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Battery-electric trucks on the rise

Truck Study 2024

September 2024

The dedication and diversification of battery-electric truck platforms will determine the next phase in road-based eMobility transformation

Executive summary

1 **Regulatory drivers** are pushing towards Battery-electric trucks, while **OEMs offer a growing range of BET products**.
Further truck electrification requires **new platforms meeting varying customer requirements** and use cases.

2 **Facilitated by innovations** in battery system, cell chemistry, eDrive and HV architecture **various use cases are enabled**.
Truck-specific developments for battery and eDrive will be the decisive differentiator.

3 **Higher initial investments remain a challenge** – yet **TCO clearly pushes towards electrification**.
BET efficiency, charging infrastructure utilization, and the right choice of cell chemistry as key TCO drivers.

4 **By 2030,** we expect more than **20% of transportation to be be electrified**.
With more than **1,700 GWh in 2040, truck batteries** gain in **importance**, with **increasing importance of LFP.**

5 **The impact of electrification** in **logistics** and **transportation** requires not only **significant investments** in public and private infrastructure, but also updated operating models.

6 To **make the BET transition a success, cross-industry efforts are required** – from regulatory, via automotive and energy towards logistics facilitated by financial services.

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1 **Regulatory and customer requirements**

Regulatory drivers are pushing towards Battery-Electric Trucks, while OEMs offer a range of BET products.

Further truck electrification requires new platforms meeting varying customer requirements and use cases.

Regulatory motivation

EU regulation sets the path for truck OEMs to **reduce their new fleet emissions** by at least **90% by 2040** and up to 45% by 2030, further pushing the decarbonization and electrification of commercial vehicles.

From first pilots to emerging BET portfolio

With the new generation BET entering the market, more use cases are enabled, yet **full portfolio enablement requires further truckification**.

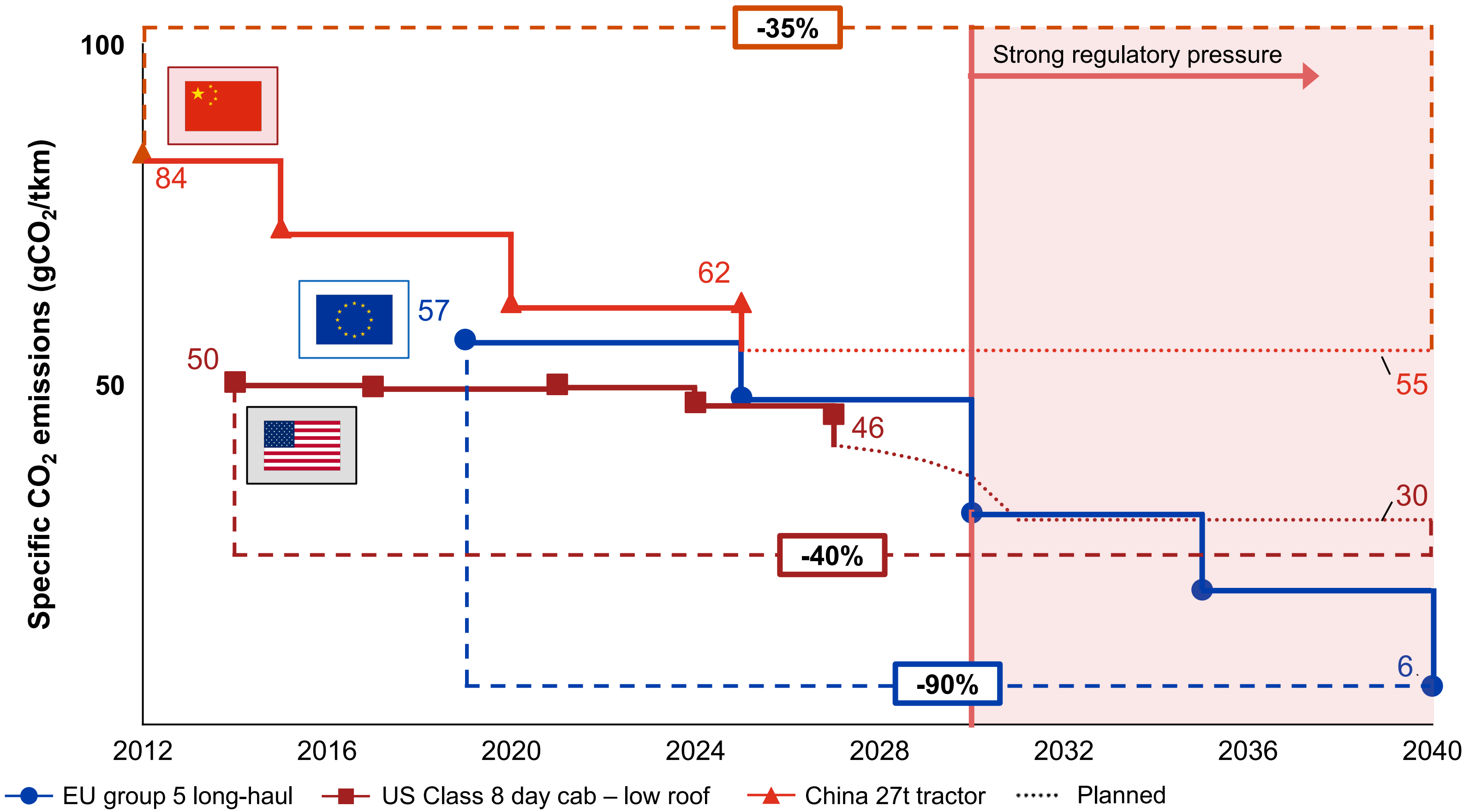
Diverse customer requirements

Depending on use case, strongly varying requirements regarding range and charging speed need to be fulfilled. **Future platforms** need to be offered to **meet customer flexibility requirements**.

Emission regulation is a strong push towards electrification of trucks – strict emission reductions targets force to action in all relevant markets

Global CO_2 regulations and economic incentives

International CO_2 emission truck fleet targets



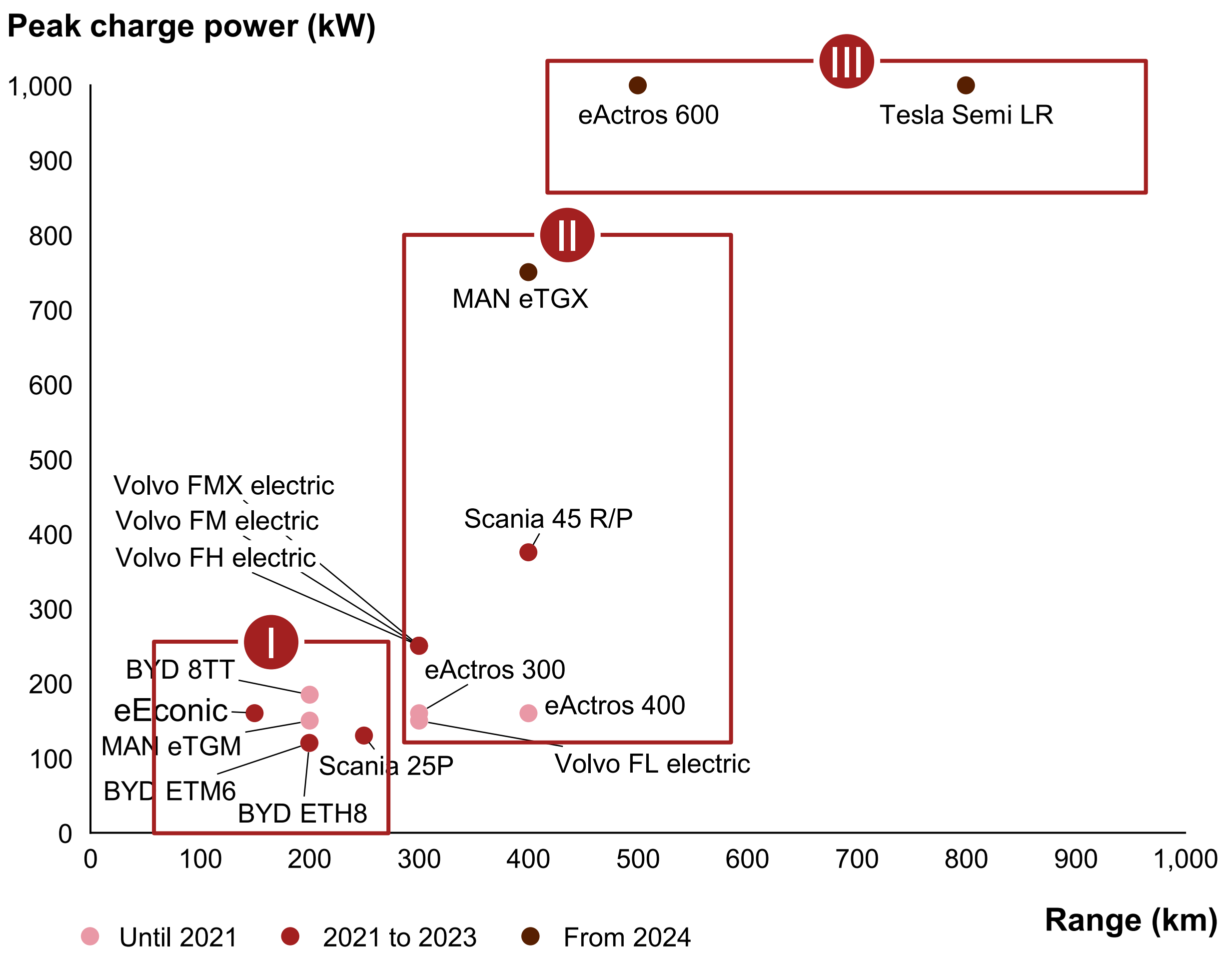
Comments

- Individual CO_2 emission targets cannot be directly compared, but require conversion with appropriate proxies
- China has the mildest CO_2 emission regulations, the EU has average CO_2 emission limits, and the US imposes the strictest regulations
- While the EU is drastically lowering its CO_2 emission target, China and the US are imposing only a modest reduction
- Nevertheless, regulatory pressure on low emission trucks enforces electrification from 2030 onwards

Assumptions:
EU base scenario, tractor group 5 long-haul; US Day cab Class 8 day cab with low roof; China fuel consumption for 27t tractor-trailer with 2.6 $kgCO_2$/l diesel and 13t payload

With the new generation BET entering the market, more use cases are enabled, yet full portfolio enablement requires further truckification

BET generation overview



Truck generations

I

First distributions and specials

- First prototype products
- Utilization of repurposed BEVs
- Limited to distribution and special uses, due to range and charging speed limits

II

First line-hauls

- Initial truck-specific development
- Suitable for everyday use with intermediate range and charging speed
- Enabling line-haul use case with increased usability

III

First long-hauls

- First long-haul products emerging
- Strong development and technological diversification
- Full portfolio development with sophisticated range and charging speed

Source: Strategy& analyses, company website

BET – Battery-Electric Truck

The global truck market can be segmented across six use cases, with highest emission impact through long-haul, line-haul, and distribution

Use cases and archetypes overview

	Heavy duty truck		Heavy and medium duty truck		Bus	
						
Use case	**Long-haul** • "Classic" long-haul with semi-trailer • Logistics and industries	**Line-haul** • Repeated transports with semi-trailer • Logistics and industries	**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	11%	22%	34%	22%	6%	5%
Yearly mileage (km)	150,000	100,000	50,000	40,000	100,000	50,000
Annual emission share	28%	31%	22%	12%	5%	2%

Source: Strategy& analyses

Across these use cases, standard and long-range variations are expected to be offered to meet customer flexibility requirements

Customer-relevant BET platform specifications (2030)

Use cases	Cont. power (In kW)	Range variations – Minimum (Customer requested ranges in km)	Range variations – Maximum (Customer requested ranges in km)	Charge speed
1 Long-haul	450	600 km	1000 km	>1 MW
2 Line-haul	450	400 km	600 km	1 MW
3 Distribution	200	300 km	500 km	350 kW
4 Specials	400	200 km	300 km	350 kW
5 Coach	250	400 km	600 km	> 1MW
6 Urban	200	300 km	400 km	350 kW

Minimum use case requirement **Maximum use case requirement**

Facilitated by innovations in battery system, cell chemistry, eDrive and HV architecture use cases are enabled.

Truck-specific developments for battery and eDrive will be the decisive differentiator.

Long-lasting batteries required

Battery-electric trucks have **high requirements regarding lifetime and battery degradation**. Cycle stability and pack energy density are key differentiators while batteries become megawatt-charging-ready.

Highly efficient eDrive concepts to be developed

First **truckified eDrive concepts enter the market**. Central motor has similar architecture to ICE compared with an axle-integrated motor, offering BET-specific design advantages.

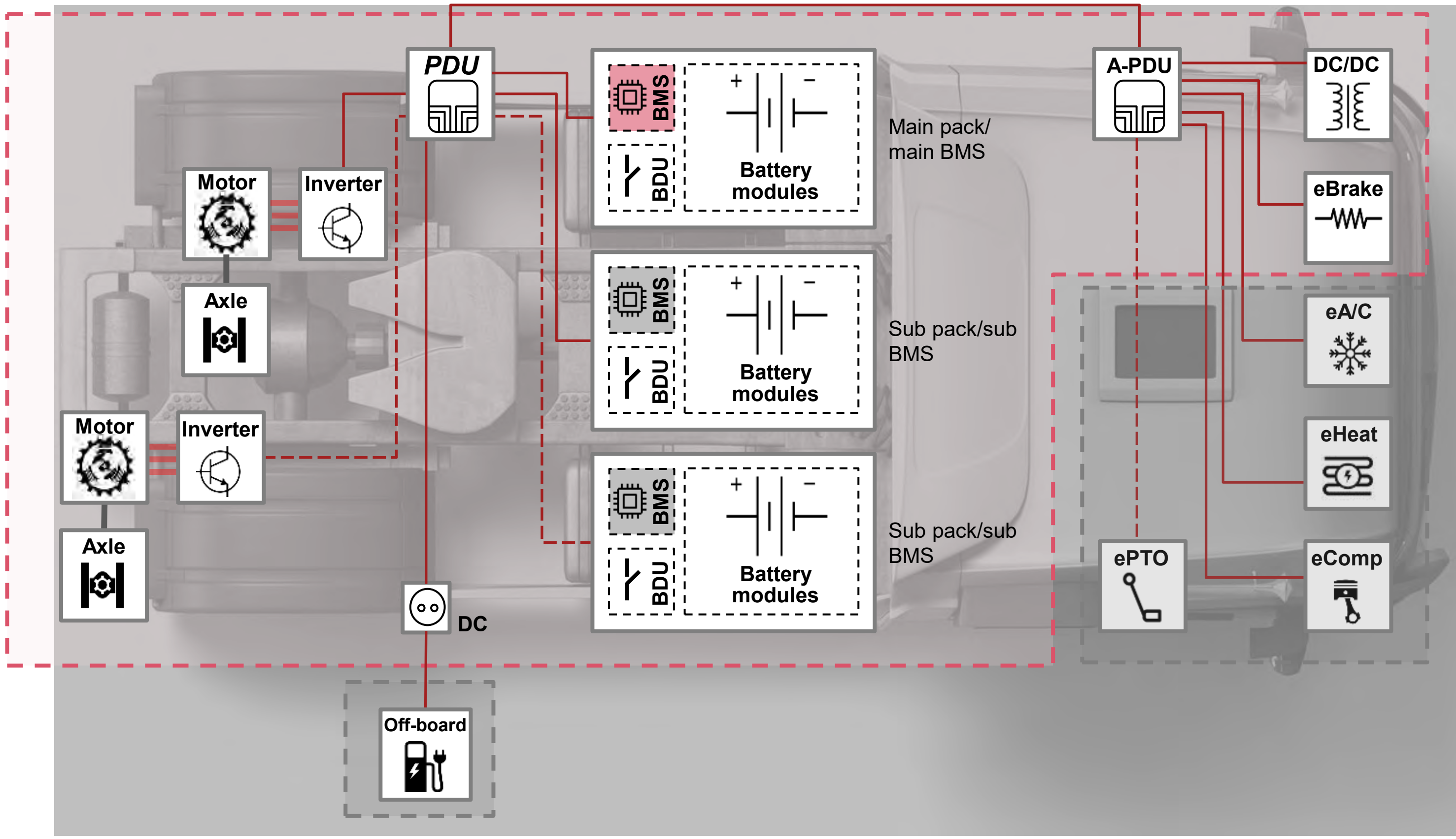
Key battery improvement drivers yet to be utilized

As BET **charging speed is currently limited** mainly due to infrastructure, major charging time reduction is expected with MCS charging. Cell still offers cost saving potential, whereas **cell-to-pack offers potential for range increase**.

A typical BET has multiple battery packs, a differentiated integrated eDrive and HV components

BET architecture

Visualization (Line-haul example)



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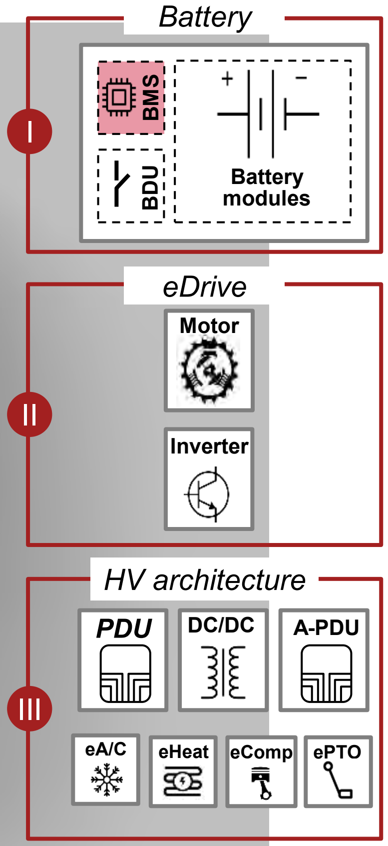


- Multiple multi-layer battery packs distributed across vehicle – vertically or horizontally to driving direction

- Central eMotor or axle-integrated eMotor
- Inverter either integrated in eMotor, axle or HV components

- HV components either integrated or distributed across vehicle
- Auxiliary HV components either integrated or distributed across vehicle

Battery packs for electric trucks consist of multiple layers and packs – cells require high cycle stability and range

I Battery pack and cell overview

Battery pack characteristics

1 Multi-layer battery

- Battery consists of multiple layers in z-dimension
- Layer consists of multiple sub-modules

2 Multi-pack battery

- Battery consists of multiple individual battery packs
- Battery packs can be arranged distributed across vehicle

3 Space utilization

- Battery is optimized for maximum design space utilization
- E/E is often positioned externally

Cell characteristics and requirements

Cycle stability
Up to 5k

- Long truck **lifetime** and high **mileage** requires long battery lifetime and **high cycle stability**
- **Customized cell chemistries** required

Range
Up to 1,000 km

- **Long distances** traveled necessitate **high battery range**
- **Operational schedule** demands **minimizing charging** and **downtime**

Weight
Up to 5 t

- High importance of **payload** demands **minimum vehicle weight**
- **High battery weight** demands **minimum cell weight**

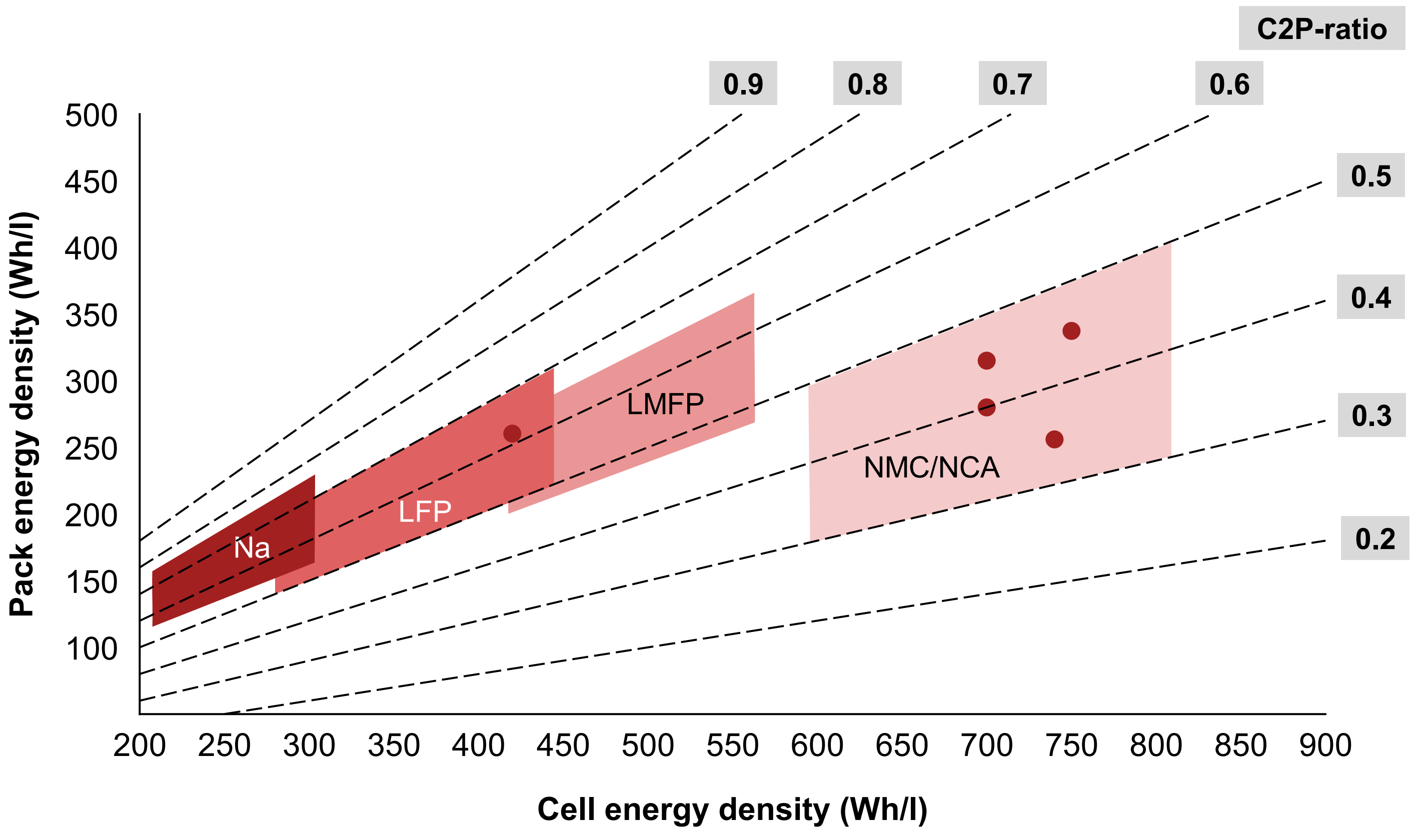
Cost
Up to 100k €

- High importance of **TCO** demands **minimum vehicle cost**
- **High battery cost** demands **minimum cell cost**

While different cell chemistries result in a similar pack energy density, weight and cost are further important characteristics

I Battery optimization levers

Cell and pack energy density overview



Takeaways

- **NMC/NCA** cells have **highest** cell **energy density**
- However, a low **Cell-to-Pack (C2P) ratio** is required for TP safety of NMC/NCA cells
- Achievable **pack energy density** of NMC/NCA is similar to LMFP and LFP cells
- **No dominating technology** can be observed on the market
- Development of a **multi-chemistry platform** with identical cell format can be reasonable for **diversification**
- Cell chemistry is not only determined by required energy density – **costs** and **weight** are further major factors

Going forward, sodium chemistry could cover short-range applications, while L(M)FP and NMC chemistries suit long-range applications

I Cell chemistry use case portfolio 2030

	Distribution[2)]		Line-Haul[2)]		Long-Haul[2,3)]		
							
Range requirement	300 km	500 km	400 km	600 km	600 km	1000 km	**Cost (€/kWh)**
Na-Ion[1)] 300 Wh/l	In target range	Outside target range	In target range	Outside target range	In target range	Outside target range	60...65
LFP 420 Wh/l	Overfulfilled	Outside target range	Overfulfilled	In target range	Overfulfilled	In target range	70…75
LMFP[1)] 480 Wh/l	Overfulfilled	In target range	Overfulfilled	In target range	Overfulfilled	In target range	65...70
NMC 800 Wh/l	Overfulfilled	In target range	Overfulfilled	In target range	Overfulfilled	In target range	85…90

Outside target range | In target range | Overfulfilled

Takeaways

- **Na-Ion** chemistry is only suitable for **short-range** variants
- **Long-range long-haul** can only be achieved by **NMC** and **LMFP**
- While **NMC** has high **maturity**, **LMFP** is **under development**
- **LMFP** has significant **cost advantage** compared to **NMC**
- **LFP** becomes **less significant** once **LMFP** is ready for market
- Development of a **multi-chemistry platform** can be reasonable to cover the **full portfolio** and offer **various segments**

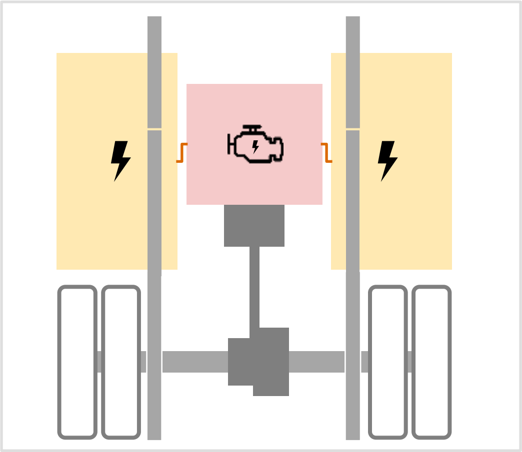
1) Current technological maturity level insufficient - development ongoing; 2) Assumed battery volume: Distribution: 1600l, Line-Haul: 2300l, Long-Haul: 3700l
3) Based on US Sleeper vehicle concepts

The Battery-electric truck eDrive can be axle-integrated or central – efficiency, cost and power are major focus areas

II eDrive overview

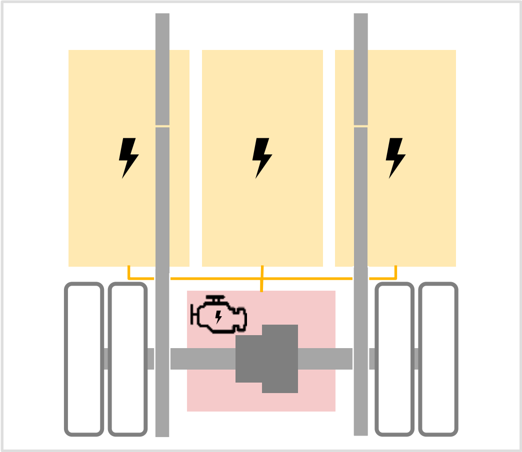
eDrive configurations

Central motor



- **Centrally-located** electric motor, power electronics and gear box
- **Cardan shaft** transmits power to axle
- Less central space for battery packs and **higher mechanical losses**
- Complex **battery packaging –** simple **auxiliary unit positioning**

Axle-integrated motor



- **Rear-axle-integrated** electric motor, power electronics and gear box
- **Direct power transmission** to wheels
- More central space for battery packs and **lower mechanical losses**
- Complex **eDrive packaging** and **auxiliary unit positioning**

Battery | eDrive (electric motor, power electronics, gearbox)

Development focus and requirements

Efficiency
Up to 90%

- High importance of **TCO** demands **minimum operational cost**
- Large effect of **eDrive efficiency** on operational cost requires **maximum eDrive efficiency**

Power
Up to 600 kW

- Heavy loads and high vehicle weights require **high power**
- **Steep inclines** and **acceleration** require **high power** from eDrive as well as **smooth operation**

Cost
Up to € 10k

- High importance of **TCO** demands **minimum vehicle cost**
- **High investment cost** demands **minimum eDrive cost**

Integrated HV architectures can reduce cost and increase performance – high requirements regarding cost and charging

III HV architecture overview

Component integration

DC/DC	DC-DC converter (DC/DC)
Inverter	Motor control unit (Inverter)
PDU	Power distribution unit (PDU)
eComp	Air compressor controller (eComp)
Steering cont.	Steering controller

Efficiency

- Reduced electrical losses
- Improved thermal management
- Lightweight design

Reliability

- Reduction in overall components
- Reduced wiring and connections

Serviceability

- Easily accessible for servicing
- Streamlined inventory for service partners

Development focus and requirements

Cost potential vs. capable suppliers

- **Integrated design** leads to **reduced overall components**
- Fewer parts leads to **reduced weight** and **reduced risk of failure**
- Only a **few suppliers** are able to develop and produce integrated HV components

Charging
>1.5 MW

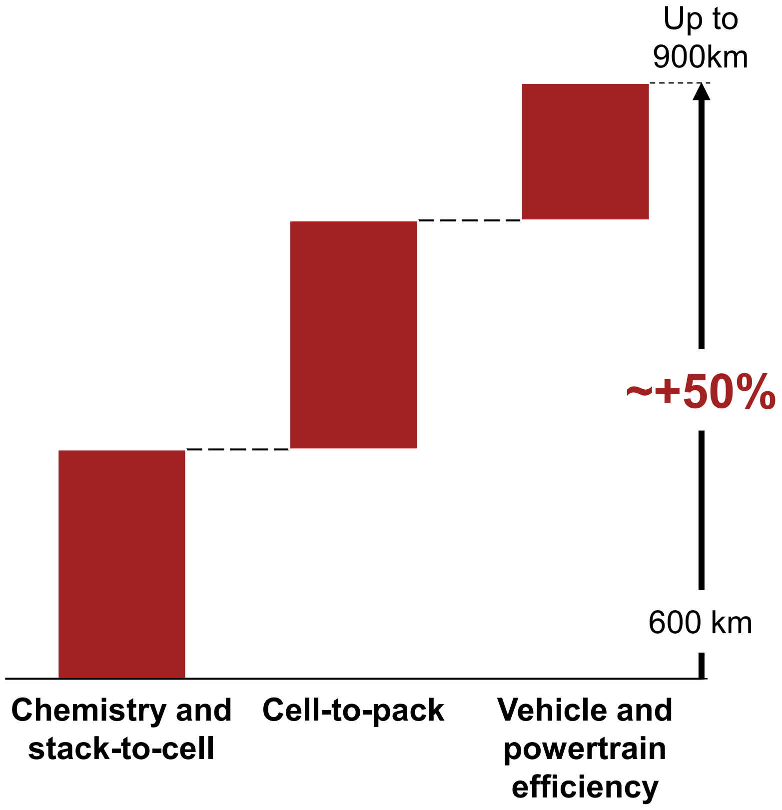
- High **daily mileage** requires **fast charging solutions**
- **Large battery capacities** lead to **high charging powers**
- Enabling **MCS charging** requires **high-performance HV architectures** handling 2000 A currents

Driven by battery innovations and infrastructure, we expect range increase and cost reductions, with a further push in charging speed

Main BET technological drivers towards 2030

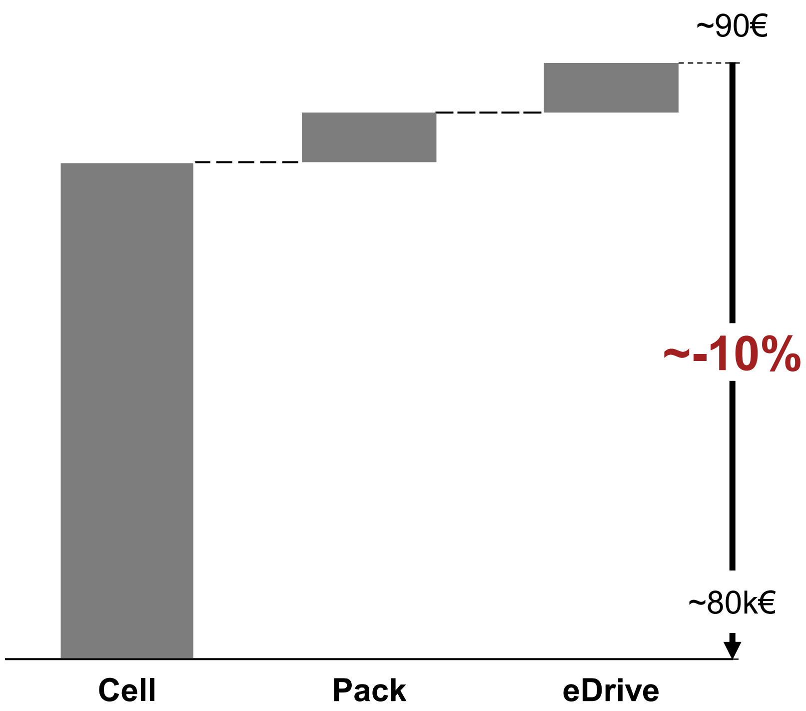
Truck range increase

Illustrative for long-haul



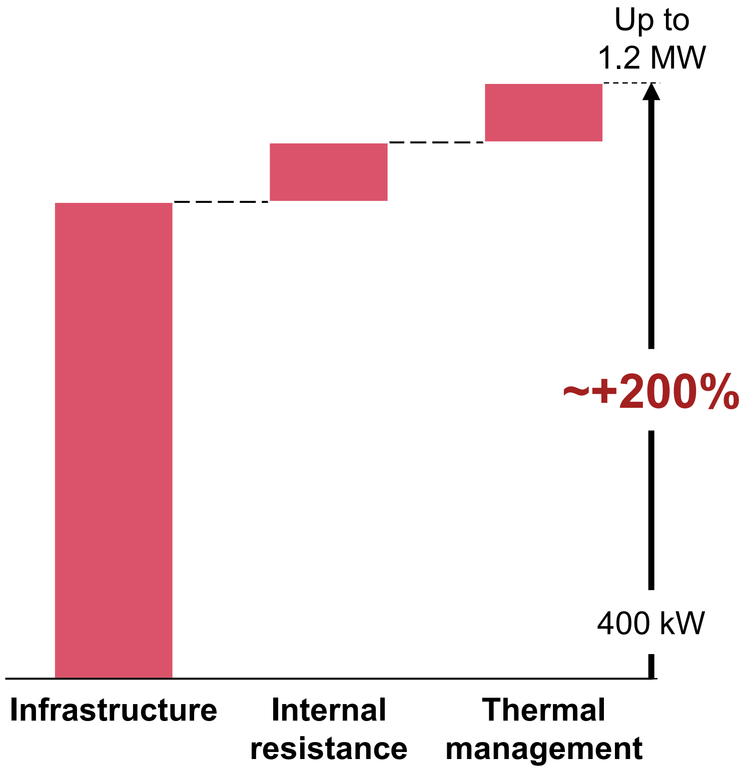
Truck ePowertrain cost reduction

Illustrative for long-haul

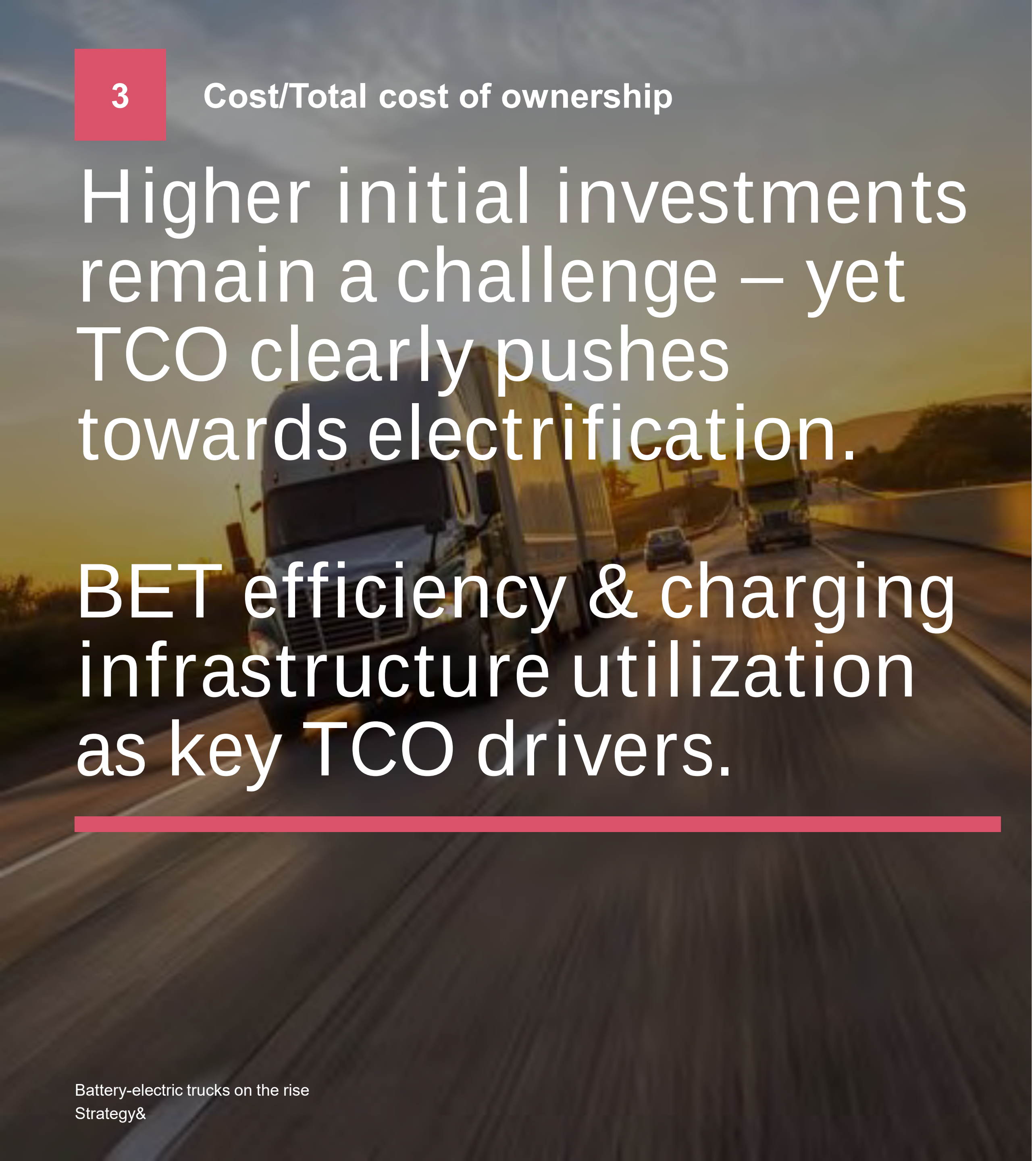


Charging speed increase

Illustrative for long-haul



1) Improvements compared to 2024 baseline



Higher initial investments remain a challenge – yet TCO clearly pushes towards electrification.

BET efficiency & charging infrastructure utilization as key TCO drivers.

Battery cell remains key cost driver

BET investment will remain above conventional ICE powertrains, especially driven by higher battery costs. To become an economic alternative, TCO and depreciation costs are critical.

BET with TCO advantages across use cases

For both mileage- and payload-sensitive use cases, **BET powertrains offer TCO advantages** from 2025 and 2030 onwards. **Competitive energy and charging costs are a key** requisite to realize TCO potential.

BET efficiency and charging infrastructure utilization as key TCO driver

TCO of BETs is significantly dependent on charging price. While the baseline electricity price is subject to moderate variance, **infrastructure markup scatters** strongly depending on **charging technology and utilization**.

Despite technological evolution, the investment gap between ICE and BET will remain, with battery being the key cost driver

Illustrative price breakdown of BET Long-Haul 2030

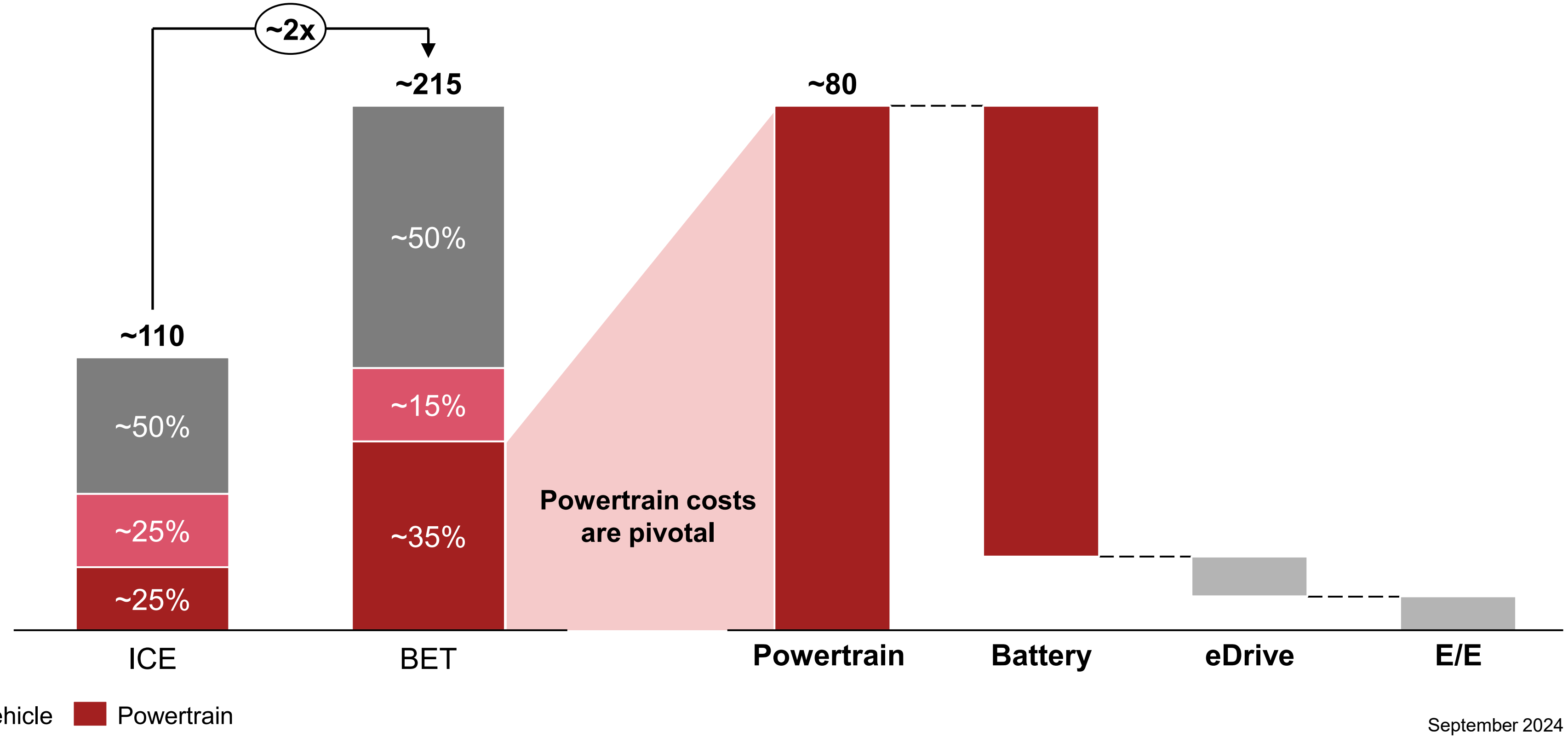
Long-haul megawatt charger

Battery[1)]	700 kWh_{use}
Power	400 kW_{cont}
Range	600 km

ICE vs. BET cost comparison (in k€) / Powertrain cost split (in k€)

Powertrain constitutes ~35% of total BET price

~90% of the powertrain cost comprises battery costs



1) LFP chemistry

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

Rough breakdown of relevant TCO elements in Europe

TCO elements	Scope[1)]	Description	Important cost levers (incl. illustrative 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** BET battery cell: 70 €/kWh **Component lifetime** BET battery: 4,500 cycles
Driver	(not considered)		
Energy	In scope	**Cost estimation** of **energy** including non-house-hold prices for **diesel** (incl. CO_2 tax), **AdBlue, electricity for depot and public charging** (incl. infrastructure investments)	**Energy costs**[2)] Diesel: 1.50 €/l (incl. CO_2 tax) Electricity: 19.0 €-cent/kWh for depot CCS charging, 40.7€- cent/kWh for public MCS charging (incl. charging infrastructure mark-up, assumed utilization of 30%/15% for depot/public)
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 BET: 0.057 €/km
Tax	(not considered)		
Toll	(not considered)		
Financing	In scope	Cost estimation of **financing** the **vehicle acquisition**	**Interest rate** Loan interest rate: 4.5%/year

1) Relevance for alternative powertrains and data availability 2) Costs for Germany assumed
Source: Strategy& analysis.

TCO – Total Cost of Ownership

BET outperforms ICE in terms of TCO from 2025 onwards across all use cases – energy costs represent the main driver

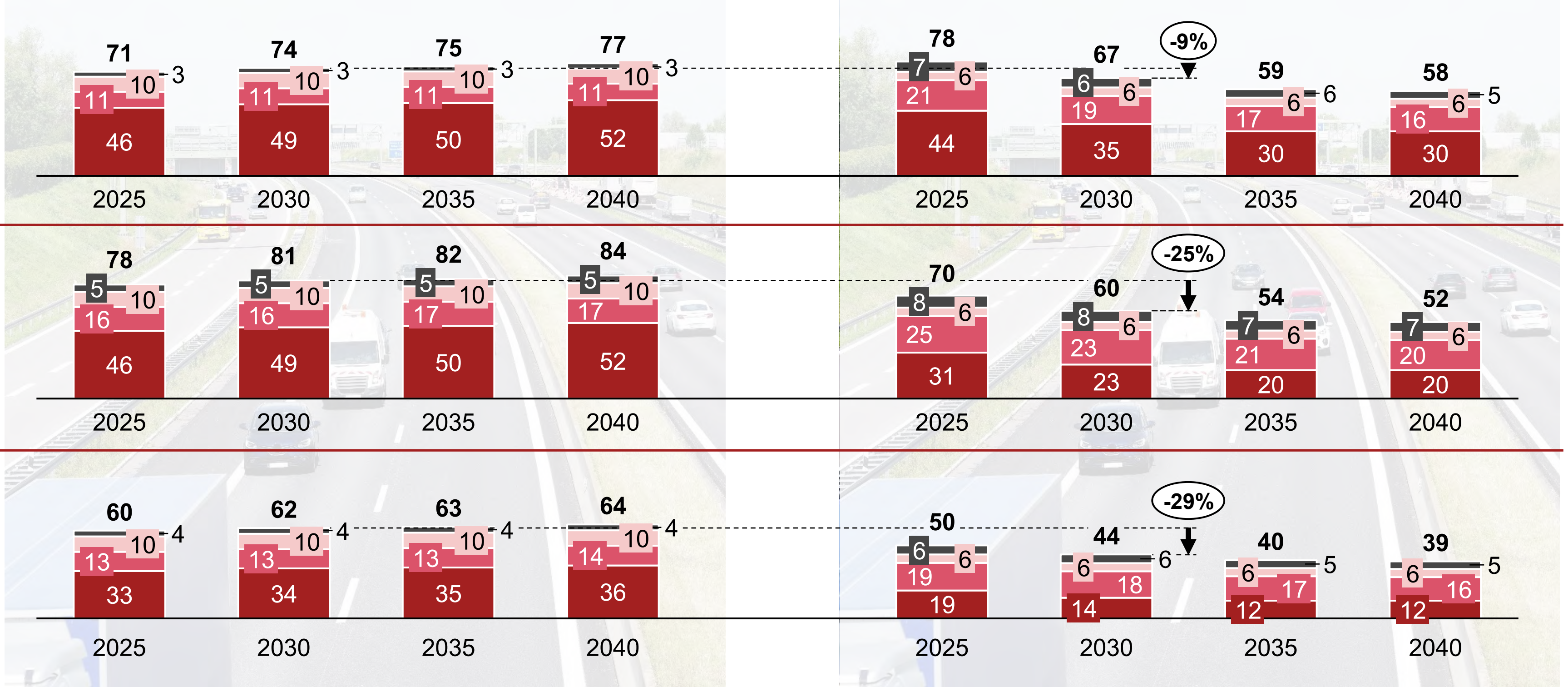
Mileage-based TCO for selected use cases across powertrain options 2025-2040 (EU, Germany)

Mileage-based TCO | **ICE** (diesel-powered) *in €-ct/km/y* | **BET** (electric-powered) *in €-ct/km/y*

HD long-haul
- ~ 600 km/d
- 400 kW
- 60% public MCS

HD line-haul
- ~ 400 km/d
- 400 kW
- 90% depot CCS

MD distribution
- ~ 300 km/d
- 200 kW
- 100% depot CCS



Mileage (km) per day (based on 250 working days per year) | Performance (const. power) | Charging share

Energy costs | Depreciation costs | Maintenance costs | Financing costs

Source: Strategy& analyses

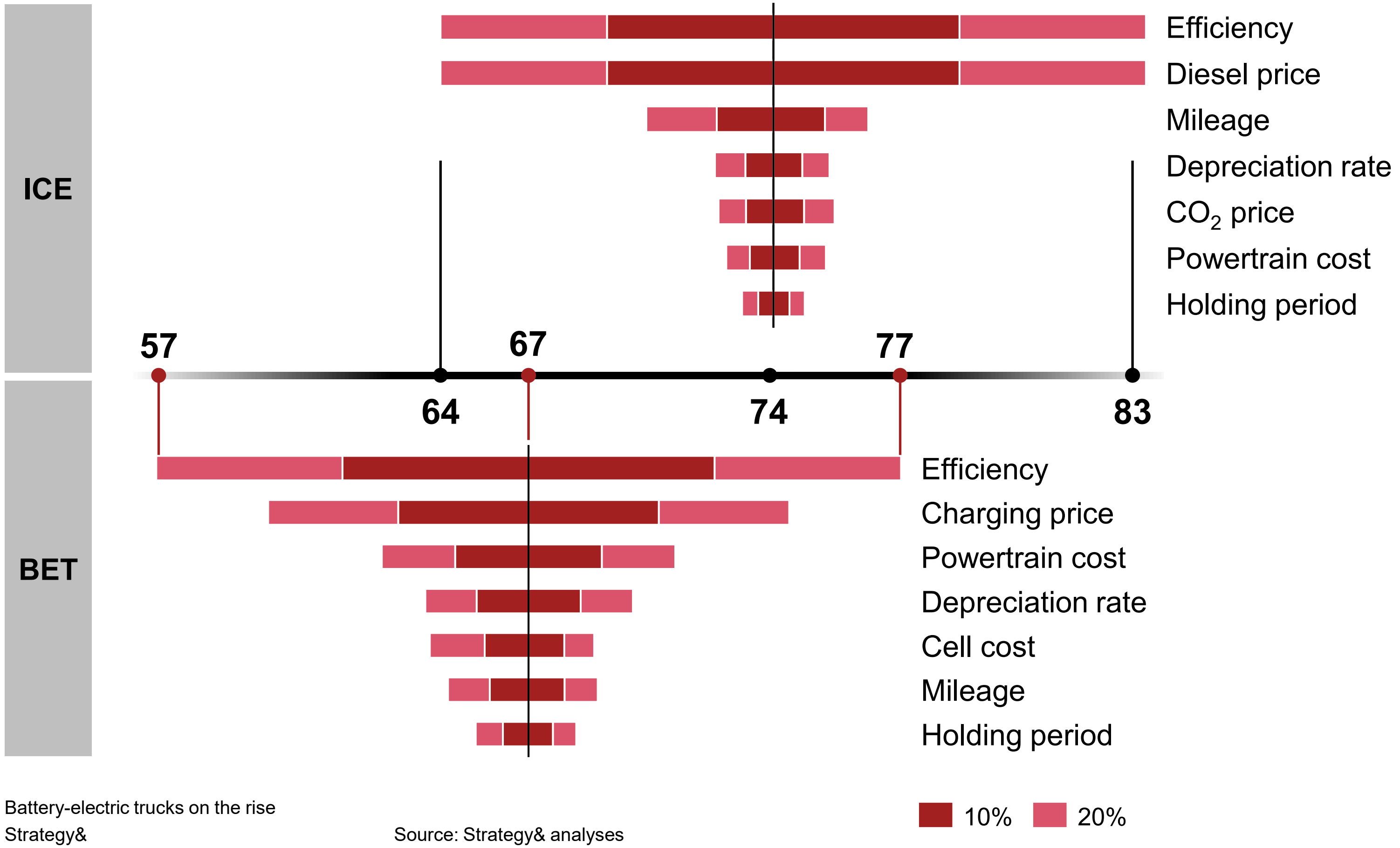
MCS – Megawatt Charging System

CCS – Combined Charging System

Energy costs are the key until 2030 – a mere 10% difference in diesel and charging prices could flip the TCO advantage of BET towards ICE

TCO sensitivity analysis for BET Long-Haul 2030 (EU, Germany)

TCO sensitivity comparison (in €-ct/km/y)



Key TCO drivers

- **Energy costs** (i.e., efficiency, and diesel price) primary driver for TCO
- **Depreciation factors** (e.g., mileage, depreciation rate, powertrain costs) secondary driver for TCO

- **Energy costs** (i.e., efficiency, charging price) primary driver for TCO
- **Powertrain** and **cell costs** as secondary driver

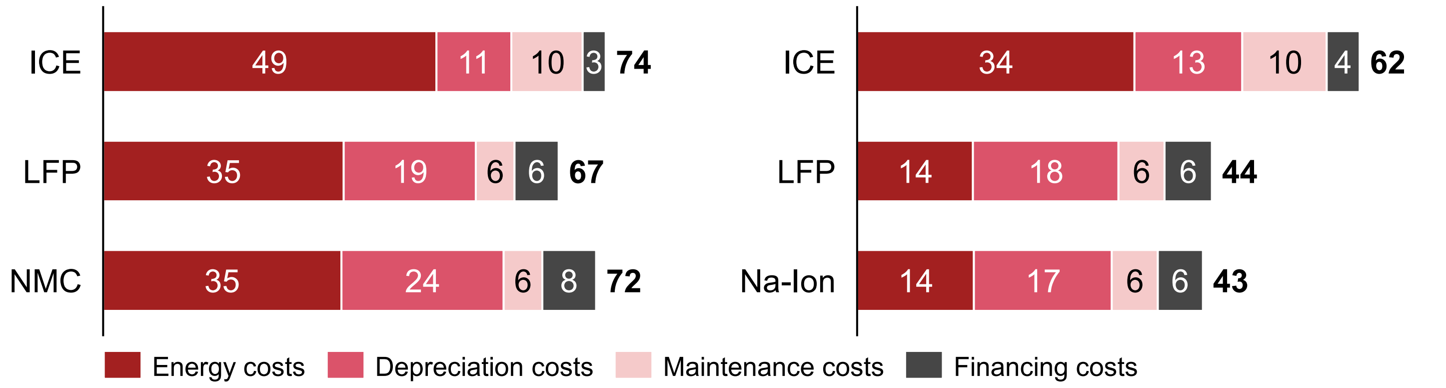
Source: Strategy& analyses

Looking at mileage-based TCO, BET have advantages over ICE – regarding payload-based TCO, long-haul electrification is on the edge

III BET chemistry 2030 TCO comparison (EU, Germany)

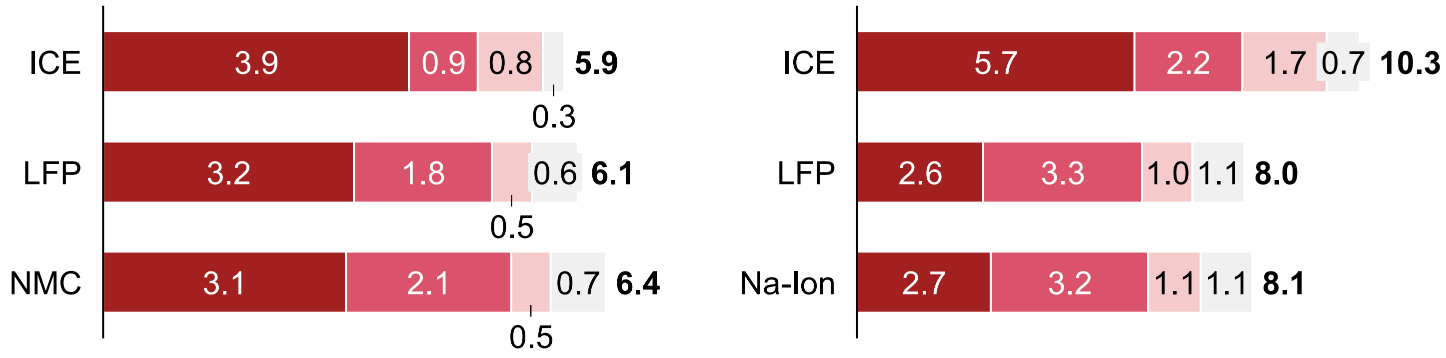
Long-haul | **Distribution** | **Comments**

Mileage-based TCO (€-ct/km/y)



- **LFP** batteries offer the **best mTCO** due to their **low cost** and **good energy density**
- **Cost-advantage** of **Na-Ion** batteries only slightly compensates for their **low energy density**

Payload-based TCO (€-ct/tkm/y)



- When considering payload, **ICE** is still the best option for **minimum pTCO**
- **NMC** has a worse pTCO compared to **ICE** long-haul trucks
- **pTCO** of **Na-Ion** is worse than **LFP** due to the **reduced payload**

Long-Haul assumptions:
ICE avg. payload 12.5t, LFP avg. payload 11.0t , NMC avg. payload 11.25t
ICE 0.28 l/km diesel consumption, LFP 1.1 kWh/km efficiency, NMC 1.09 kWh/km efficiency
LFP 70 €/kWh cell cost, NMC 80 €/kWh cell cost

Distribution assumptions:
ICE avg. payload 6t, LFP avg. payload 5.5t , Na-Ion avg. payload 5.25t
ICE 0.19 l/km diesel consumption, LFP 0.75 kWh/km efficiency, Na-Ion 0.76 kWh/km efficiency
LFP 70 €/kWh cell cost, Na-Ion 60 €/kWh cell cost

4 **Market development**

By 2030 we expect more than 20% of transportation will be electrified.

With more than 1,700 GWh in 2040, truck batteries gain in importance – with increasing importance of LFP.

Tipping point from 2030

With emission regulation being sharpened and beneficial TCOs across regions and use cases, **electrification to gain speed from 2030 onwards** – energy costs and decarbonization efforts as potential drivers

BET reaches ~20% market share in 2030

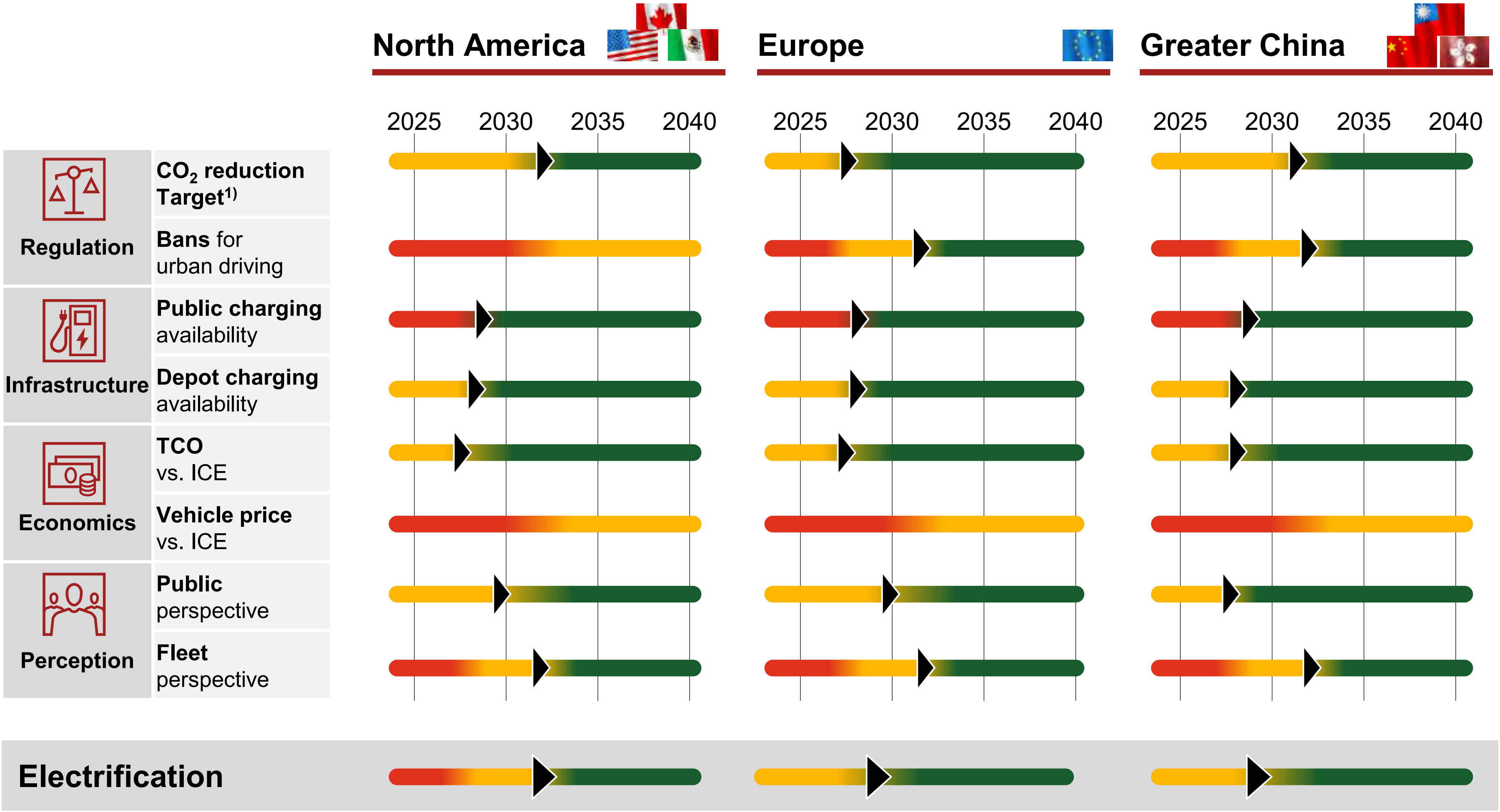
Driven by diffusion of Heavy-Duty vehicles and urban buses, BET to reach more than 20% market share 2030 – **in 2040 BET will be the dominant powertrain option**, with ~90% market share

Global BET battery demand surpasses 400 GWh in 2030

Based on the spur in demand for BET, truck battery and cell demand will reach 450 GWh by 2030. **BET constitutes a relevant market share of ~13% of automotive battery cell demand in 2030**, growing to 25% (2040), **enabling truck-specific battery development and production**

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

Drivers pushing BET diffusion (HD, MD and BUS)



Comments

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

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

BET exhibits lower TCO than ICE from 2025+, especially for distribution use cases

Public concern over **climate change** to **remain** a driver for **ZEV technologies –** yet at decreased speed

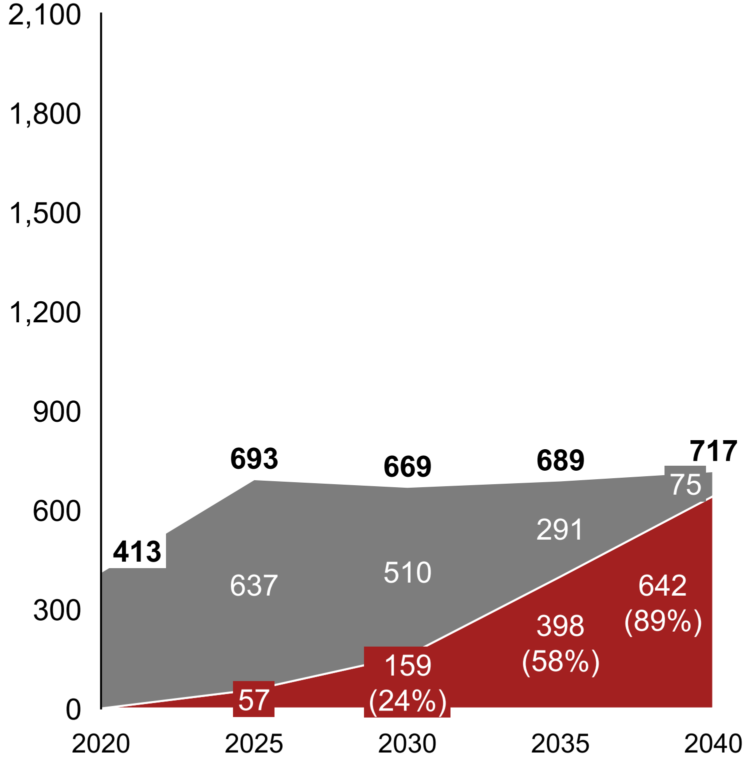
Impact on electrification ramp-up:
Negative, Marginal, Positive, Tipping point

Source: Strategy& analyses

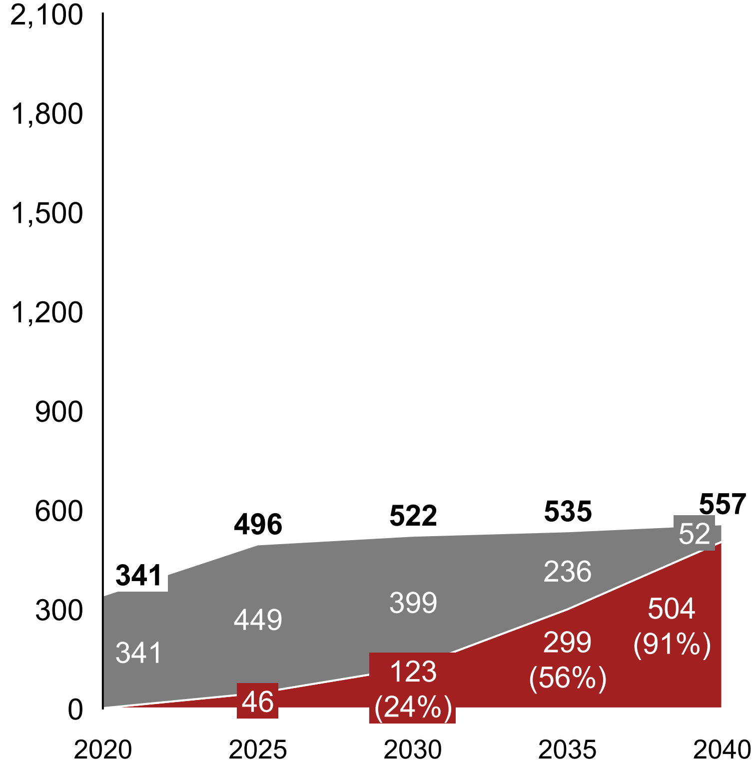
In 2030, ~600k BET will be produced in the Triad markets – ~120...160k units in North America & Europe, ~340k units in CN

Truck electrification ramp-up 2020-2040 in selected regions[1)]

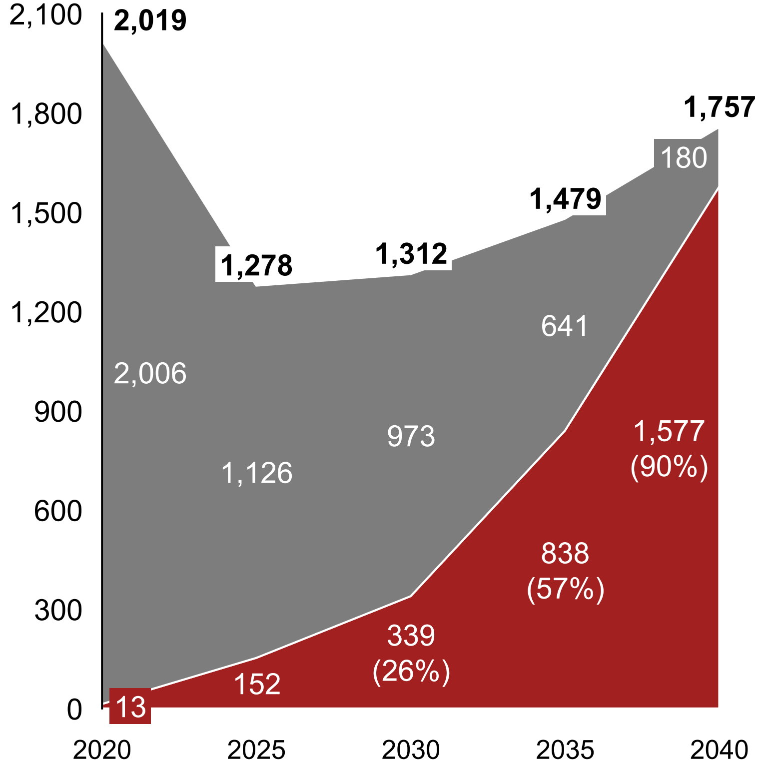
North America (k vehicles)



Europe (k vehicles)



Greater China (k vehicles)

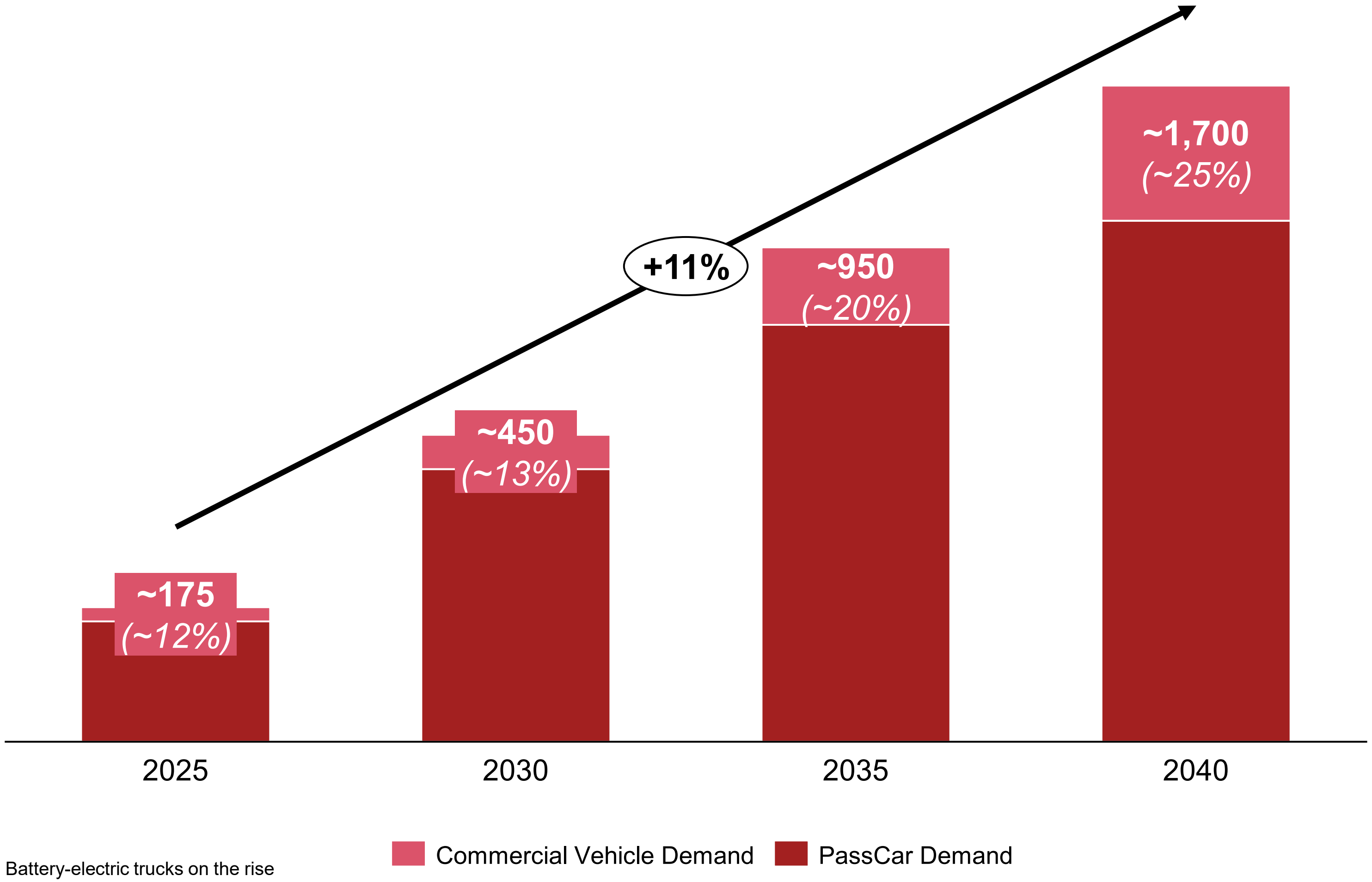


BET Others

1) Includes EU 27
Source: Strategy& analyses, IHS 04.2024 (MHCV Engine Installation)

With this uptake of BET over coming years, more than 1.7 TWh of batteries will be required by 2040 – 25% market share vs. PassCar

Global battery demand (in GWh)



Source: Strategy& analyses

Key takeaways

BET on the rise

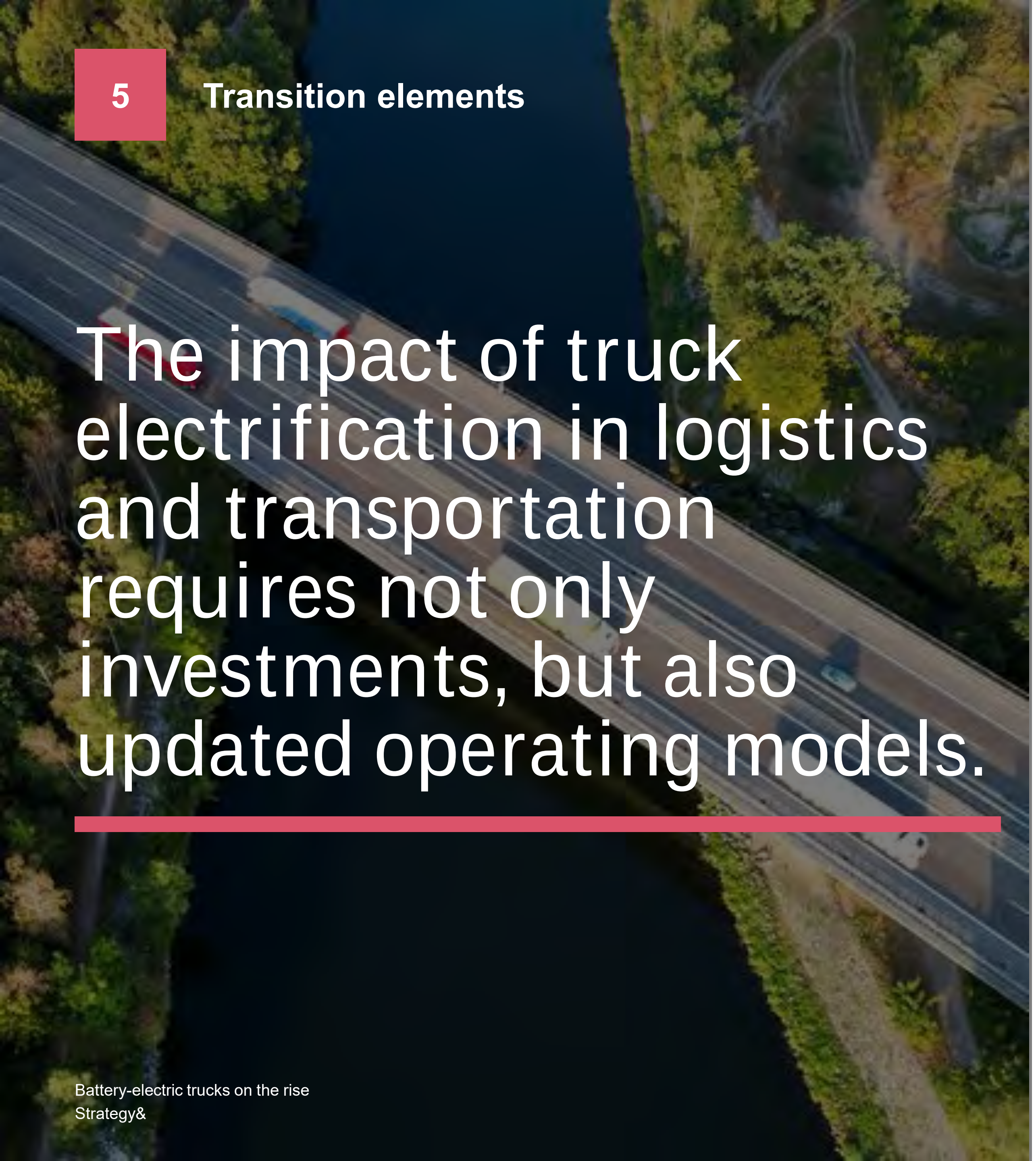
Global demand for commercial vehicle batteries rises from ~175 GWh in 2025 to more than 1.7 TWh in 2040 (~10% CAGR)

Truck-specific development

With a market share of ~25% in 2040, truck-specific cell developments and cell production are expected soon – with scale and cost advantages

Cell chemistry

Mix of NMC and L(M)FP expected, with an increasing share of L(M)FP due to its cost and lifetime advantages – Na-Ion offers potential for medium-duty applications



The impact of truck electrification in logistics and transportation requires not only investments, but also updated operating models.

BET with high invest cost due to battery

Battery is the key cost driver of BET, and leads to significantly higher invest cost compared to ICE. To overcome the transition hurdle, **leasing can facilitate BEV diffusion.**

Building the right infrastructure

Fleet electrification requires build-up of the charging infrastructure. While **depot charging offers utilization advantages and TCO benefits**, **public charging is needed for wide-ranging coverage.**

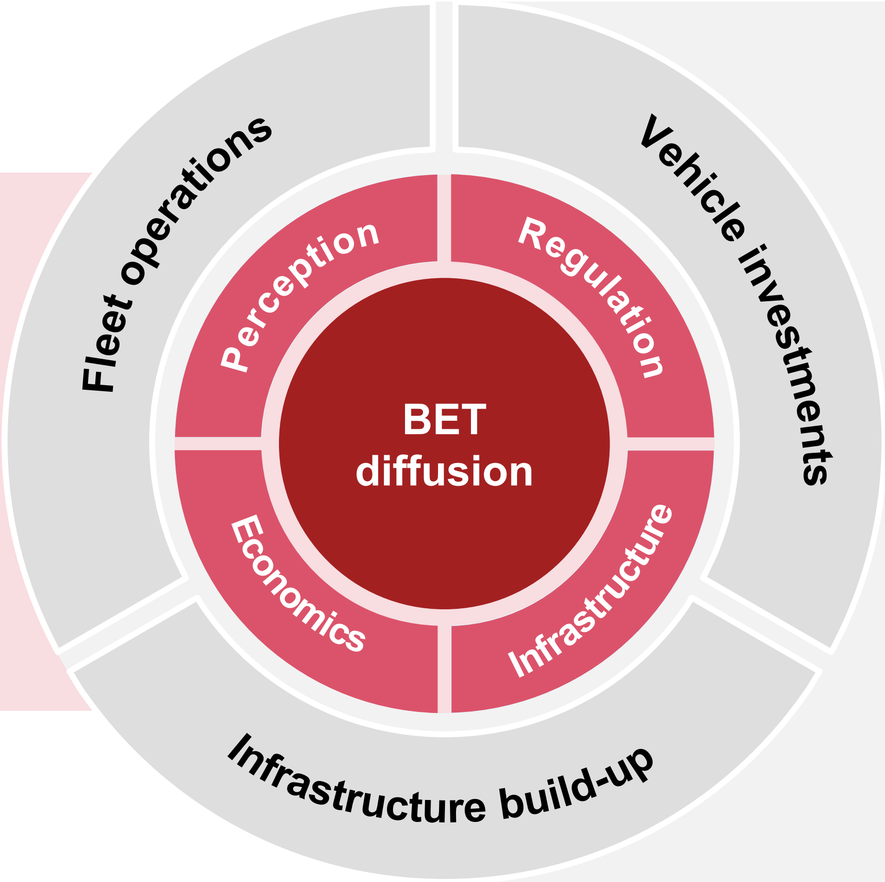
BET-specific adaption of fleet operations

BET characteristics will drive **adaptations in vehicle utilization, vehicle holding periods, and hub logistics**. This will remain a cross-industry challenge.

The advancing electrification of commercial vehicles requires transition support regarding vehicle invest, infrastructure and operations

Main BET transition elements

Market diffusion of BET supported by transition elements



Market transition elements

Vehicle investments

- Vehicle price reduction[1)]
- Leasing as facilitator

Infrastructure build-up

- Enable optimal charge costs (e.g., through utilization)
- Build and invest in infrastructure
- Expand grid and power distribution

Fleet operations

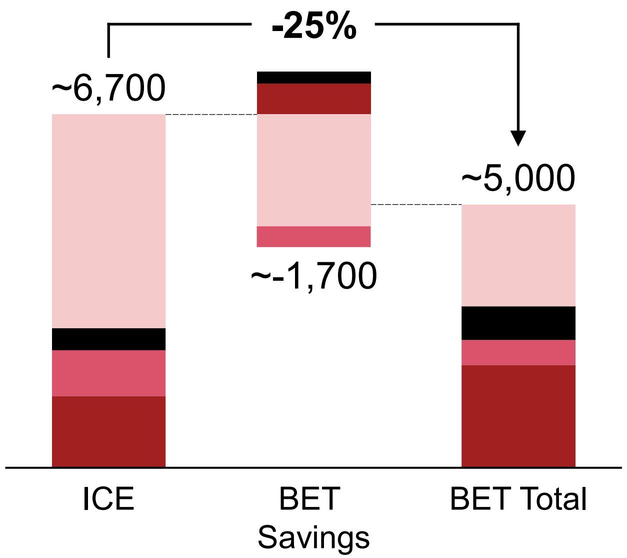
- Intensified vehicle utilization
- Increased holding periods
- Adjusted logistics models and hub models

1) Covered in TCO analyses

Leasing can be a key lever for small- and mid-sized companies to facilitate BET diffusion – leasing premium to be offset by energy costs

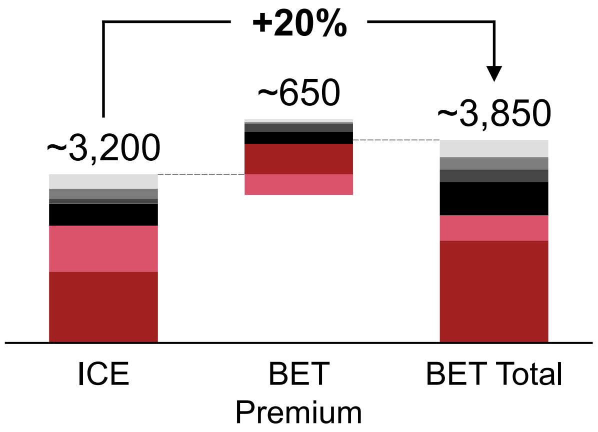
Vehicle investments: Leasing lever (in €/month, EU line-haul, 2030)

TCO (in €/month)



- Driven by energy costs, BET realizes a competitive advantage across TCO compared to ICEs

Leasing cost (in €/month)



- **Residual value** and **depreciation** costs as leasing drivers
- BET premium due to higher **invests,** financing costs and residual value risk

Leasing as lever for BET adoption

Lower investment burden and improved financing

- Leverage improved financing conditions of leasing companies compared to small- to mid-sized companies

Cash flow optimization

- Leasing lifts the investment burden – especially on electric trucks with higher vehicle prices

Residual value risk externalization

- Reduction of asset burden and depreciation costs
- Shift of residual value and maintenance risks from truck operator towards leasing company, especially in times of used-car truck market build-up phase

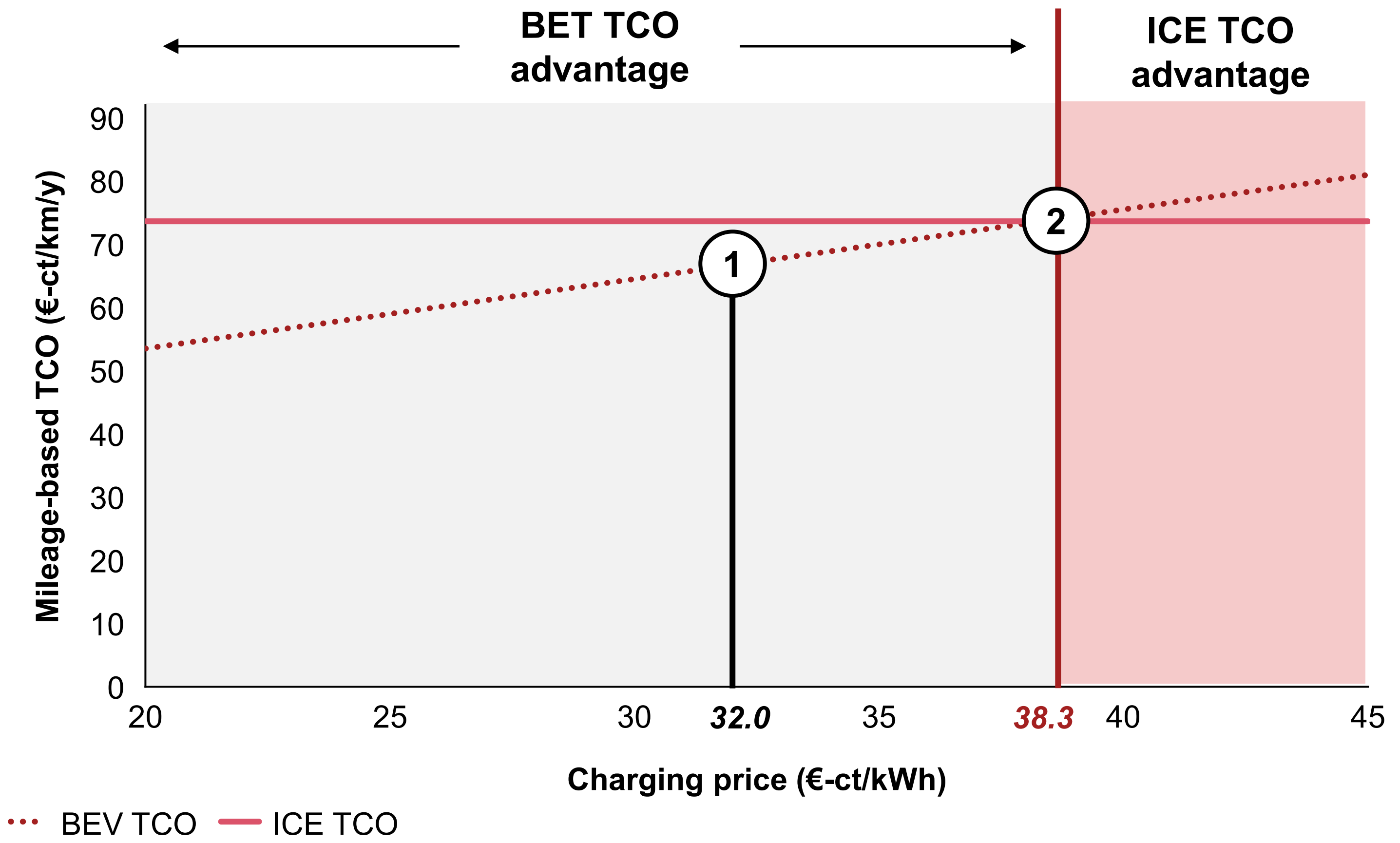
Depreciation | Maintenance | Financing | Residual value risk | SG&A | Profit | Energy costs

1) Leasing cost assumptions: Leasing costs incl. depreciation, maintenance, financing, residual value risks and SG&A and profits, 4 year holding period, 100k km/year
Higher residual value risks for BEV

For EU long-haul applications, the TCO requires charging costs below 38 ct/kWh to remain competitive in comparison with ICE towards 2030

Charging price: TCO analysis for 2030 BET long-haul (EU, Germany)

TCO sensitivity of charging price



Comments

General assumptions on charging price

- Charging prices are derived based on a charging mix of public and depot charging infrastructure, respective electricity costs, and infrastructure mark-ups
- Besides charging type, infrastructure utilization is decisive for charging price

(1) BET TCO advantage

- Projected charging price in 2030 for long-haul BET, at ~32 ct/kWh, is sufficient to create TCO advantage over ICE trucks

(2) ICE TCO advantage

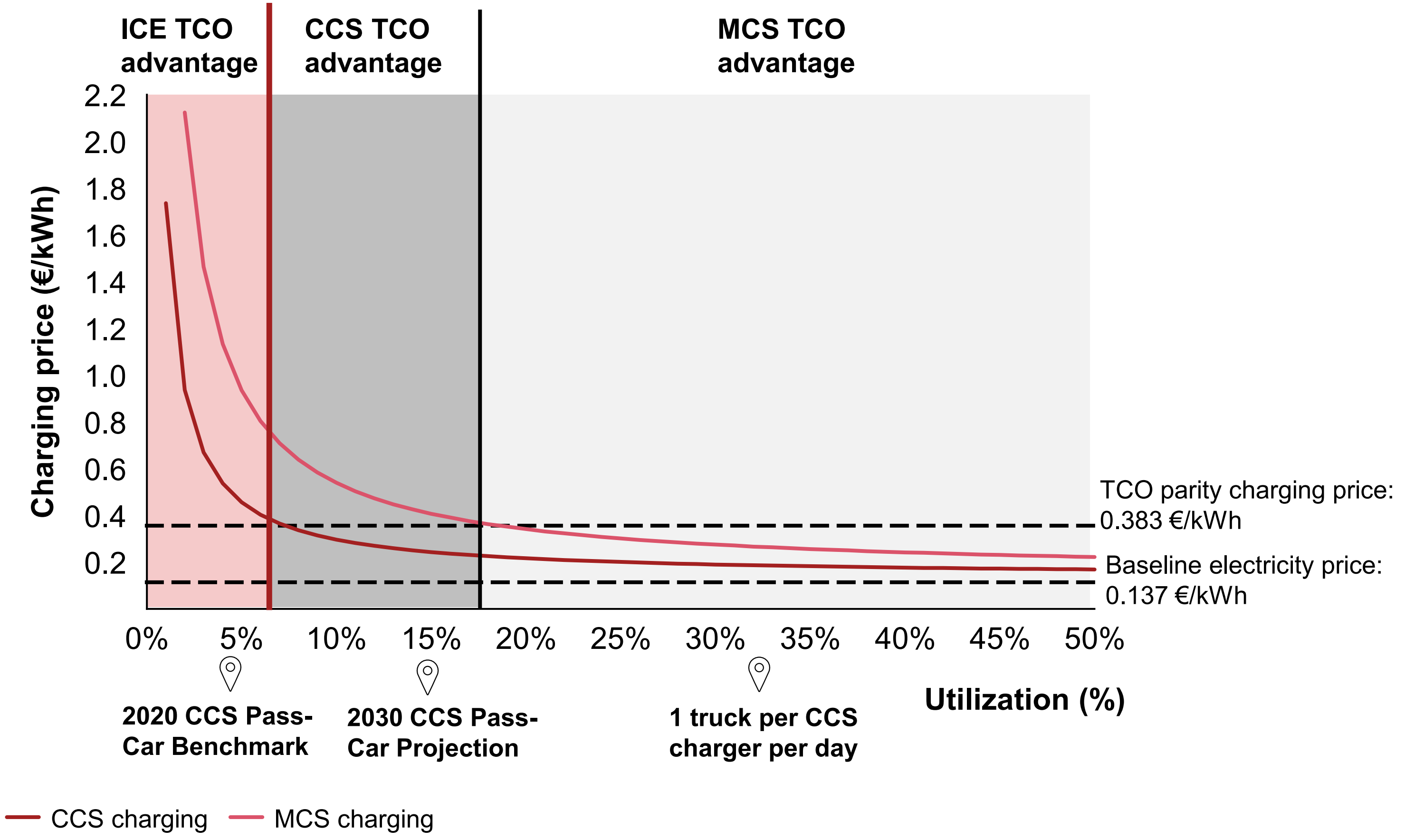
- At charging costs above ~38 ct/kWh, TCO advantage shifts towards ICE

ICE avrg. payload 12.5t, BET avrg. payload 11t
31.25 l/100 km diesel consumption at 1.5 €/l

To realize 38 ct/kWh and thus a positive BET-TCO, MCS charging requires utilization rates >17%, CCS charging already at utilization >7%

Charging price: MCS and CCS price sensitivity on utilization for 2030 BET Long-Haul 2030 (EU, Germany)

Utilization impact on charging price



Comments

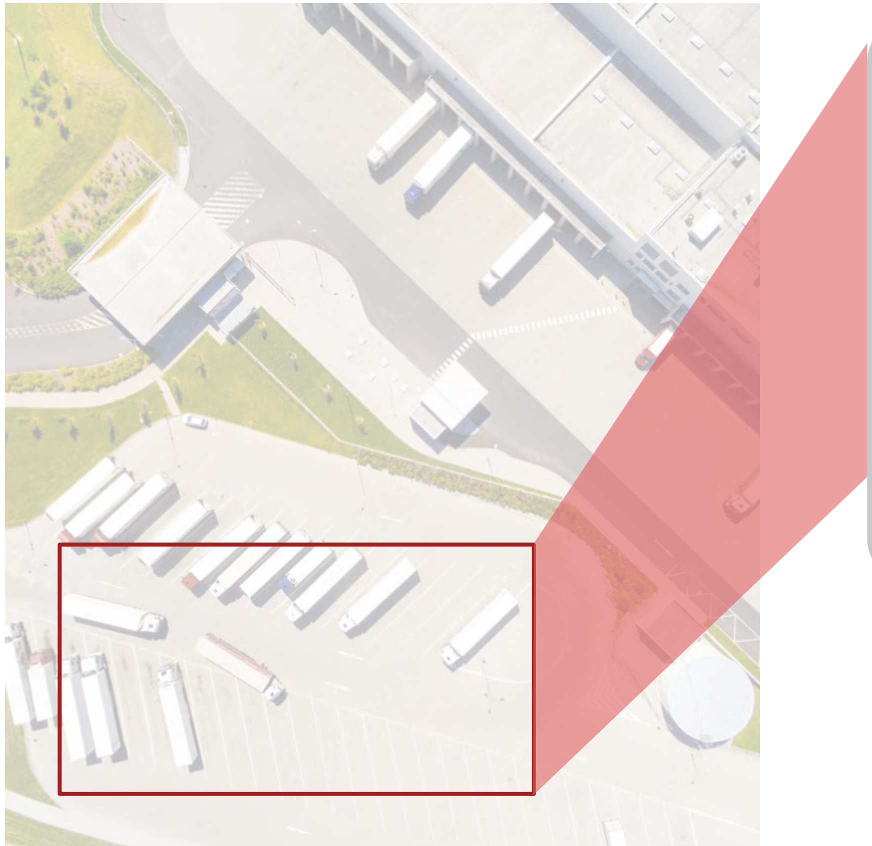
- While CCS charging requires a utilization of 7% to be TCO positive, MCS charging requires 17% utilization
- CCS utilization for slow charging can frequently reach >30% and is thus a feasible TCO option
- MCS utilization is expected to be around 15% in 2030 and hence is not a positive TCO option
- In consequence, the mixture between CCS and MCS charging strongly determines TCO

Assumptions CCS: €150k CAPEX, €7.5k OPEX, €7.5k SG&A Battery size 480 kWh, 8 hours charging time
Assumptions MCS: €1 million CAPEX, €50k OPEX, €50k SG&A

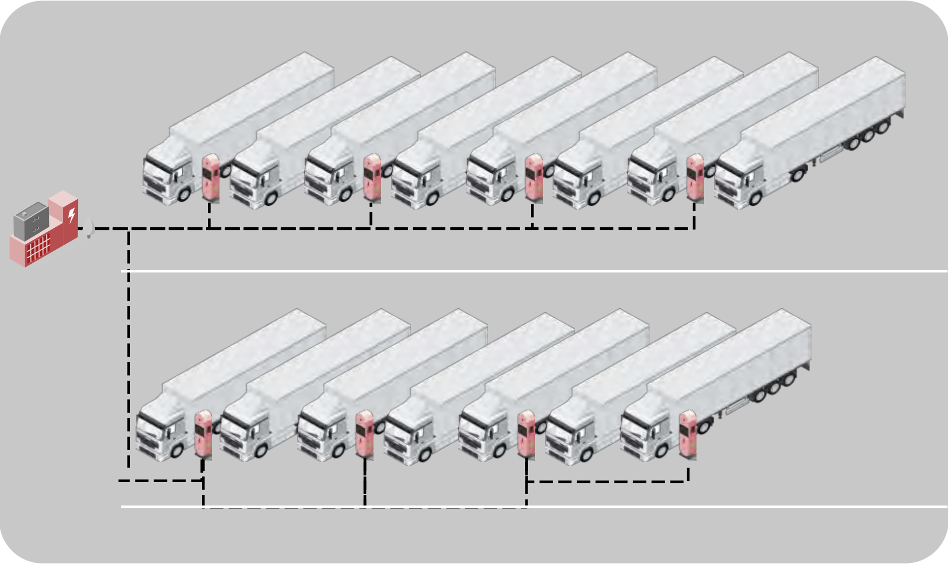
Charging infrastructure design has significant impact on CAPEX, required peak power, and charge costs – suitable layout critical for TCO

Illustrative charging depot build-up

Build-up challenges

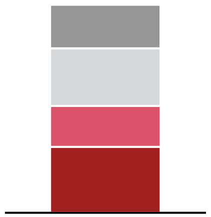


Small fleet depot infrastructure



Trucks	CCS Chargers	Area (m²)
15	8	3,300

CAPEX (in k€)



Grid peak power (in MW)

Charge costs (in €/kWh)

Charger | Construction and cabling | Grid infrastructure and electronics | Area

Electricity | Depreciation | SG&A | OPEX | Energy losses

The new HDT infrastructure requires significant multi-billion invests into depot charging stations, in parallel to public charge park set-ups

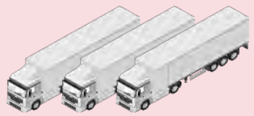
Charging infrastructure ramp-up for Europe

Ramp-up stage public		Description	Public charging parks	Depot charging stations
1 **Pilot network** 2024 (BET)	2020–2025	Pilot projects with focus on areas with high traffic volumes (over 100,000 HDTs annually)	**€0.2 bn** (35 charging parks) First stations	**€6.8 bn** *(~6,900 depots[2])* Stations to enable operations
2 **Area-coverage network** 2027 (BET)	2025–2030	Complete coverage of Europe as a consistent network	**€0.7 bn** (120 charging parks) Increased network to enable pan-European trips	**€17.8 bn** *(17,800 depots[2])* Stations to enable operations
3 **High-demand network** ~2035	2030–2035	Complete coverage of Europe with sufficient capacity	**€6.1 bn** (720 charging parks) Complete network with more stations to meet energy demand	**€28.6 bn** *(28,500 depots[2])* Stations to enable operations

1) BET charging considered as 20% public and 80% private, with additional private depot charging 2) Based on small depots with 8 CCS chargers
Source: Strategy& analysis, Statista.

Differences in investment, market, and technology between BET and ICE push to adjust fleet operations to realize the eTransformation

Fleet operations

	Vehicle utilization	Vehicle holding period	Depot network
 **BET vs. ICE differences**	**Increased investments** in both vehicle and charging infrastructure	Traditional **used-car markets** (e.g., Eastern Europe or North Africa) with **BET transformation lag**	**Lower range** of BET may require intermediate charging in-between hubs
 **Potential fleet operations impact**	**Intensified** vehicle **utilization** to leverage investments, e.g., **increased multi-shift operations**	Longer initial **vehicle holding periods** to reduce depreciation risks, e.g., holding periods of **up to 6…8 years**	**More dense** logistics **hub** / charging hub operations, e.g., to **enable depot charging** and **increase flexibility**

To make the BET transition a success, cross-industry efforts are required – from regulatory, via automotive and energy towards logistics facilitated by financial services.

Give regulatory stability for strategic planning

Facilitate the transformation with a **clear regulatory framework** and support to enable strategic long-term planning. **Investments in infrastructure build-up and fleet transformation are required**.

Enable further technology improvements

The **automotive industry and beyond** – chemical, energy and equipment – need to **enable further technological developments** to increase portfolio coverage.

Foster leasing instead of purchasing

Reduce the investment barrier for new trucks via competitive leasing offerings. **Better understanding** of battery aging and its second-life/end-of-life opportunities **allows risk premiums** in leasing contracts **to be better managed.**

Build the infrastructure and adjust operations

To enable the transformation, both public and depot infrastructure needs to be built. To **enable sufficient utilization of infrastructure equipment**, **optimized logistics operations** are pivotal.

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

Logistics

Get it on the road

… meet fleet and CO_2 targets
… rethink mobility concepts
… build infrastructure

Financial services

Fuel the transformation

… provide required investments
… enable use cases by leasing
… setup investment strategy

Energy and infrastructure

Power the transformation

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

Public sector

Lay the foundations

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

Production equipment

Technically enable transformation

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

Materials and chemicals

Mine and refine the new oil

… scale the value chain
… meet automotive standards
… conceptualize recycling

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