE hybrids endure where permitted, batteries already suited for high power, fuel cells may enter for long range.

High power and performance vehicles are typically higher priced, allowing them to overcome early-adoption barriers to investment costs for advanced technologies. Advanced (hybrid) ICEs may endure the longest in this segment, not least because of their higher power to weight capability. High performance BEVs are well-suited to this segment and likely to be the first adoption point for advanced EV architecture and battery innovation that appear later in more mainstream vehicles. FCEVs are suited to applications where high onboard energy is required, such as heavier SUVs, or work vehicles featuring auxiliary power supply. Power hungry solutions, for high torque (e.g., towing), are possible across all propulsion technologies and best customised on a case-by-case basis.

High Power and Performance
Net-zero* emissions led

Typically High Power

High Performance

High Power SUV / Pick-up

High Power and Performance
Net-zero emissions led

ICE and Hybrids: Augmenting ICE performance

Dedicated Hybrids: Using net zero fuels with urban emission zone compliance

BEV: 800V systems, wireless charging

BEV: Mainstream performance with high performance battery chemistries, light weight designs, ultra-fast charging

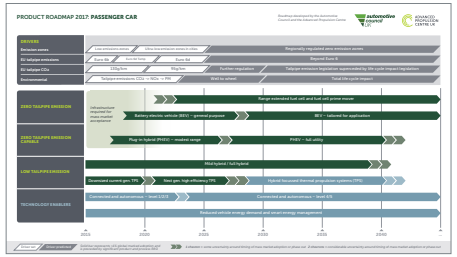
Fuel Cell: Mainstream performance – SUVs, pick-ups, sports and luxury segments

2020 2025 2030 2035 2040 2045 2050 ...

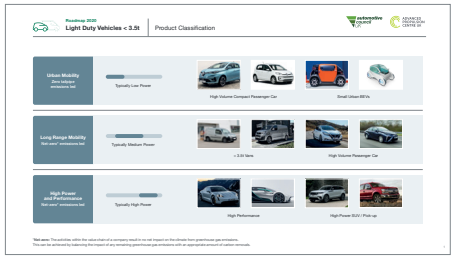
Roadmap Development

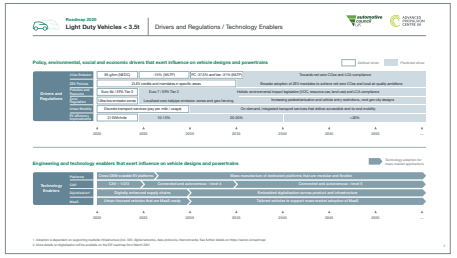
The 2020 roadmap responds to a changing automotive environment

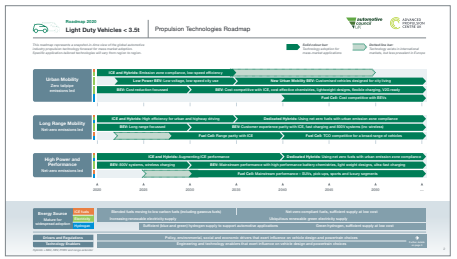
2017 Passenger car roadmap



2020 Light Duty Vehicle roadmap







Changes to industry drivers

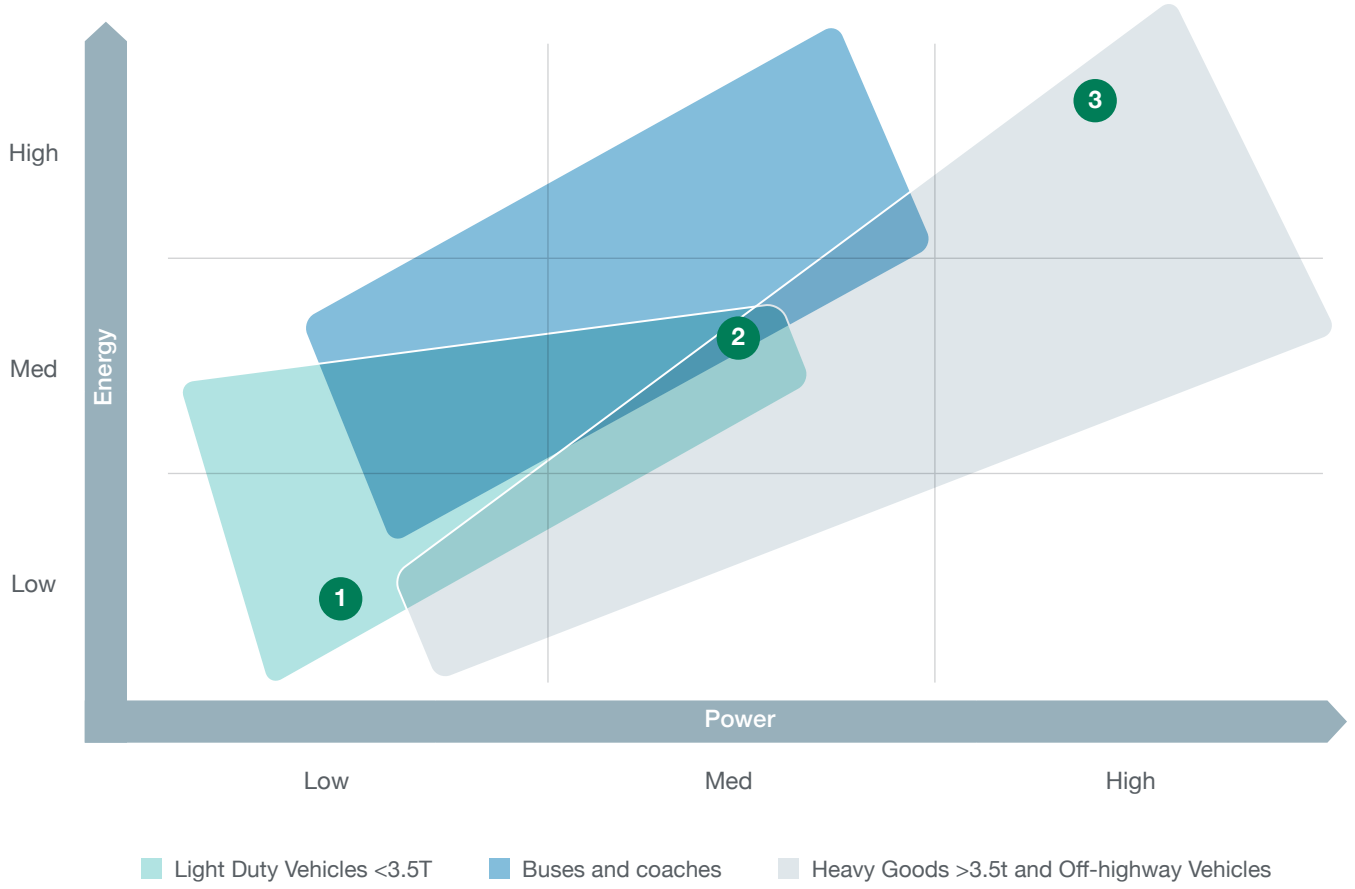
- Net-zero ambitions to decarbonise transport by 2050
- ZEV mandates and ICE sales bans entering many markets
- Zero emission zone regulation growing in several cities
- Novel mobility and last mile goods services growing
- Discerning consumers are demanding higher EV efficiencies

Changes to roadmap structure

- A three-page format explaining vehicle types, the roadmap, and drivers and enablers
- Vans combined into the LDV roadmap, having common regulation and platform requirements with passenger cars
- Product types split based on power and energy:
  - Urban mobility (low power, low/medium energy)
  - Long range mobility (medium power, medium/high energy)
  - High power and performance (high power, medium/high energy)
- Energy carriers are linked to each propulsion technology

Presenting products in a new way

A new classification using product type combined with typical usage patterns; expressed in POWER and ENERGY.



The new Automotive Council roadmaps for 2020 appreciate that different vehicle applications will require different powertrain solutions based on their energy and power demands.

Roadmap Narrative

Roadmap 2020

Light Duty Vehicles < 3.5t

Product Classification

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Urban Mobility
Zero tailpipe emissions led

Typically Low Power


High Volume Compact Passenger Car


Small Urban BEVs

Long Range Mobility
Net-zero* emissions led

Typically Medium Power


< 3.5t Vans


High Volume Passenger Car

High Power and Performance
Net-zero* emissions led

Typically High Power


High Performance


High Power SUV / Pick-up

*__Net-zero:__ The activities within the value chain of a company result in no net impact on the climate from greenhouse gas emissions.
This can be achieved by balancing the impact of any remaining greenhouse gas emissions with an appropriate amount of carbon removals.

Urban Mobility
Zero tailpipe emissions led

Urban Mobility

Typically, low peak power due to modest weight and acceleration requirements. Low to medium onboard energy is required as range needs are constrained by urban usage in most cases.

Product types vary from small passenger cars which are often produced by global OEMs, to emerging concepts that are dedicated urban BEVs, some from new market entrants. The latter are most prevalent where BEV and CAV combine. Last mile delivery vehicles and specifically designed 'pods' for mobility-as-a-service are also captured in this segment.

Significant pressures or mandates to achieve zero tailpipe emissions to improve urban air quality.

Zero tailpipe
No pollutant or GhG emissions at tailpipe.

Long Range Mobility
Net-zero* emissions led

Long Range Mobility

Typically, medium power as vehicle mass and acceleration needs are higher. Medium to high energy required as users require versatility in range.

Product types vary between family-type cars to executive cars. Many <3.5t vans also fall into this application category, since weight and power/energy are broadly comparable.

The focus of these vehicles is on achieving net-zero emissions compliance for a wider and varied range of duty cycles.

***Net-zero:**
The activities within the value chain of vehicle manufacturing result in no net impact on the climate from GhGs. This can be achieved by balancing the impact of any remaining GhG emissions with an appropriate amount of GhG removal.

High Power and Performance
Net-zero* emissions led

High Power & Performance

Typically, high power due to high vehicle mass and/or acceleration requirements. Also medium to high onboard energy requirement due to range or operating hours.

Product types include performance and luxury vehicles with varying mass, to heavier SUVs and 'workhorse' LDVs offering power offtake.

The focus of these vehicles is on achieving net-zero emissions compliance whilst delivering application-specific high power and performance.

Roadmap 2020

Light Duty Vehicles < 3.5t

Propulsion Technologies Roadmap

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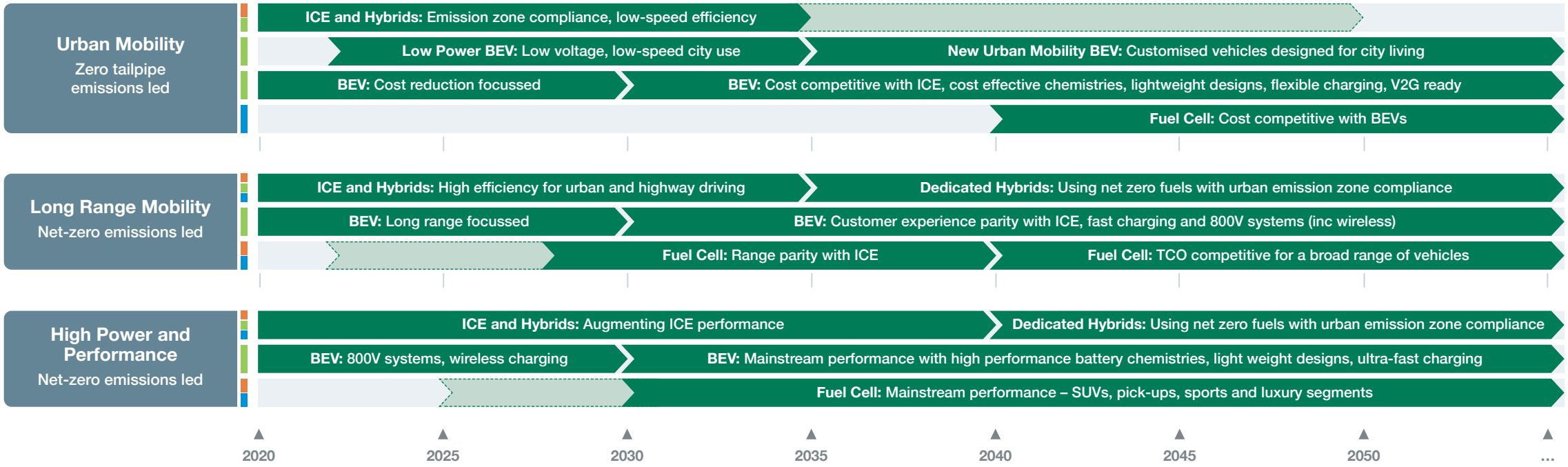
This roadmap represents a snapshot-in-time view of the global automotive industry propulsion technology forecast for mass market adoption. Specific application-tailored technologies will vary from region to region.

Solid colour bar: *Technology adoption for mass-market applications*

Dotted line bar: *Technology exists in international markets, but less prevalent in Europe*



Energy Source
Mature for widespread adoption

ICE fuels	Blended fuels moving to low carbon fuels (including gaseous fuels) → Net-zero compliant fuels, sufficient supply at low cost
Electricity	Increasing renewable electricity supply → Ubiquitous renewable green electricity supply
Hydrogen	Sufficient (blue and green) hydrogen supply to support automotive applications → Green hydrogen, sufficient supply at low cost

Drivers and Regulations	Policy, environmental, social and economic drivers that exert influence on vehicle design and powertrain choices
Technology Enablers	Engineering and technology enablers that exert influence on vehicle design and powertrain choices

→ Further details on page 3

Hybrids = Mild, HEV, PHEV and range extender

Energy Source and Applicability

Urban Mobility
Zero tailpipe emissions led

Example 1: Urban BEV energy sources
The expanding product range of urban BEVs designed for zero-tailpipe emissions, including new mobility vehicles, require a renewable electricity supply. The demand for clean grid electricity will rise as numbers of low-cost battery vehicles increase and additional low-speed power-efficient urban solutions appear in the market.

Long Range Mobility
Net-zero emissions led

Example 2: Long range ICE & Hybrid energy sources
ICE fuels, electricity and hydrogen all potentially relevant. Need for very low carbon liquid and gaseous fuels derived from biomass, waste or renewable electricity sources (and combinations of). Plug-in hybrids featuring net-zero fuelled ICE and renewably sourced electricity are possible in the long-term.

High Power and Performance
Net-zero emissions led

Example 3: Fuel cell energy sources
Hydrogen fuel cells require low carbon sources i.e., blue hydrogen (from natural gas with CCS) or green (from renewable electricity). Solid Oxide fuel cells can operate on existing commercial fuels e.g., blended bio-fuels.

Energy Source
Mature for widespread adoption

- ICE fuels
- Electricity
- Hydrogen

Energy Source
The roadmap provides a list of relevant low-carbon energy carriers that support the vehicle propulsion technologies. The colours codes (orange, green and blue) are shown against each vehicle application, some of which can be supported by more than one energy source. An increasing supply of carbon-neutral energy, based on renewable sustainable sources are of interest for transport decarbonisation. These are current forecasts aimed at mature mass-market adoption.

Drivers and Regulations
Technology Enablers

Drivers and Enablers are provided on a separate page
The link on the RHS of this bar takes you to the relevant drivers and enablers.

Hybrids = Mild, HEV, PHEV and range extender

Urban Mobility

Roadmap 2020

Light Duty Vehicles < 3.5t

Propulsion Technologies Roadmap

Urban Mobility
Zero tailpipe emissions led

1. **ICE and Hybrids:** Emission zone compliance, low-speed efficiency
2. **Low Power BEV:** Low voltage, low-speed city use → **New Urban Mobility BEV:** Customised vehicles designed for city living
3. **BEV:** Cost reduction focussed → **BEV:** Cost competitive with ICE, cost effective chemistries, lightweight designs, flexible charging, V2G ready
4. **Fuel Cell:** Cost competitive with BEVs

Long Range Mobility
Net-zero emissions led

High Power and Performance
Net-zero emissions led

1 Urban ICE and Hybrids

Historically gasoline and diesel ICEs have dominated the LDV sector, but the growing impetus for change is leading to new OEM propulsion strategies. Mandates for low- and zero- carbon propulsion are increasing, resulting in greater ICE efficiency and hybridisation, giving way to other propulsion types in the medium term. The transition point will vary by country as regulation dictates.

2 Urban low power BEV

These new-mobility vehicles operate at low speed in an urban environment, demand the least power and energy of all the LDVs. Batteries are well-suited to these emerging applications and the low voltages and power allow for cost-efficient designs. As CAV technologies mature, and new driving habits emerge, these products will adapt and evolve to suit.

3 City car BEV

BEV city cars are growing in number. Increasing battery energy density and faster charging are expected to improve BEV applicability for drivers who are not able to recharge at home or work. Light weight, correctly-sized and suitable battery chemistries will help bring purchase costs down.

4 Urban Fuel Cell

There is potential for cost-competitive FCEVs to serve part of the urban mobility segment in the longer term, providing greater flexibility and faster re-fueling than equivalent BEVs. This will require a suitable urban hydrogen infrastructure. Competitive and low-cost fuel cells will determine adoption, expecting technology maturation and benefits to come from the HGV sector.

Energy Source
Mature for widespread adoption

- ICE fuels: Blended fuels moving to low carbon fuels (including gaseous fuels) → Net-zero compliant fuels, sufficient supply at low cost
- Electricity: Increasing renewable electricity supply → Ubiquitous renewable green electricity supply
- Hydrogen: Sufficient (blue and green) hydrogen supply to support automotive applications → Green hydrogen, sufficient supply at low cost

Drivers and Regulations: Policy, environmental, social and economic drivers that exert influence on vehicle design and powertrain choices

Technology Enablers: Engineering and technology enablers that exert influence on vehicle design and powertrain choices

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Hybrids = Mild, HEV, PHEV and range extender

Long Range Mobility

Roadmap 2020

Light Duty Vehicles < 3.5t

Propulsion Technologies Roadmap

Urban Mobility
Zero tailpipe emissions led

High Power and Performance
Net-zero emissions led

Long Range Mobility
Net-zero emissions led

1 **ICE and Hybrids:** High efficiency for urban and highway driving → **Dedicated Hybrids:** Using net zero fuels with urban emission zone compliance

2 **BEV:** Long range focussed → **BEV:** Customer experience parity with ICE, fast charging and 800V systems (inc wireless)

3 **Fuel Cell:** Range parity with ICE → **Fuel Cell:** TCO competitive for a broad range of vehicles

1 Long Range ICE and Hybrids

Long range mobility brings greater power and energy requirements. High efficiency ICE vehicles, in conjunction with zero carbon fuels and/or electric-only mode operation in cities, will continue to support the versatility in range required for this class of vehicle. Stricter emissions regulation and fuel bans will move these solutions to dedicated hybrids supported by net-zero compliant combustion fuels.

2 Long Range BEV

BEVs are already available in this vehicle category and technology advances are expected to increase in appeal as costs come down and charging infrastructure improves. A fast-charging network, widely available beyond cities, is critical to expanding the adoption of long-range BEVs. For LDVs, this must offer long range without significant cost and weight increase from today's equivalents in order to provide a competitive offering.

3 Long Range Fuel Cell

Early commercialisation has begun in a few markets globally. For example, Toyota Mirai, Honda Clarity and Hyundai Nexo in Japan and Korea. FCEVs provide range parity with ICE vehicles and shorter refueling times relative to BEVs. In the long-term, FCEV adoption will depend on the total cost of ownership relative to BEV and ICE and is heavily reliant on a suitable hydrogen refueling infrastructure. Increasing volumes will allow costs to come down. The quicker refueling and longer range might make a hydrogen refuelling network more commercially attractive than battery fast-charging and supplement the expected over-demand on the electric grid.

Energy Source
Mature for widespread adoption

ICE fuels	Blended fuels moving to low carbon fuels (including gaseous fuels)	Net-zero compliant fuels, sufficient supply at low cost
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Technology Enablers — Engineering and technology enablers that exert influence on vehicle design and powertrain choices

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High Power and Performance

Roadmap 2020

Light Duty Vehicles < 3.5t

Propulsion Technologies Roadmap

Urban Mobility
Zero tailpipe emissions led

Long Range Mobility
Net-zero emissions led

High Power and Performance
Net-zero emissions led

1 High Power ICE and Hybrids

Advanced (hybrid) ICEs are expected to endure in this segment, thanks to their high power to weight capability the category has a relatively higher cost-tolerance and consumer's may continue to demand ICE capabilities.

As pressures to decarbonise increase, net-zero capability and sustainable fuels will be critical. Together with dedicated hybrids, they can keep this technology relevant.

On an LCA basis, hybrids running on sustainable fuels might well deliver attractive net-zero solutions for the global market.

2 High Power BEV

High performance BEVs are well-suited to this category and are likely to be the first adoption point for many of the improved technologies (e.g., 800 volts, ultra-fast charging) that appear later in more mainstream vehicles.

There is an increasing number of BEV super cars and hyper cars emerging in the market that require specific battery chemistries and designs, tailored for their use case.

3 High Power Fuel Cell

FCEVs are expected to be suited to applications where high onboard energy is required, such as heavier SUVs requiring continuous high torque, or work vehicles featuring auxiliary power takeoff for tools. Some military vehicles may fall into this category and silent running has additional benefits (e.g., GM prototypes).

1 **ICE and Hybrids:** Augmenting ICE performance → **Dedicated Hybrids:** Using net zero fuels with urban emission zone compliance

2 **BEV:** 800V systems, wireless charging → **BEV:** Mainstream performance with high performance battery chemistries, light weight designs, ultra-fast charging

3 **Fuel Cell:** Mainstream performance – SUVs, pick-ups, sports and luxury segments

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Roadmap 2020

Light Duty Vehicles < 3.5t

Drivers and Regulations / Technology Enablers

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Policy, environmental, social and economic drivers that exert influence on vehicle designs and powertrains

Defined driver | Predicted driver

		2020	2025	2030	2035	2040	2045	2050	…
Drivers and Regulations	CO_2e Emission	95 g/km (NEDC)	-15% (WLTP)	PC -37.5% and Van -31% (WLTP)	Towards net-zero CO_2e and LCA compliance				
	ZEV Policies	ZLEV credits and mandates in specific areas			Broader adoption of ZEV mandates to achieve net-zero CO_2e and local air quality ambitions				
	Pollution and Resource	Euro 6d / EPA Tier 3	Euro 7 / EPA Tier 3	Holistic environmental impact legislation (VOC, resource use, land use) and LCA compliance					
	Zone Regulation	Ultra-low emission zones	Localised zero tailpipe emission zones and geo-fencing		Increasing pedestrianisation and vehicle entry restrictions, next gen city designs				
	Urban Mobility	Discrete transport services (pay per mile / usage)		On-demand, integrated transport services that deliver accessible end-to-end mobility					
	EV efficiency improvements	215Wh/mile	10-15%	20-30%	>30%				

Engineering and technology enablers that exert influence on vehicle designs and powertrains

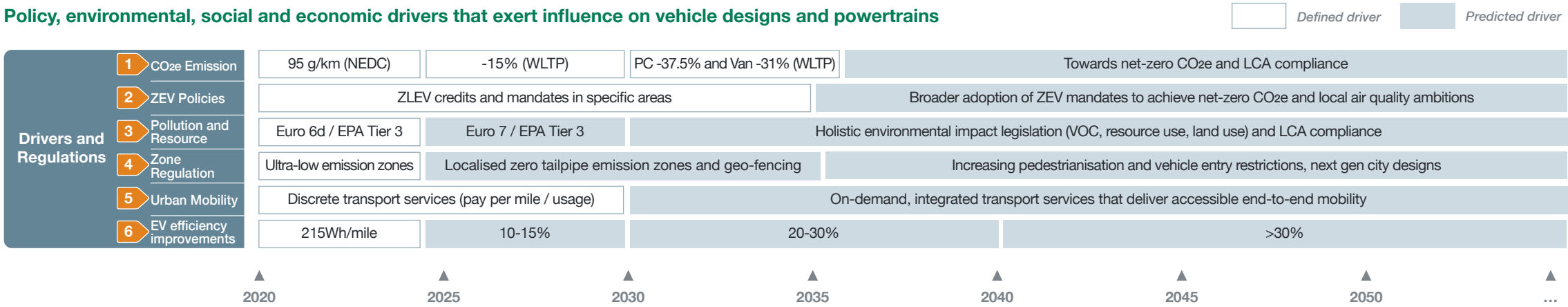
Technology adoption for mass-market applications

		2020	2025	2030	2035	2040	2045	2050	…
Technology Enablers	Platforms	Cross-OEM scalable EV platforms		Mass manufacture of dedicated platforms that are modular and flexible					
	CAV[1]	CAV – 1/2/3	Connected and autonomous – level 4		Connected and autonomous – level 5				
	Digitalisation[2]	Digitally enhanced supply chains		Embedded digitalisation across product and infrastructure					
	MaaS	Urban-focused vehicles that are MaaS-ready		Tailored vehicles to support mass market adoption of MaaS					

1. Adoption is dependent on supporting roadside infrastructure (incl. V2X, digital networks, data protocols, interconnects). See further details on https://zenzic.io/roadmap/
2. More details on digitalisation will be available on the IDE roadmap from March 2021

Drivers and Regulations

Policy, environmental, social and economic drivers that exert influence on vehicle designs and powertrains



1

CO_{2e} Emissions

For the past decade OEMs have responded to tailpipe CO_2 regulations, with challenging sales-weighted fleet targets already announced to 2030. These do not yet preclude the sale of ICE vehicles; however, this will change in the longer term. Life cycle CO_2 measures are also being contemplated at a European level.

2

ZEV Policies

ZEVs are already favoured by credits within CO_2 policies. These are giving way to mandates for ZEV sales proportions and to ICE sales bans in some jurisdictions. In the long-term these can be expected to grow in number and across more markets to meet net-zero targets.

3

Pollution and Resource

Tailpipe pollutants and vehicle end-of-life are already governed by regulations. These are being tightened and likely to feature greater life cycle considerations, reflecting a more circular economy.
A more complete approach to life cycle assessment can be expected via the introduction of holistic environmental regulations.

4

Zone Regulation

Many cities are already incentivising the use of cleaner vehicles through diesel bans and differentiated access charges, with the prospect of geofencing and vehicle-free zones to come. This can encompass urban pedestrianisation zones restricting vehicle access or the introduction of new city movement models.

5

Urban Mobility

In urban locations, mobility will evolve beyond journey-based transactions encouraging integrated mobility solutions as an alternatives to single and multiple vehicle ownership. In the EU vehicle manufacturers have already launched mobility apps to serve the demands of a city population.

6

EV efficiency improvements

A more sophisticated understanding by drivers and pressure groups will lead to a call for higher BEV (and potentially FCEV) efficiency and low carbon energy supply. Consumers are increasing informed and discerning about their choice of vehicle, ensuring costs, efficiency and environmental standards are the highest possible obtainable.

Technology Enablers

1

Platforms

OEMs continue to centre vehicle designs upon a small number of underpinning platforms, providing a cost-effective production footprint, and the advent of EVs accentuates this. Scalable, modular BEV platforms lend themselves to mass manufacture, with platforms being shared across several OEMs who apply their own body designs and specific powertrain features.

2

CAV

Connected and autonomous vehicles are continuing their progression towards high levels of autonomy, at the higher levels (4 and 5) enabling mobility as a service (MaaS). These are well-suited for EV integration and new mobility solutions.

More information on this is available on the Zenzic roadmaps.

3

Digitalisation

Supply chain interaction on a common digital platform for engineering, manufacturing and procurement allows just-in-time logistics and concurrent vehicle development across multiple companies. Advanced digital tools, processes and systems for vehicle design & development is growing at pace.

More information on this is available via the IDE roadmaps.

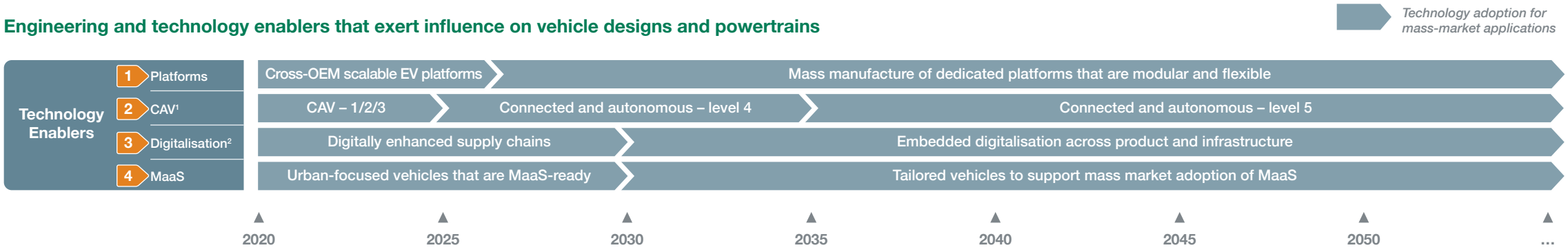
4

MaaS

Mobility as a Service is expected to evolve beyond MaaS-compatible urban vehicles towards dedicated MaaS vehicles, potentially in conjunction with CAV. Changing future population demands means that vehicle products are not just for single person ownership.

MaaS enables alternative commercial and product design solutions for the changing mobility needs.

Engineering and technology enablers that exert influence on vehicle designs and powertrains



Glossary

Glossary

Abbreviation	Explanation
BEV	Battery Electric Vehicle
CAV	Connected and autonomous vehicle
CCS	Carbon capture scheme
FCEV	Fuel cell electric vehicle
GhG	Greenhouse gas
HGV	Heavy goods vehicle
ICE	Internal combustion engine
LCA	Lifecycle assessment
LDV	Light-duty vehicle
MaaS	Mobility as a Service
ZEV	Zero-emission vehicle

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This is an industry consensus roadmap facilitated by the APC

Summary of engagements during the 2020 roadmap refresh

Spread of companies that participated in the refresh

109 industry organisations participated in Workshops and Interviews

38 additional industry organisations participated via the Online Survey

Total engagements 147 Industry Organisations

A global view with international participation

Austria	Singapore
Belgium	Sweden
England	Switzerland
Germany	United States
Netherlands	Wales
Scotland	Japan