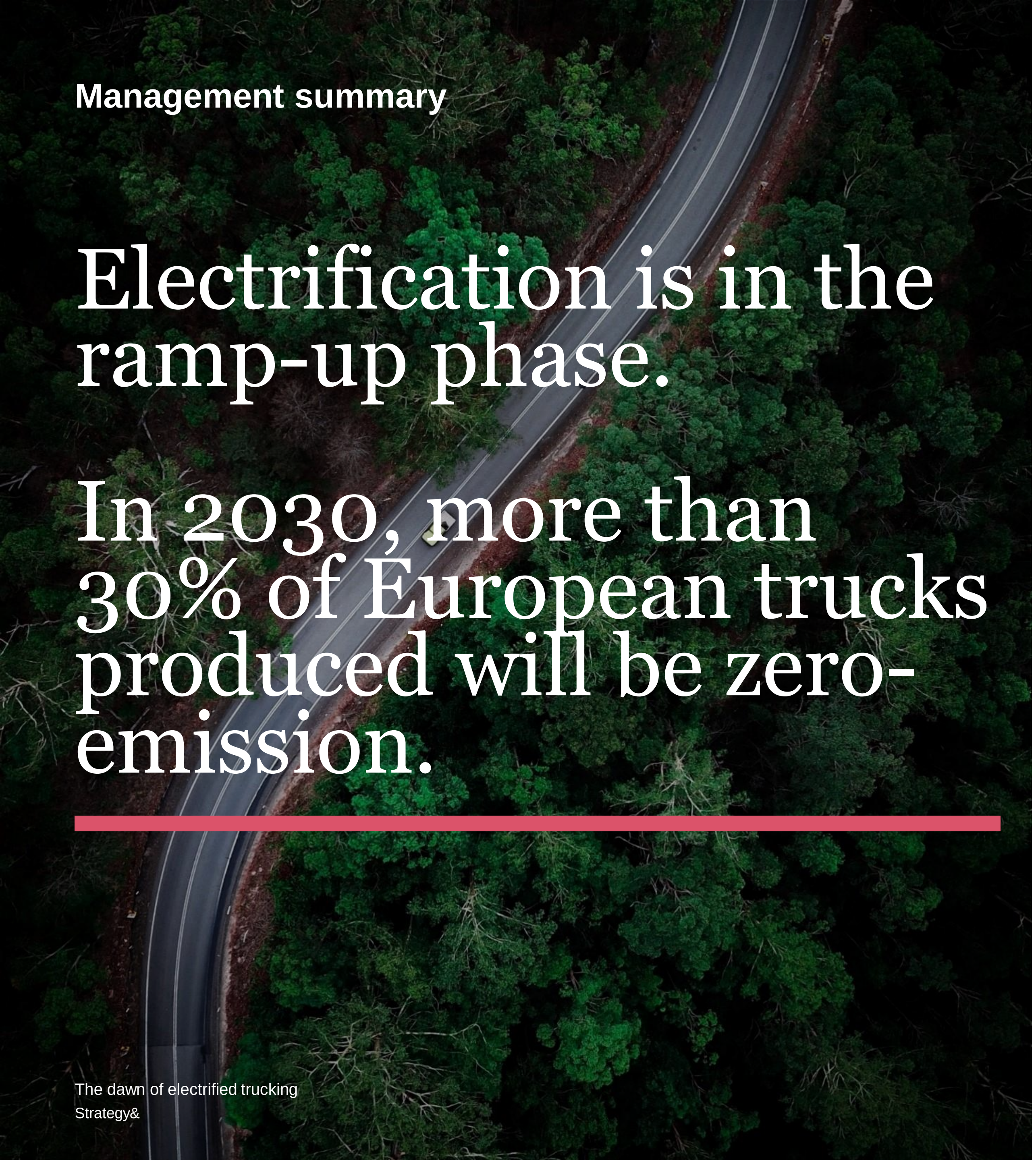
strategy&
Part of the PwC network

The Dawn of Electrified Trucking

Truck Study 2022: Routes to decarbonizing commercial vehicles

October 2022



Electrification is in the ramp-up phase.

In 2030, more than 30% of European trucks produced will be zero-emission.

Electrification diffusion 2025, breakthrough 2030

In the **triad markets** of **North America** (USA, Canada, Mexico)**, the EU, and Greater China** (China, Taiwan, Hong Kong) we expect a **fast ramp-up of electrification** to 2035 – electric truck **market diffusion** from **2025** with **~5%, breakthrough** from **2030** with **~30%,** and dominance from **2035** with **~80%.**

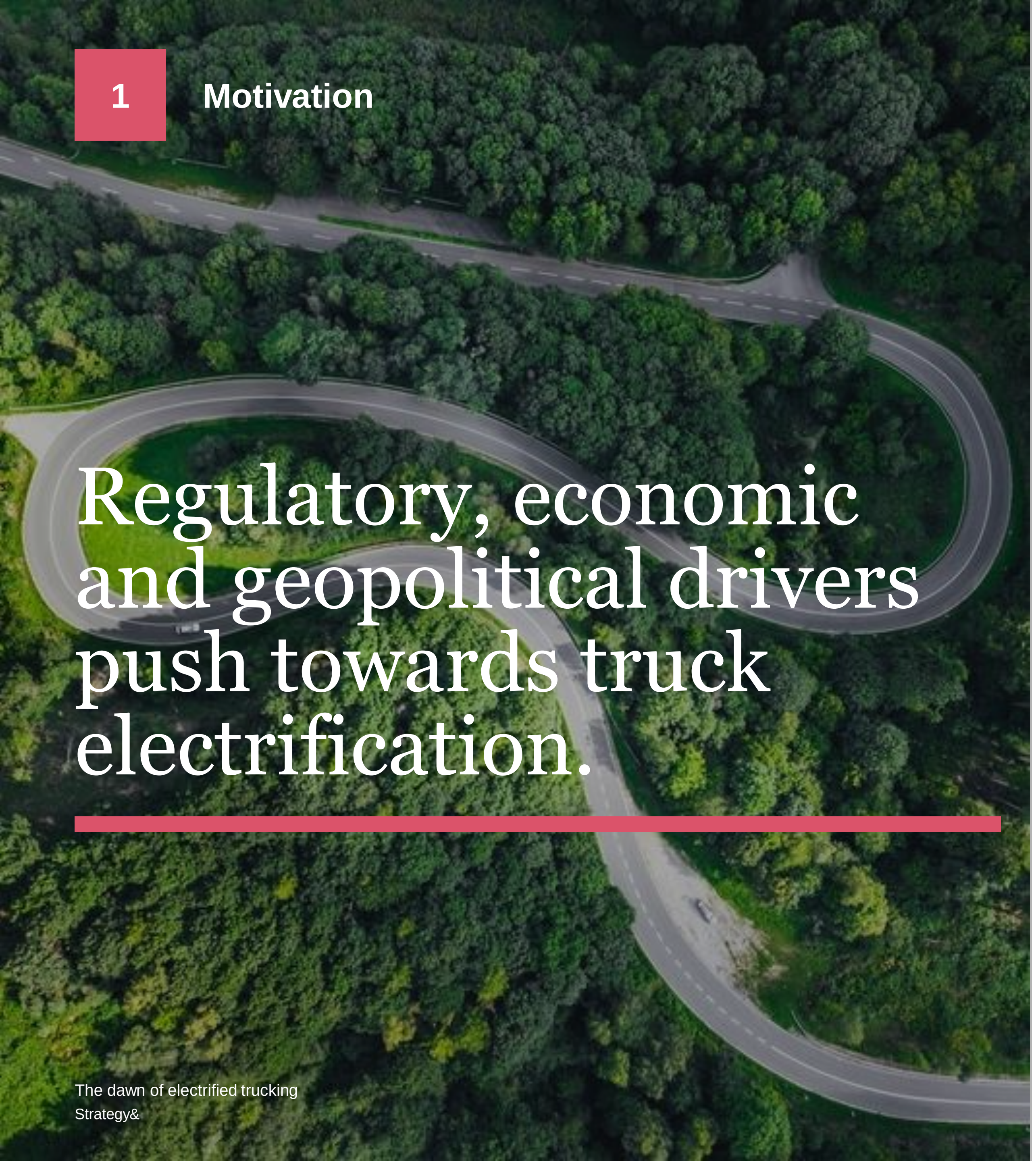
Total cost of ownership (TCO) and regulation drive electrification

Electrification is mainly **driven by TCO** and **regulation**, with **Europe** and **Greater China** as **front runners** – **battery electric trucks (BET) outperform internal combustion engine (ICE) technology** from **2025 onwards** in terms of **TCO,** reaching a **cost advantage** of **~30% in 2030.**

Urgent need for new infrastructure expansion

The forecast **electric vehicle (EV) volume** requires a **quick ramp-up** of the **new infrastructure network** translating into **~30 stations for a European pilot network** by **2023/24**, **~100** stations for an **area-coverage network** by **2025/27** and **~2,000** stations for a **high-demand network** by **2035.**

Table of contents



1 Motivation

Regulatory, economic and geopolitical drivers push towards truck electrification.

Regulatory motivation

Commercial vehicle makers **(OEMs)** are under pressure to **electrify** their truck **portfolio** in order to **comply** with environmental **regulations – EU regulation** is forcing truck manufacturers to **reduce their new fleet emissions** by at least **30% by 2030** (and potentially up to 60%).

Economic motivation

Fleets are incentivized to **electrify** their **vehicle pools** due to **EU** and **country-specific funding** – e.g., the EU plans a **new road toll system** from May 2023 which gives **Zero Emission Vehicles (ZEVs) a 50% discount**, which could save fleets up to €25k per year and truck.

Geopolitical motivation

European countries envision greater **energy autarky** in the mid-term. **Truck electrification** can make an important contribution, as **100% electrification** would mean around **22% less oil consumed.**

Truck electrification in Europe is accelerated by regulatory, economic and geopolitical motivations

Motivations for truck electrification in Europe up to 2030

Emissions regulation

DEEP DIVE NEXT SLIDE

- **EU targets for average CO_2 emissions** reduction from new trucks
  - → **15% in 2025,** driven by increased ICE efficiency and hybridization
  - → **30% in 2030,** driven by electrification
- **Penalties** for **manufacturers** starting from 2025 in case of **excess emissions** of CO_2

Regulatory motivation for manufacturers to avoid penalties

Green funding

- **EU funding:** New road toll system from May 2023 grants ZEVs a 50% discount - up to €25k in savings per truck p.a.
- **DE funding:** €5bn for the charging network expansion for commercial vehicles (CVs) & passenger cars (PCs); €1.6bn for purchasing zero-emission CVs
  - → Funding of 80% of additional investment for purchasing BET over ICE
  - → Funding of 80% of operating costs for zero-emission charging/fueling infrastructure

Economic motivation for fleets to electrify the vehicle pool

Energy autarky

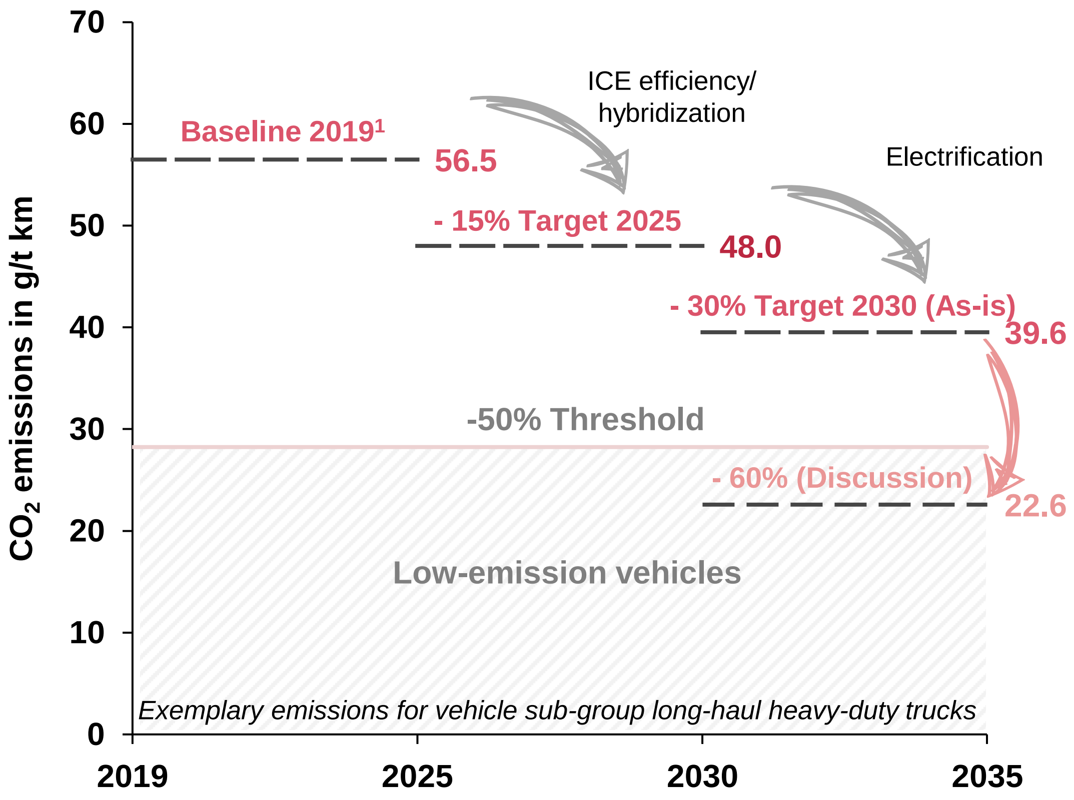
- German truck milage corresponds to oil consumption of ~21 Mt p.a.[1]
  - → **~22% less oil consumption** p.a. in case of **100% electrification**
- German truck mileage is equivalent to electricity consumption of ~77 TWh p.a.[2]
  - → **~15% additional electricity consumption** p.a. in case of **100% electrification**

Geopolitical motivation for countries to reduce oil consumption

EU regulations in particular force OEMs to electrify trucks to achieve up to 60 percent less emissions by 2030

Deep dive: EU emissions regulation for trucks

EU emissions regulation for trucks



Key facts on emissions regulation

- **Reduction** of average **CO_2 emissions** from new trucks by **15%** in **2025** and by **30%** in **2030**, both relative to a **2019 baseline**
- Regulators currently discussing **tighter CO_2 emissions targets** to **45%-60%** in **2030**
- **Four** out of **18 vehicle groups** are **regulated** and divided into **sub-groups** to **account for** different use **profiles**, such as **urban**, **regional**, or **long-haul**
- **Incentives** for **zero-** and **low-emission vehicles**
- **Mileage** and **payload weighting factors** are used in **calculating** the **total fleet emissions**
- From 2025 to 2029, **manufacturers** are required to **pay a per-vehicle penalty** of up to **€4,250 for each gram of CO_2 per tonne-km** of excess emissions. This penalty will **increase to €6,800** for each gram of CO_2 per tonne-km **from 2030 onwards**

Battery electric (BET) and fuel cell (FCT) trucks are the most promising powertrain technologies for the future.

BET and FCT are most promising for the future

BET and FCT technology are regarded as **competitive** technologies for the future due to decreasing vehicle costs, declining energy prices and public acceptance – the **competitiveness** of overhead **catenary hybrid trucks (CAT) and synthetic fuel-powered ICE trucks (SYT)** is **questionable:** for CAT, high upfront investments paired with underutilization of infrastructure is expected, while SYT requires high primary energy investments.

Electric truck vehicle cost gap shrinks but stays

Alternative powertrains translate into **additional vehicle costs** of approximately **€90k** for **long-haul BET and FCT in 2030** – the **cost gap shrinks** over time, with medium-duty BET coming close to ICE costs by 2035.

Four green technology options exist to decarbonize trucks: While BET and FCT are promising, CAT and SYT competitiveness is questionable

Alternative powertrain options for trucks: typical characteristics and evaluation

BET

Purely battery electric truck

Direct use of electricity in electric motor for propulsion; battery used as energy storage.

Competitive technology

- Decreasing vehicle costs as well as increasing load capacity and range
- High efficiency, low energy costs and high public acceptance

FCT

Hydrogen-powered fuel cell truck

Conversion of electricity into hydrogen; fuel cell to transfer hydrogen into electricity to be used in electric motor for propulsion.

Competitive technology

- Decreasing vehicle and energy costs
- High flexibility due to low refueling speed (compared with charging) and high public acceptance

CAT

Overhead catenary hybrid truck

Direct use of electricity in electric motor for propulsion; small battery used as energy storage, as main energy is transferred via catenary.

Competitiveness questionable

- Non-scalable upfront investments with under-utilization of infrastructure
- Low public acceptance

SYT

Synthetic fuel-powered ICE truck

Conversion of electricity into carbo-naceous fuel or "synthetic fuel" (Power-to-Liquid or Power-to-Gas); internal combustion engine used for propulsion.

Competitiveness questionable

- High renewable primary energy investments due to low end-to-end efficiency
- High latency of additional renewable energy production to facilitate large-scale "synthetic fuel"

The global truck market can be segmented across nine use cases – long-haul, line-haul and distribution have the highest emission impact

Global truck segments and use cases

Truck segment	Heavy-duty truck					Medium-duty truck		Bus	
Vehicle set-up	Tractor			Rigid (box, fridge, others)		Rigid (box, fridge, others)		Coach	
Use case									
	Long-haul • "Classic" long-haul with semi-trailer • Logistics and industries	**Line-haul** • Repeated transports with semi-trailer • Logistics and industries	**Specials** • Heavy goods • Hazardous goods • Special applications	**Distribution** • Parcel and mail • Industries • Food • Municipal (garbage, firefighter, utilities, etc.)	**Specials** • Road construction (dump truck, cement mixer etc.) • Special applications	**Distribution** • Parcel and mail • Industries • Food • Municipal (garbage, firefighter, utilities, etc.)	**Specials** • Road construction (dump truck, cement mixer etc.) • Special applications	**Coach** • Line traffic • On demand	**Urban** • City service bus • Event short-range transports
Production volume share	12%	20%	5%	18%	11%	15%	10%	5%	4%
Yearly mileage (km)	150,000	100,000	50,000	50,000	30,000	50,000	30,000	100,000	50,000
Annual emission share[1,2]	28%	31%	4%	14%	5%	8%	3%	5%	2%

Focus of study

By 2030 we expect BET market offerings with up to 850 kWh electric energy on board and FCT with up to 80 kg stored in hydrogen tanks

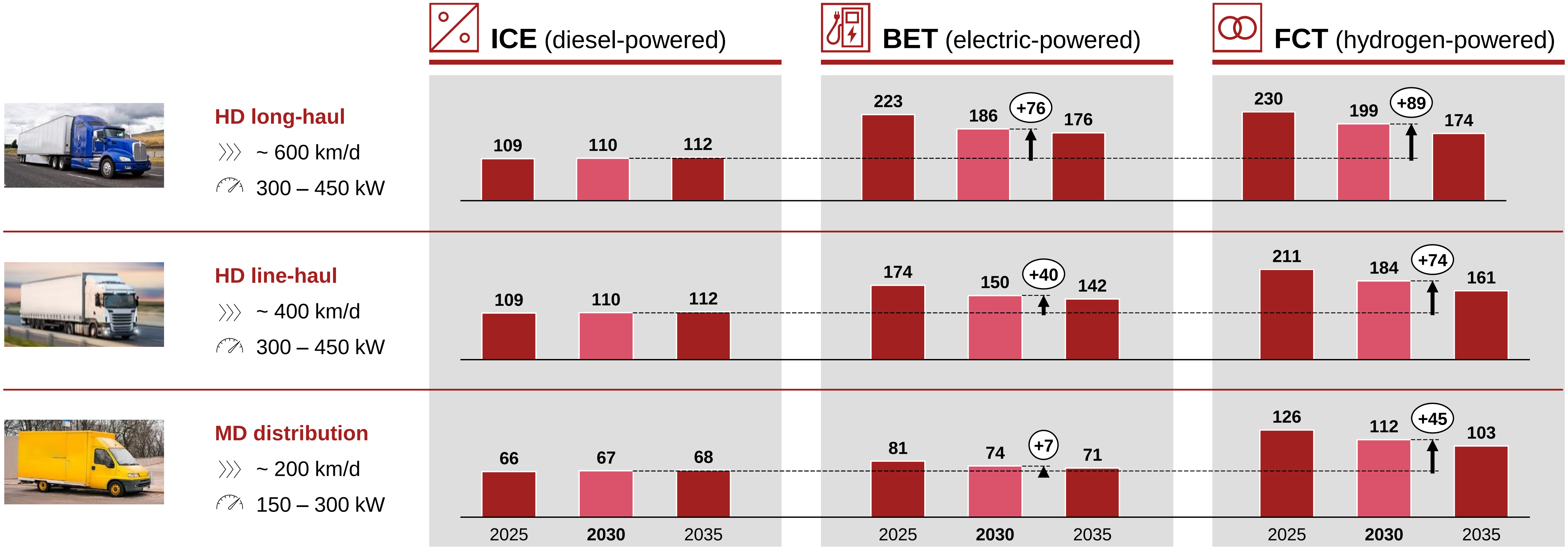
Powertrain options for trucks: technological characteristics up to 2030

		ICE[1] (diesel-powered)	BET[2] (electric-powered)	FCT[3] (hydrogen-powered)
	**HD long-haul** ~ 600 km/d 300 – 450 kW	700 – 1,500 l (diesel) 2,000 – 4,000 km 2,200 kg	600 – 850 kWh 500 – 700 km 4,300 – 5,300 kg	~ 80 kg (hydrogen) + 50 kWh (electricity) ~ 900 km 2,300 kg
	**HD line-haul** ~ 400 km/d 300 – 450 kW	700 – 1,500 l (diesel) 2,000 – 4,000 km 2,200 kg	300 – 600 kWh 250 – 500 km 3,100 kg – 4,300 kg	~ 80 kg (hydrogen) + 50 kWh (electricity) ~ 900 km 2,300 kg
	**MD distribution** ~ 200 km/d 150 – 300 kW	200 – 700 l (diesel) 500 – 2,000 km 1,700 kg	200 – 300 kWh 150 – 250 km 2,700 kg – 3,100 kg	~ 45 kg (hydrogen) + 50 kWh (electricity) ~ 400 km 2,100 kg

Mileage (km) per day (based on 250 working days per year) | Performance (power) | Energy on board | Range | Powertrain weight.

Alternative powertrains translate into additional vehicle costs – although BET and FCT cost gap versus ICE decreases over time

Powertrain options for trucks: vehicle prices in 2025-2035 in Europe for selected use cases (€k)[1]



Mileage (km) per day (based on 250 working days per year) Performance (power)

Urgent call for action: Build-up of public truck charging infrastructure required now.

Investments up to €1 billion needed to set up 120 Megawatt charging systems (MCS) by 2025.

Fleets with option for public and depot charging

Different options are available to enable alternative powertrains for truck traffic – **high-performance** highway charging, **low speed overnight** depot charging or **hydrogen refueling stations** (HRS) – **depot charging** offers **good value** for **limited investment.**

Urgent need for pilot and area-coverage network

Expected **BET volume rise** by 2025 requires **action to build up a pilot charging network** (35 MCS stations) **by 2023** and up to **120 MCS stations by 2025** to enable an area-coverage network – with **total investment** up to **€1bn.**

Large scale infrastructures required in long-term

In the **long-term,** further **ramp-up** of **charging and refueling infrastructures is required** capacity-wise – in **Europe,** a high-demand scenario needs **1,800 charging parks (MCS + overnight) & additional 600 pure overnight parks** and/or ca. **2,100 HRS stations by 2035** with required **investment** of up to **~€15bn for the MCS network** and **€21bn for the HRS network**.

Several infrastructure options are available to enable alternative truck transport – depot charging offers good value for only limited investment

Infrastructure options for alternative HDTs

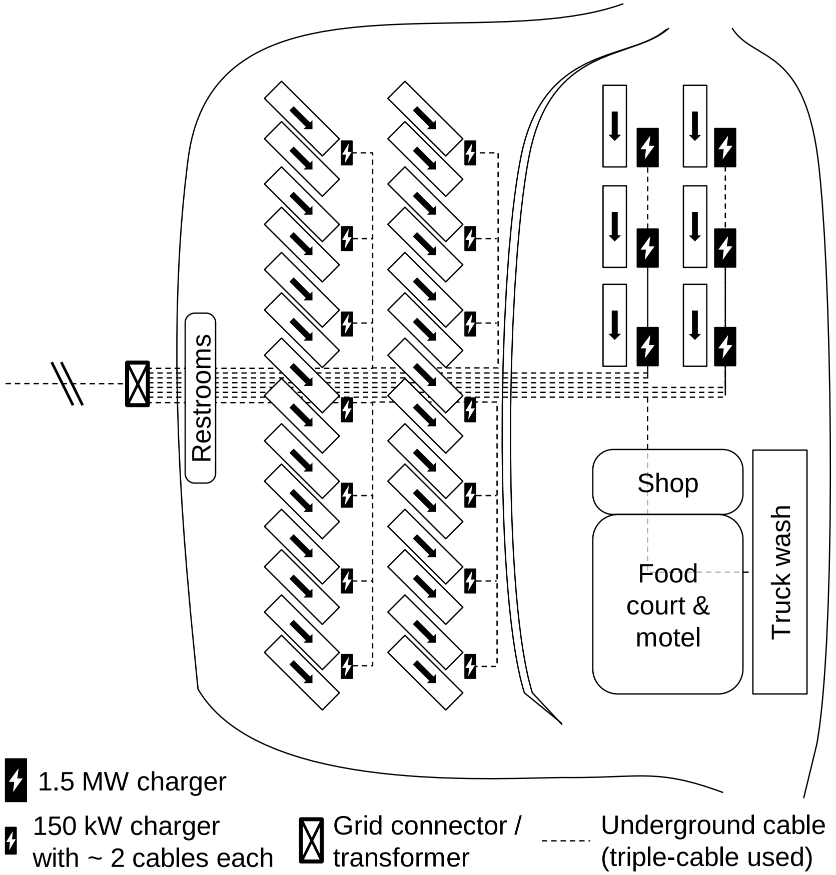
	BET – Depot charging system (DCS)	BET – Charging park (MCS + Overnight)	FCT – Hydrogen refueling station (HRS)
Visualization			
Charge speed	Up to ~**50km/h**	**MCS:** Up to ~**850 km/h** **Overnight:** Up to ~**50 km/h**	Up to ~**3,400 km/h**
Refill duration	Charge for ca. **400 km range in 8h (overnight)**	**MCS:** Charge for **400 km range in ~30 min** **Overnight:** Charge of **400 km range in 8h**	Hydrogen filling for ca. **700 km range** at 700bar in **about 15 minutes**
Power	Total power of **ca. 750 kW** required per depot (for fleet of ~10 trucks)[1)]	**MCS:** Power up to **1.5 MW** per charger **Overnight:** Required power of **ca. 75 kW per truck** (150 kW charger with ~ 2 cables)	Filling capacity up **to 5 kg hydrogen per minute** per dispenser
Cost	Medium-sized logistics company with fleet of ca. 10 trucks requires **3x 250 kW chargers** with investment of **~€450,000**[1)]	Charging parks for 200 HDTs per day with **6 MCS chargers** and **28 overnight charging bays** require invest of **~€8.5 million** per park	Large stations to refuel 200 HDTs per day with **five dispensers** require investment of approx. **€10 million** per station

We envision highway charging parks for HDTs containing about 6 MCS chargers and ~28 overnight chargers for 34 truck bays

Vision of future highway charging park

Model charging park

Visualization – Highway charging park



Key numbers

 # Truck charging bays
34

 # Megawatt chargers
6

 # Overnight chargers
28

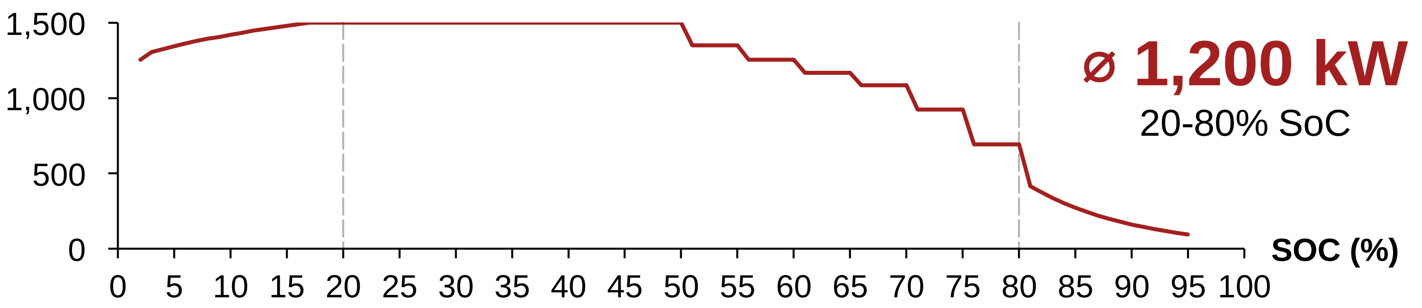
km underground cable
11-12

€ charging setup cost
€ 8.5m

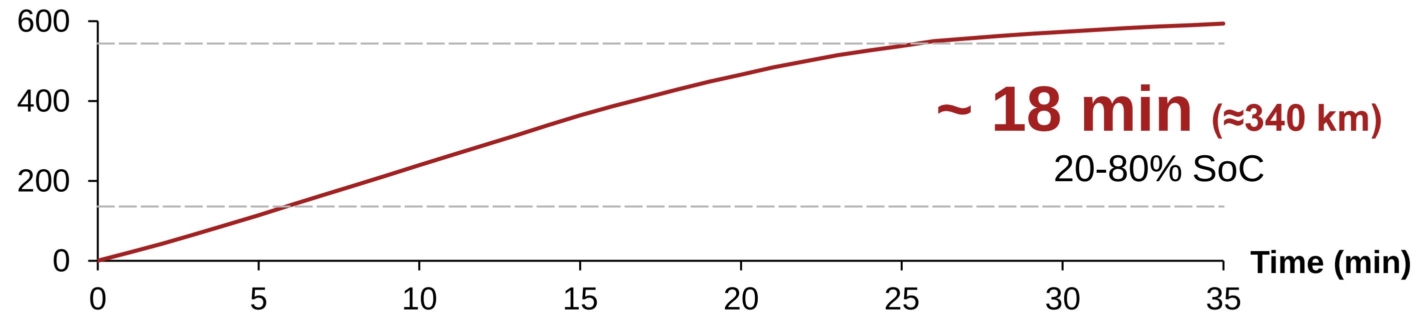
Especially for very high power levels, the impact of the charging curve needs to be taken into account in charging infrastructure planning

Megawatt charging system – schematic curve for charging power and capacity

Charging power *(kW)*



Charged capacity *(kWh)*



Assumptions/comments

The charging curve was **estimated for an 800V battery architecture** taking into account the following assumptions:

- Average power of **1,200 kW** with peak of **1,500 kW** after **15%** SoC
- Limited **pre-conditioning** restricting load shortly after charging initialization
- Assumed **constant voltage cycle** lowering peak power output after 50% SoC
- To prevent excessive **battery degradation** the current is dropped after 80% SoC

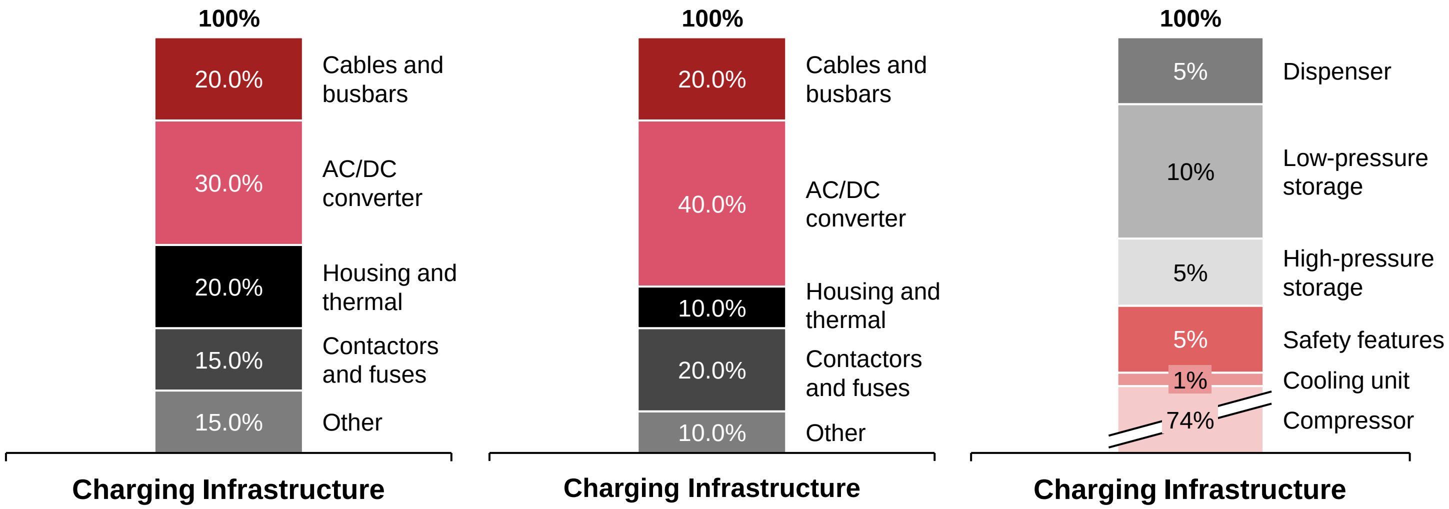
The actual curve will be strongly impacted by the OEM's individual **charging strategy**

Total cost and cost structures for BET and FCT infrastructure vary strongly with regard to the power level and type of supply station used

Infrastructure options cost distribution – expectation 2030

	BET – DCS[1]	BET – MCS	FCT – HRS	Comments

Cost structure



	BET – DCS[1]	BET – MCS	FCT – HRS
Power	250 kW	1.5 MW	5 kg/min
Cost	~ €150,000	~ €1,000,000	~ €2,000,000

Comments

Further costs for charging solutions are to be considered:

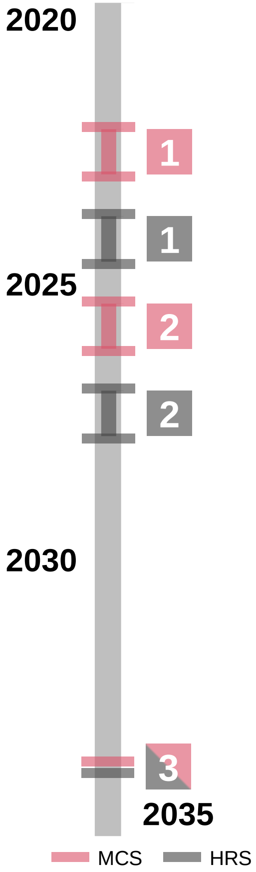
- **Planning and installation**: ~10-20% on charger cost (e.g., €2M for FCT)
- **Grid connection/transformer and space**: ~10-30% on charger cost

However, the **costs cannot be generalized** and may **vary strongly** due to many factors:

- **Current grid connection** (at hub) and **capacity** will affect **transformer price** and **installation complexity**
- **Misleading picture** looking **only** at **one charger** due to **unconsidered scale effects** (installation cost split across multiple chargers with same grid connection)
- **Impact of overall setup** (e.g., battery storage system) on costs for grid connection/transformer/converter

During ramp-up of new HDT infrastructure, MCS requires similar investments to FCT to enable initial cross-European trips

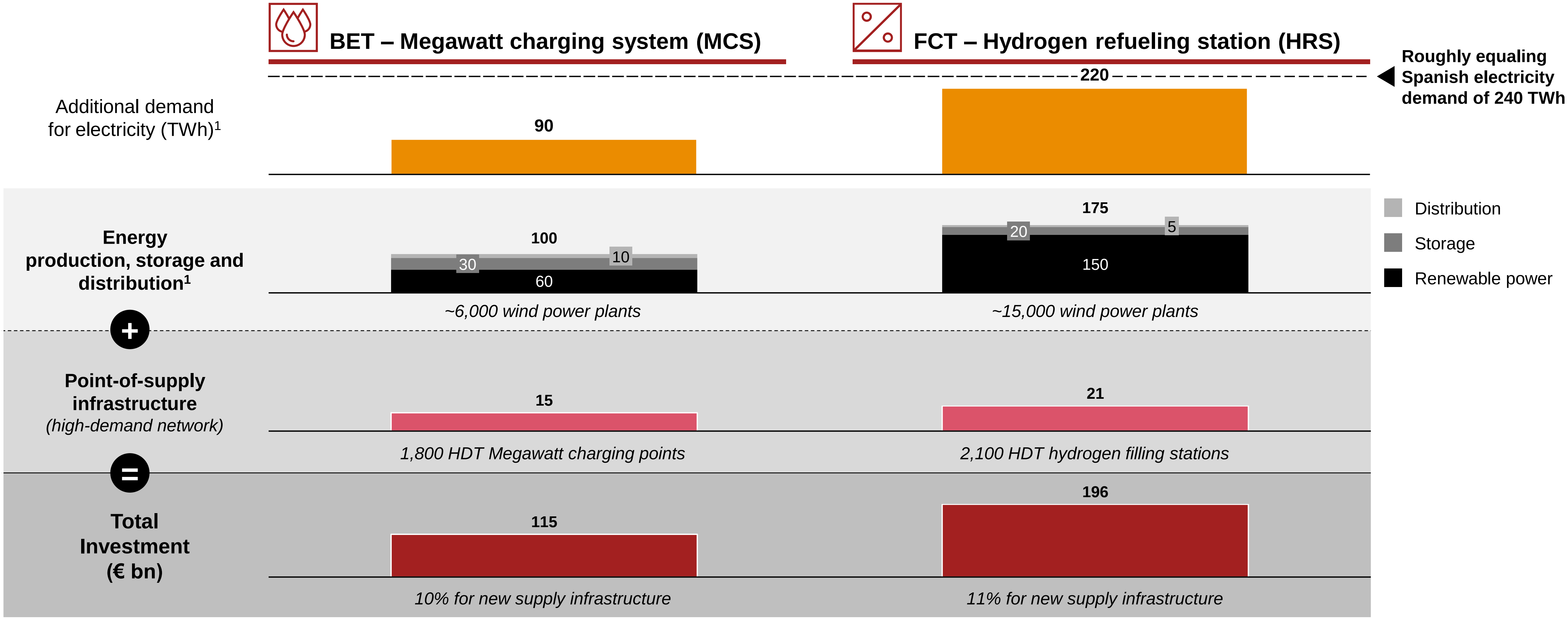
Ramp-up of alternative HDT infrastructure for Europe by 2035



Ramp-up stage	Description	BET – Charging park[1]	FCT – HRS
1 **Pilot network** *2022/2023 (MCS)* *2024/25 (HRS)*	Pilot projects with focus on areas with high traffic volumes (over 100,000 HDTs annually)	**€0.2 bn** (35 MCS) First stations	**€0.2 bn** (20 HRS) First stations
2 **Area-coverage network** *2025/26 (MCS)* *2026/2027 (HRS)*	Complete coverage of Europe as a consistent network	**€0.7 bn** (120 MCS) Increased network to enable pan-European trips	**€0.7 bn** (70 HRS) Increased network to enable pan-European trips
3 **High-demand network** *~2035*	Complete coverage of Europe with sufficient capacity	**€15.2 bn** (1,800 MCS incl. overnight charging + addtl. 600 pure overnight charging stations) Complete network with more stations to meet energy demand	**€21.0 bn** (2,100 HRS) Complete network with more stations to meet hydrogen demand

However, the investment in the supply infrastructure is only a small share compared with the cost to produce the extra electricity required

Comparison of renewable energy vs. point-of-supply infrastructure CAPEX (€bn)



BET outperforms ICE from 2025 onwards when it comes to total cost of ownership.

BET exhibits ~30% lower TCO than ICE in 2030

BET outperforms ICE technology from 2025 onwards in most use cases **in terms of total cost of ownership**, reaching a cost advantage of 26-34% in 2030 – **FCT** achieves **TCO competitiveness** versus ICE starting **from 2030.**

Energy costs are the main TCO driver

Among the elements analyzed, **TCO** is to a large extent **driven by energy costs** – **variances** in future **energy prices** result into TCO shifts of up to **± 14 €-ct/km** change versus the base scenario.

Demand determines BET fleet electricity costs

The **electricity price corridor** of **16.2-28.8 €-ct/kWh** for BET charging is mainly driven by **political-economic factors**, **energy demand size** and **infrastructure mark-up** – **fleets** with ambitions for electrification have to **mitigate electricity price risks** in the short-term.

The four most relevant TCO elements of alternative powertrains depreciation, energy, maintenance and financing are analyzed in more detail

Rough breakdown of relevant TCO elements

TCO elements	Scope[1]	Description	Important cost levers (incl. exemplary 2030 assumptions)
Depreciation	In scope	**Cost estimations** and **residual value** calculation for **truck/bus vehicle components** including **powertrain/energy storage, vehicle body/ manufacturing and overhead/margins**	**Component costs** BEV battery cell: 65 €/kWh FCEV stack: 55 €/kW_{peak} **Component lifetime** BEV battery: 5,000 cycles FCEV stack: 30,000 hours
Driver	(not considered)		
Energy	In scope	**Cost estimation** of **energy** including non-household prices for **diesel** (incl. CO_2 tax), **AdBlue, electricity for depot and public charging** (incl. infrastructure investments) and **hydrogen**	**Energy costs** Diesel: 1.38 €/l (incl. CO_2 tax) Electricity: 19.5-24.4 €-cent/kWh depending on use case (incl. charging infrastructure mark-up) Hydrogen: 4.65 €/kg
Insurance	(not considered)		
Maintenance	In scope	Cost estimation for **wear and tear** of vehicle parts incl. **labor for inspections** and **replacement of components**	**Number of moving powertrain components** Maintenance costs: ICE: 0.105 €/km BEV: 0.057 €/km FCEV: 0.071 €/km
Tax	(not considered)		
Toll	(not considered)		
Financing	In scope	Cost estimation of **financing** the **vehicle acquisition**	**Interest rate** Loan interest rate: 2.5%/year

1) Relevance for alternative powertrains and data availability
Source: Strategy& analysis 08/2022.

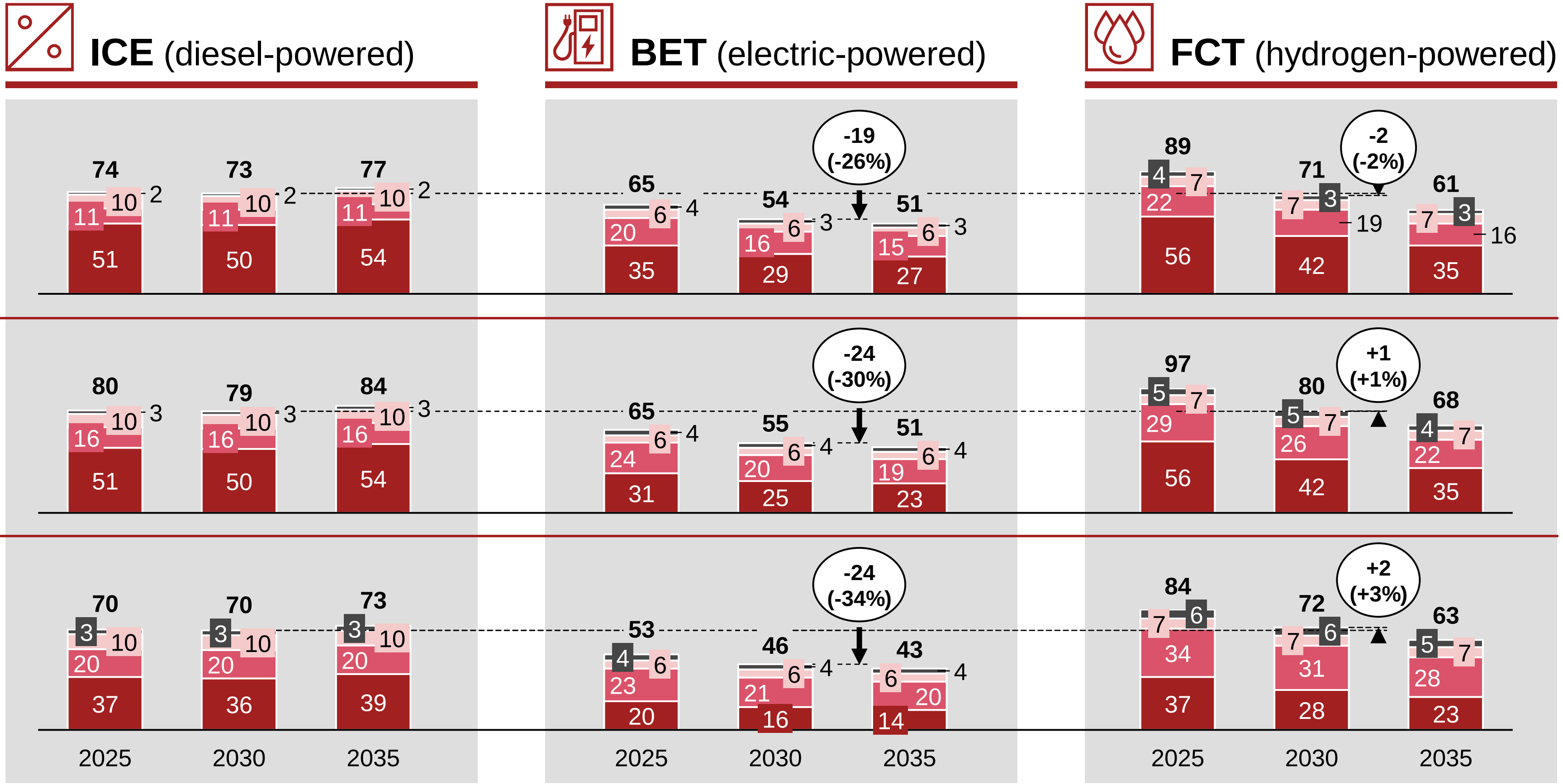
BET outperforms ICE in terms of TCO from 2025 onwards, FCT from 2030– energy costs represent the main driver

TCO for selected use cases across powertrain options 2025-2035 (€-ct/km/y)

HD long-haul[1]
~ 600 km/d
300 – 450 kW

HD line-haul[2]
~ 400 km/d
300 – 450 kW

MD distribution[3]
~ 200 km/d
150 – 300 kW



Mileage (km) per day (based on 250 working days per year) Performance (power)

Financing costs | Maintenance costs | Depreciation costs | Energy costs

Future energy prices may vary – selected opportunities and risks for energy costs were investigated

Truck energy prices opportunities and risks in Europe in 2030

	ICE	BET – DCS	BET – MCS	FCT – HRS
Top range (price raising potential)	**High CO_2 tax** **€1.60/L** with €150/tCO_2 currently discussed in scientific community	**Low utilization and unfavorable price** Price at **24.0 €-ct/kWh** with unfavorable electricity price scenario and less than one truck charged per day	**Low utilization and unfavorable price** Price at **28.8 €-ct/kWh** with unfavorable electricity price scenario and low utilization (30% utilized, 15h operating)	**Low network utilization** Price at **€6.20/kg** with area-coverage HRS network
Base case	**Enacted CO_2 tax** **€1.38/L** with CO_2 tax at €80/tCO_2 as already planned for Germany in 2025	**Base utilization and medium price** Price at **19.5 €-ct/kWh** with medium electricity price scenario and one truck charged per day	**Base utilization and medium price** Price at **24.4 €-ct/kWh** with medium electricity price scenario and base utilization (40% utilized, 15h operating)	**Medium network utilization** Price at **€4.65/kg** with area-coverage HRS network
Bottom range (price lowering potential)	**No CO_2 tax** **€1.14/L** with €0/tCO_2 sensitivity for fossil fuels support	**Increased utilization and favorable price** Price at **16.2 €-ct/kWh** with favorable electricity price scenario and more than one truck charged per day	**Increased utilization and favorable price** Price at **20.3 €-ct/kWh** with favorable electricity price scenario and higher utilization (50% utilized, 15h operating)	**High network utilization** Price at **€3.10/kg** with area-coverage HRS network

Future electricity costs for BET fleets vary based on socio-economic conditions, companies' energy demand and infrastructure investment

Deep dive: Fleet electricity price ranges in Europe in 2030 (€-ct/kWh)

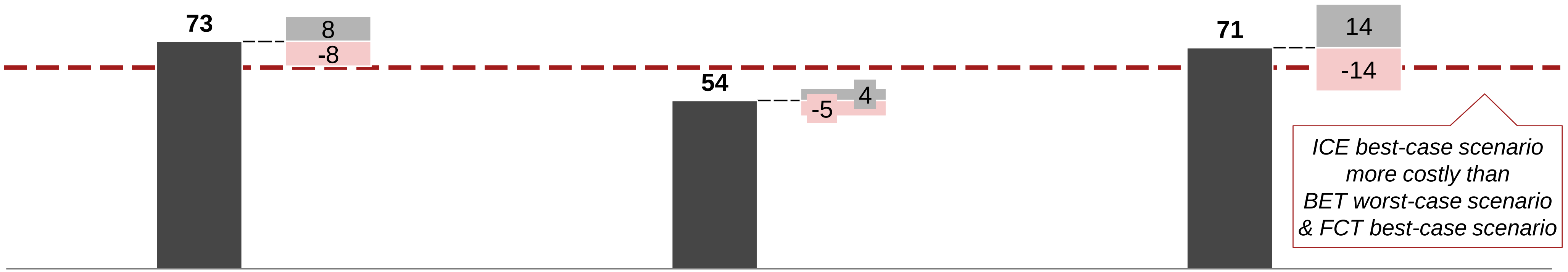
	Political-economic conditions *Average baseload electricity price €-cents/kWh in 2030*		Fleet energy demand *Average taxes and levies % mark-up per consumer group in 2030*		Infrastructure investments *Average charging infrastructure mark-up €-cents/kWh in 2030*		Electricity price *Final electricity price €-cents/kWh in 2030*
Top range (price raising potential)	Supply shortage/ disruptions paired with growing demand and reliance on fossils while increasing CO_2 price	11.2	Non-household consumption < 2,000 MWh/year for a fleet <15 BET	+ +50%	MCS: 30% utilized, 15h operating DCS: <1 BET charged per day	+ 14.0 + 8.0	= 30.8 = 24.8
Base case	Flexibilization of demand with sustainable energy mix balancing economics and climate goals	10.5	Non-household consumption < 20,000 MWh/year for a fleet <100 BET	+ +40%	MCS: 40% utilized, 15h operating DCS: 1 BET charged per day	+ 10.7 + 4.8	= 25.4 = 19.5
Bottom range (price lowering potential)	Supply security/ independence with significant shift to renewables and associated scale effects	9.3	Non-household consumption > 20,000 MWh/year for a fleet >100 BET	+ +30%	MCS: 50% utilized, 15h operating DCS: >1 BET charged per day	+ 8.2 + 3.2	= 20.3 = 15.3

The TCO of ICEs is expected to be inferior to alternative powertrains in the base scenario by 2030 - BET with lowest TCO

TCO sensitivity analysis for HD long-haul use case in 2030 (€-ct/km/y)

TCO for HD long-haul in 2030
(€-ct/km/y)

ICE (diesel-powered) | **BET** (electric-powered) | **FCT** (hydrogen-powered)



Scenario	Diesel (€/l) [1]	Electricity price (€-cent/kWh) [2]	Hydrogen (€/kg) [3]
High energy price	1.60	28.8	6.20
Medium energy price	1.38	24.4	4.65
Low energy price	1.14	20.3	3.10

Electric truck production will breakthrough in 2030 with more than 30% being zero-emission vehicles.

The battery demand through the truck industry will surpass 800GWh in 2035

Breakthrough of electrification expected from 2030

In **2030**, we expect ~**900k BET/FCT produced** in the **triad markets,** which translates into ~200k units in North America and Europe respectively, ~500k units in Greater China – BET/FCT production increases to **2,250k units** in **2035**.

TCO and regulation drive electrification

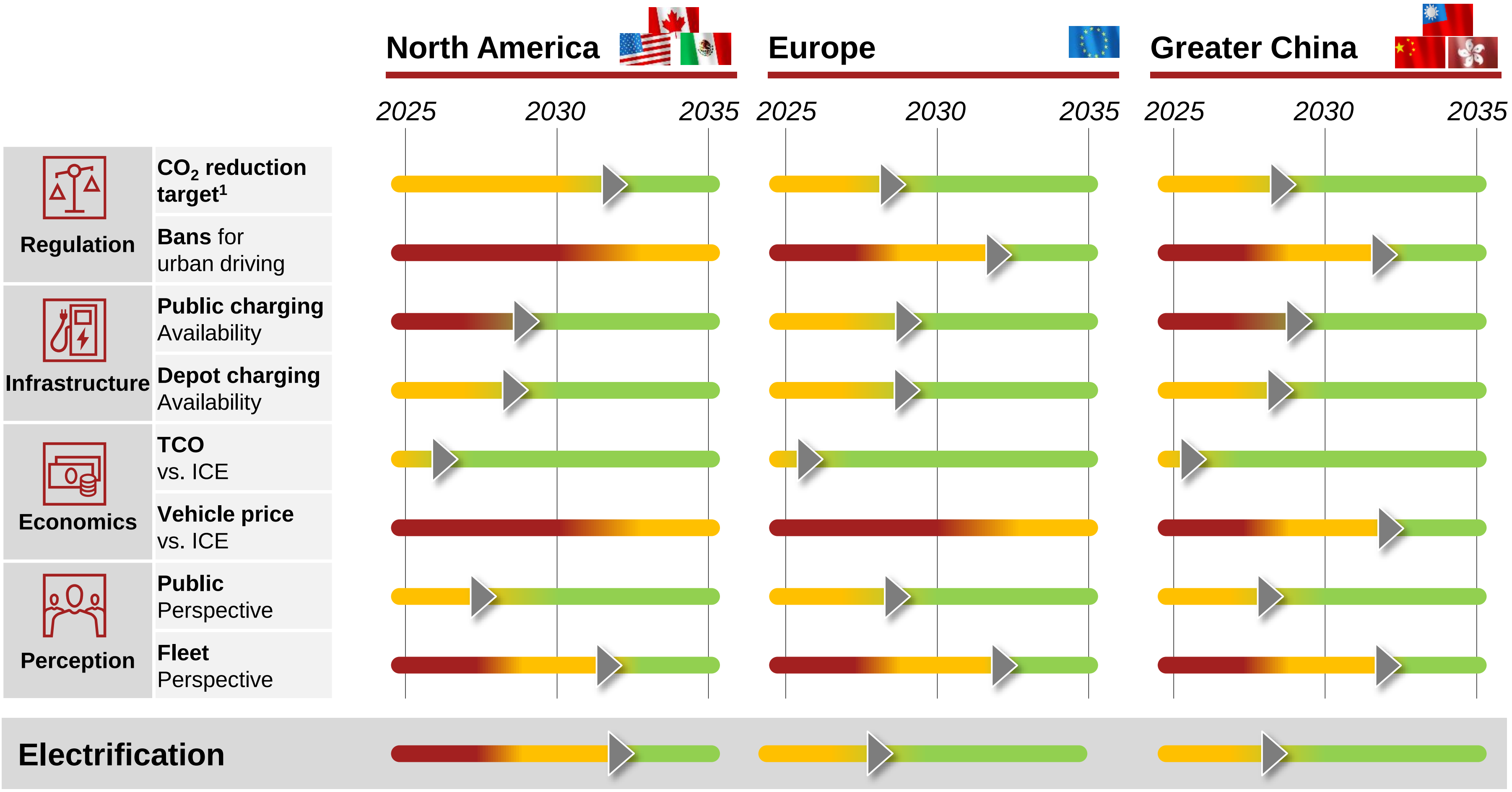
Electrification is mainly **driven by TCO** and **regulation**, with **Europe** and **Greater China** as **front runners** – **charging infrastructure** readiness is a **key prerequisite** for ramp-up.

Electrification ramp-up increases battery demand

Increasing **ZEV diffusion** and **battery capacities** result in a significant **truck battery demand** of **~170GWh** in **Europe** by **2035, >800 GWh in the triad markets.**

Electrification is mainly driven by TCO and regulation, and expected to breakthrough from 2030 onwards – CN and EU are front runners

Drivers towards electric CV covering MD, HD and BUS



Comments

Regulatory environment **facilitates adoption** through increasing pressure (e.g., EU emissions regulation)

Charging infrastructure expected to be **sufficiently available from 2030+**

ZEV exhibits lower TCO than ICE from 2025+, mainly driven by BET

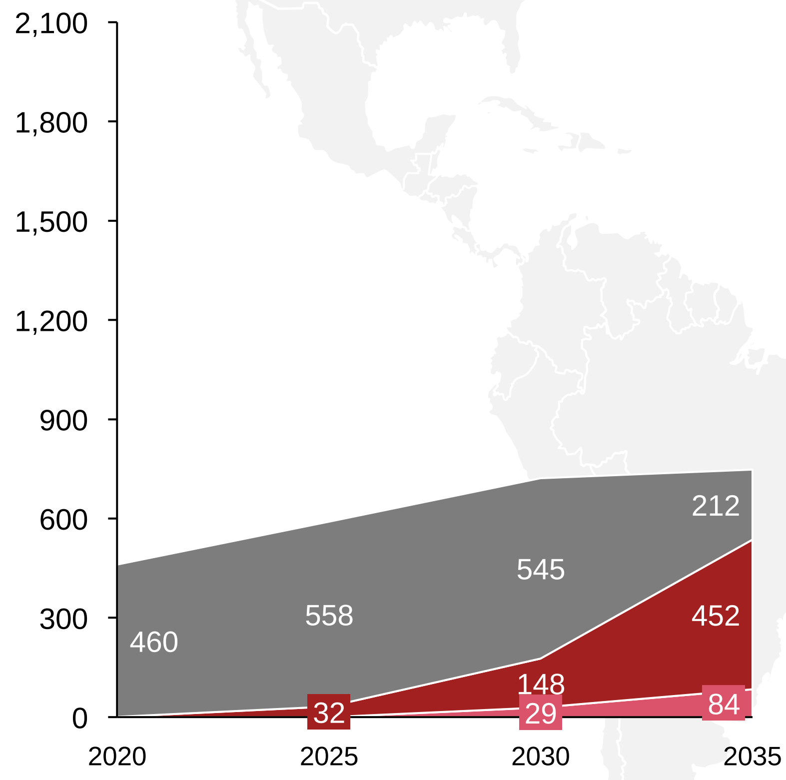
Increased public concern over **climate change** to **facilitate** demand and trust in **ZEV technologies**

Impact on electrification ramp-up:
Negative Marginal Positive Tipping point

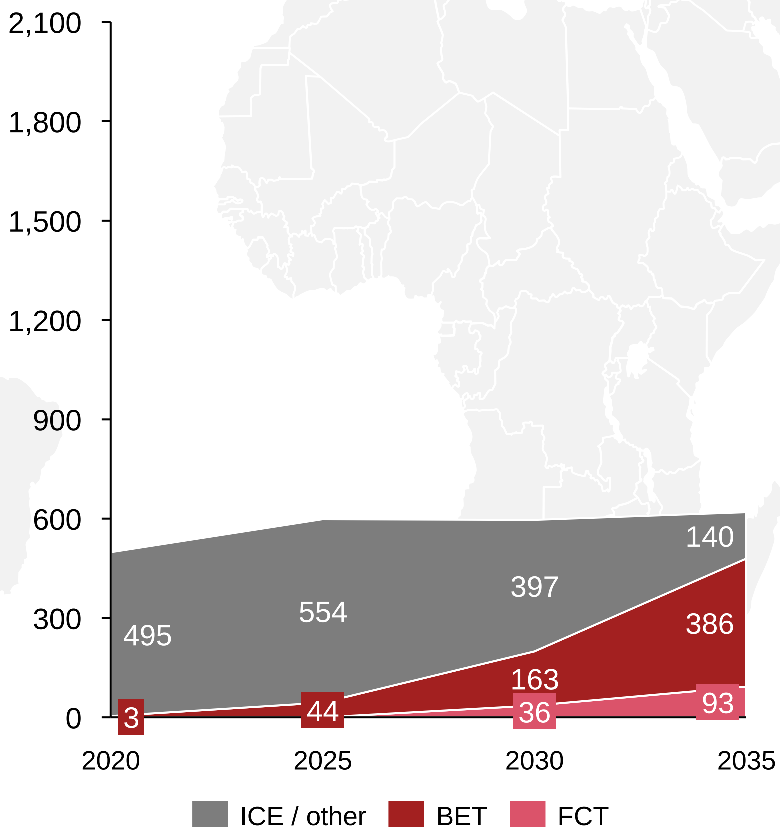
In 2030, ~900k BET/FCT will be produced in the triad markets – ~200k units in North America & Europe, ~500k units in CN

Truck electrification ramp-up 2020-2035 in selected regions[1]

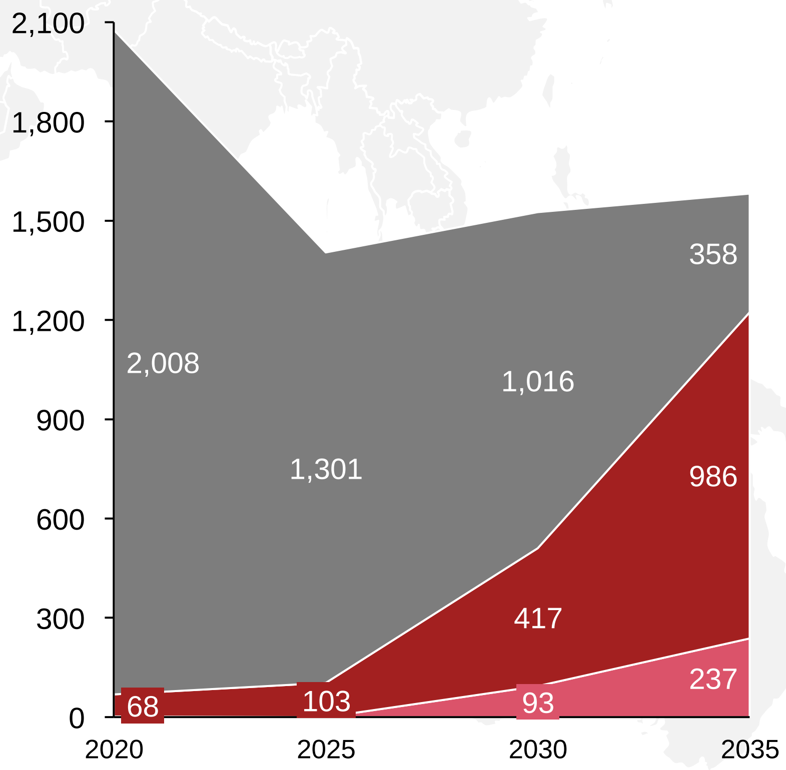
North America *(k vehicles)*



Europe *(k vehicles)*

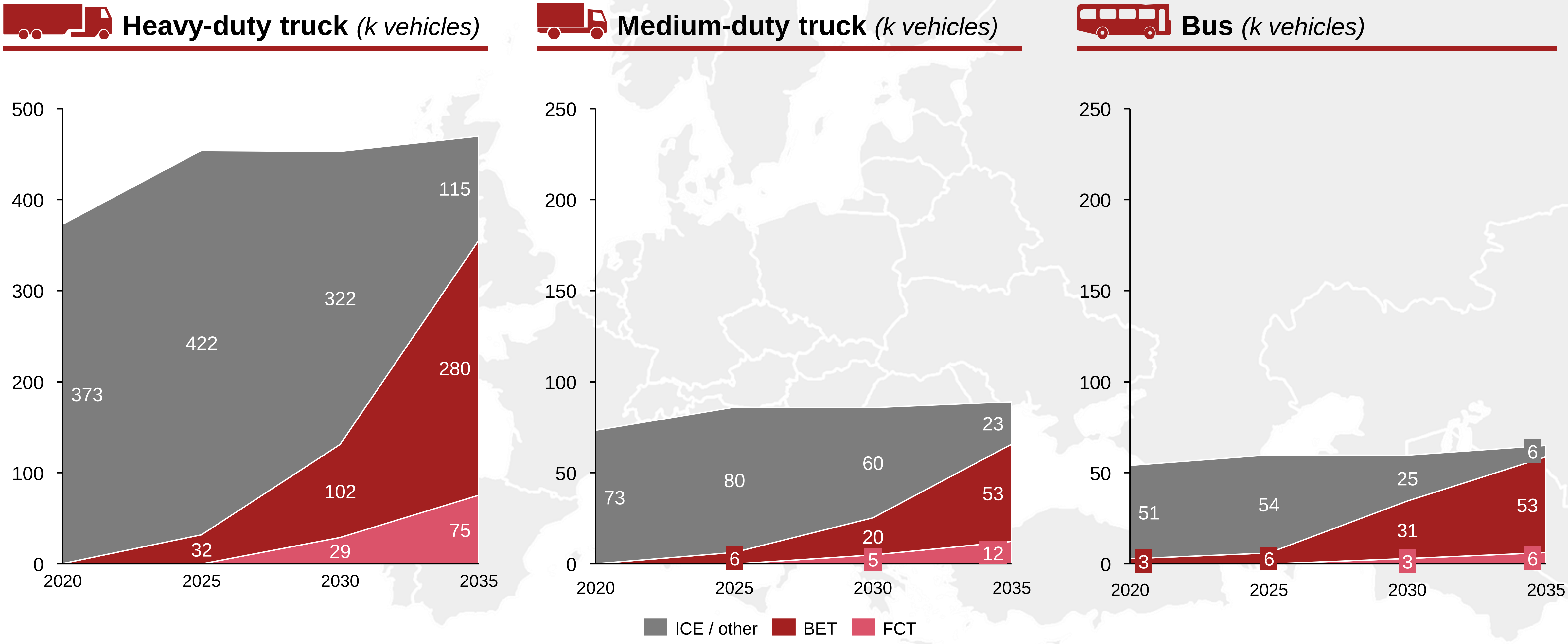


Greater China *(k vehicles)*



Europe's heavy-duty BET/FCT production will reach ~130k units in 2030 – medium-duty trucks and buses have lesser relevance

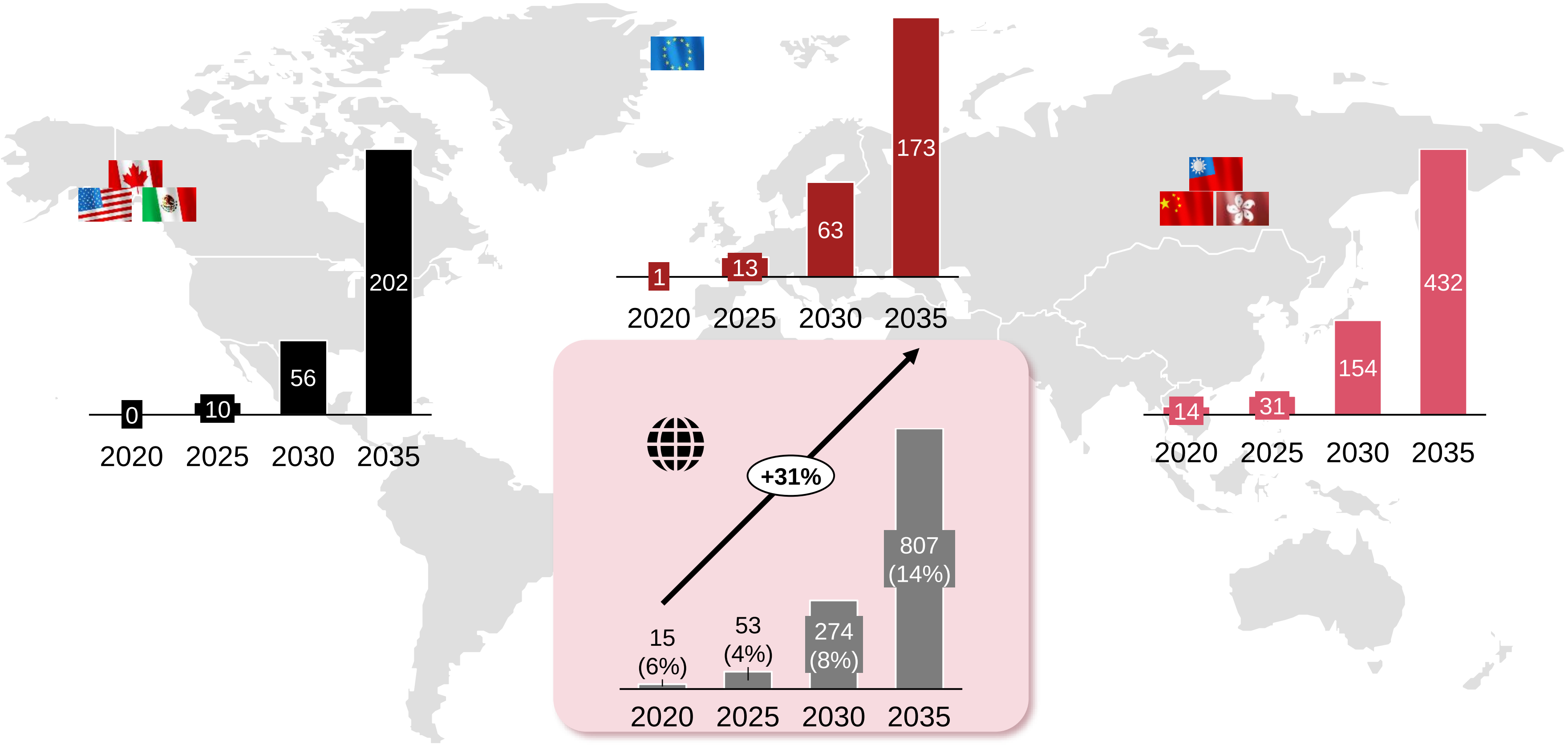
Truck electrification ramp-up 2020-2035 for selected segments in Europe



Increasing ZEV diffusion and battery capacities result in truck battery demand of >800 GWh in the triad markets by 2035

Deep dive: Battery demand ramp-up 2025-2035

HD & MD trucks battery demand ramp-up[1] *(GWh)* and share of total demand[2] *(%)*



Comments

Gigafactory demand[3]

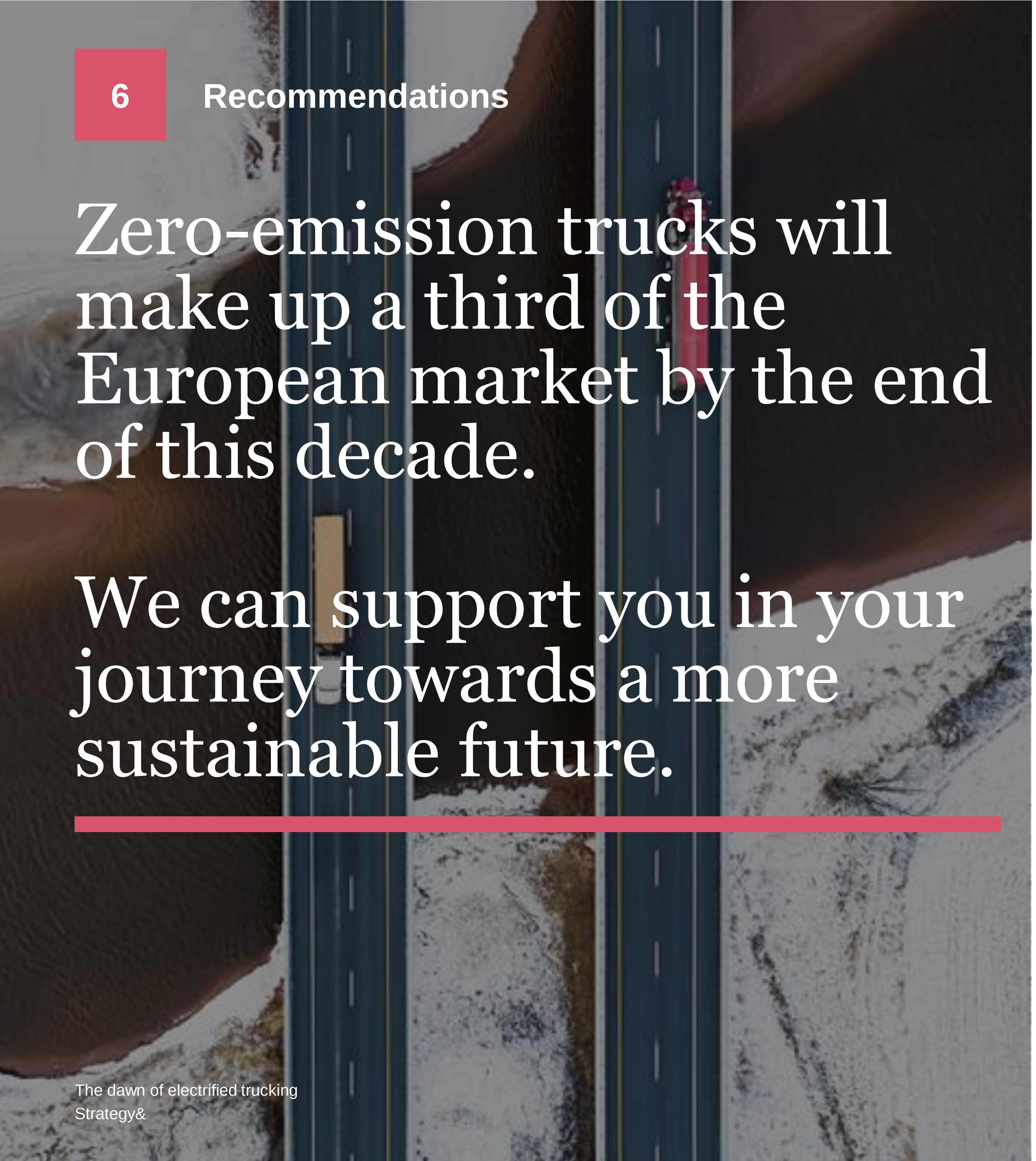
- ~ 20 gigafactories required to cover HD & MD truck battery demand by 2035

Production stream demand[4]

- ~ 100…150 gigafactory streams required to cover HD & MD truck battery demand by 2035

Ratio to total battery demand

- Truck battery demand share expected to be ~15% of total battery demand (2035)
- Higher ramp-up dynamics expected compared to PC and CV (>30% CAGR)[5]



Zero-emission trucks will make up a third of the European market by the end of this decade.

We can support you in your journey towards a more sustainable future.

Build up an attractive zero-emission portfolio

OEMs need to **aim for a competitive zero-emission product portfolio** with a **focus on product cost and efficiencies** – from light-duty to heavy-duty trucks. We also recommend a **concentration of R&D resources on battery and fuel cell trucks**, as these have the most competitive positioning.

Support infrastructure availability

OEMs should actively develop and **offer infrastructure options for truck users**. **Turnkey depot solutions are mandatory** (in cooperation with energy suppliers), while **public infrastructure** investments require **governmental backing.**

Prepare the value chain

Faced with declining revenues from conventional powertrain business, **suppliers should** review their portfolio and **assess their opportunities** for **taking part in the new zero-emission trucking business.**

Offer attractive financing

Due to higher prices, as well as the durability and residual value risks of zero-emission trucks, **OEMs should adjust their financing models** for logistics companies, including hedging electricity prices by securing long-term energy supply contracts.

Truck electrification is a cross-industry effort, requiring activities throughout the value chain by multiple players

Cross-industry impact and recommendations

Automotive

Replace oil by lithium

… change revenue pools
… build new competencies
… transform organizations

Production equipment

Technically enable transformation

… provide production equipment
… build new value/supply chains
… conceptualize recycling

Public sector

Lay the foundations

… regulate emissions targets
… support supply chain deals
… provide green funding

Energy & infrastructure

Power the transformation

… build required infrastructure
… supply renewable energy
… balance and manage grid

Logistics

Bring it on the road

… meet fleet and CO_2 targets
… rethink mobility concepts
… define new investment needs

Financial services

Fuel the transformation

… provide required investments
… define asset ownership
… setup investment strategy

Materials & chemicals

Mine & refine the new oil

… scale value chain
… meet automotive standards
… conceptualize recycling

Strategy& is a global strategy consulting business uniquely positioned to help deliver your best future: one that is built on differentiation from the inside out and tailored exactly to you. As part of PwC, every day we're building the winning systems that are at the heart of growth. We combine our powerful foresight with this tangible know-how, technology, and scale to help you create a better, more transformative strategy from day one.

As the only at-scale strategy business that's part of a global professional services network, we embed our strategy capabilities with frontline teams across PwC to show you where you need to go, the choices you'll need to make to get there, and how to get it right.

The result is an authentic strategy process powerful enough to capture possibility, while pragmatic enough to ensure effective delivery. It's the strategy that gets an organization through the changes of today and drives results that redefine tomorrow. It's the strategy that turns vision into reality. It's strategy, made real.

www.strategyand.pwc.com

Contact us

Dr. Jörn Neuhausen
Director E-Mobility
PwC Strategy&
joern.neuhausen@strategyand.de.pwc.com

Dr. Christian Foltz
Partner Automotive
PwC Strategy&
christian.foltz@strategyand.de.pwc.com

Dr. Philipp Rose
Director E-Mobility
PwC Strategy&
philipp.rose@strategyand.de.pwc.com

Andreas Thalmair
Manager
PwC Strategy&
andreas.thalmair@strategyand.de.pwc.com

Tobias Kasseroler
Senior Associate
PwC Strategy&
tobias.kasseroler@strategyand.de.pwc.com

Lorenz Kehrbein
Associate
PwC Strategy&
lorenz.kehrbein@pwc.ch

The authors would like to thank Steven James Van Arsdale, Morten Grunwald and Dr. Naser Almohammed for their contribution.