Impact Assessment of the Transition to Zero-Emission Trucks in Europe
Executive summary

The truck industry is a central part of Europe’s economy, contributing €75B in GDP and 577K jobs in 2022, causing ~4% of Europe’s CO₂ emissions. Zero-emission vehicle technology provides new opportunities to achieve climate ambitions while retaining economic contribution. Previous BCG research shows an expected rise to 55% ZEV in 2030 and 77% ZEV in 2035.

Regulation mandates the baseline for the shift from ICE to ZEV, resulting in demanded adoption rates of at least 49% by 2035 (base case: EU commission), or 97% by 2035 respectively (more ambitious T&E case). In this study, we investigate the economic impact of both regulatory scenarios on GDP and employment development in Europe.

Shift to ZEV has potential to create up to €32B in GDP and 30K additional jobs in Europe by 2035 (T&E case) versus 2022. Key drivers are battery cell production and the shift from foreign fossil fuels to domestically produced electricity.

Despite an overall positive effect on Europe’s economy, a redistribution of value and jobs is created by the shift from ICE to ZEV, impacting current suppliers and OEMs, moving away from ICE components and periphery manufacturing toward battery cells, electric drive, power electronics, and less labor-intensive module packaging.

Key levers for strong positioning of the EU in light of new industry dynamics entail a buildup of domestic battery cell production, reskilling of labor force, charging infrastructure readiness, and affordable renewable electricity.

Technology shift enables market entry for new, foreign ZEV players. While exports represent starting point to compete in major markets, localized production becomes crucial for long-term dominance. Negative impact from non-European ZEV players on GDP and employment depends on the concrete scenario, esp. no. of entrants, localization degree etc., while benefits from transitioning to ZEV along the full value chain are expected to outweigh losses from new competition.

Source: BCG
The European trucking sector’s shift to ZEVs could create up to €32 billion GDP and add 30,000 jobs by 2035.

**OEMs**
- Could lose up to 35,000 positions related to making ICE, while GDP contribution is positive. Requires a substantial workforce transformation towards new capabilities to produce and market ZEVs.
- +€3B GDP
- -35,000 Jobs

**Suppliers**
- Expected to add value by switching from making ICE to ZEV components, in particular battery cells, electric drives, which will be needed for 400,000 ZEV trucks by 2035. Requires distinct new capabilities for supplier base.
- +€6B GDP
- +3,000 Jobs

**ZEV infrastructure players**
- Will contribute towards GDP and job growth. Need to install up to 185,000 charging points by 2035 and overcome implementation hurdles to ensure sufficient charging network coverage.
- +€1B GDP
- +6,000 Jobs

**MHDT-related utilities**
- Need to ramp up renewable electricity generation from <1 TWh in 2022 to >160 TWh in 2035 to fuel up to 1.8M BEV trucks on the road. Major driver of positive economic impact due to high European added value for renewable electricity generation, compared to fossil fuel import.
- +€22B GDP
- +55,000 Jobs

**Sources:** Statista; BCG analysis.

**Notes:** GDP and employment increases from 2022 to 2035 under high adopt scenario.
### Preface: What this study is—and what it is not

#### In scope

- **Medium- and heavy-duty trucks (in following referred to as MHDTs)**
  - Heavy-duty (HDT > 15 t GVW), medium-duty (MDT 6-15 t GVW)

- **EU-27 + UK, Switzerland, Norway and Iceland**
  - US and China in extended scope to understand competitive landscape

- **Powertrain-related value chain steps**
  - Suppliers, OEMs, ZEV infrastructure, and MHDT-related utilities

- **Contribution of defined value chain steps to European GDP**
  - Components and production of new MHDTs (supplier, OEM), ZEV charging infrastructure hardware, and energy consumption for MHDT ops. (utilities)

- **Employment in Europe for defined value chain steps**
  - Components and production of new MHDTs (supplier, OEM), ZEV charging infrastructure hardware, and energy consumption for MHDT ops. (utilities)

- **Truck-level trade flows from and into Europe**
  - Focus on imports and exports from and to US and China

#### Out of scope

- **Vehicles used for passenger transport, buses and coaches, trailers, and other light commercial vehicles (LCV < 6 t GVW)**

- **Other regions of the world**

- **Raw materials and impact on value chain steps with no major dependence on powertrain (e.g., after sales), included via steady state assumption**

- **Trade of components and detailed analysis of worldwide trade flows between other regions**

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Note: Assuming no strategic changes to current OEM business model; GVW = gross vehicle weight
This study covers the shift of the MHDT industry in Europe toward zero emissions.
Along the value chain, the study focuses on shifts in powertrain-related elements.
Impact of ZEV adoption on competitiveness of Europe’s truck industry¹ until 2035...

... presented along five building blocks

1. Current state of the European truck industry
2. Shift to ZEV and underlying key drivers
3. Impact of ZEV shift on European economy on GDP and employment until 2035
4. Supporting the shift to zero emissions
5. Emerging competition from ZEV trend in US and CN

1. Consisting of EU-27 + UK, Norway, Switzerland and Iceland, covering suppliers, OEMs, ZEV infrastructure, and CV-related utilities

Source: Statista; BCG

€75B
GDP (2022)

577K
Jobs (2022)
Agenda

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5. Outlook: Emerging competition from new non-European ZEV players
Europe’s truck industry in figures

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>380K</td>
<td>MHDTs sold on average in Europe in the years from 2019 to 2035</td>
</tr>
<tr>
<td>GDP</td>
<td>€75B</td>
<td>contribution of the MHDT industry to Europe’s GDP in 2022</td>
</tr>
<tr>
<td>Jobs</td>
<td>577K</td>
<td>jobs associated with Europe’s MHDT industry in 2022</td>
</tr>
<tr>
<td>Trade balance</td>
<td>33K</td>
<td>out of ~430K EU-produced MHDT units exported from Europe in 2022</td>
</tr>
<tr>
<td>CO₂ emissions</td>
<td>4%</td>
<td>of Europe’s total 3.4 Gt CO₂ emissions produced by MHDTs in 2019</td>
</tr>
</tbody>
</table>

1. In considered value chain elements
2. For EU-27, excludes the sector “Land use, land-use change, and forestry” (6.9%)

Source: Eurostat; European Environmental Agency (EEA); IHS Markit (Feb 2023); Statista; World Bank; BCG
~ 380K MHDTs sold every year in Europe at a mostly stable rate until 2035

MHDT sales (in K units)

Note: EU-27 + UK, Switzerland, Norway, and Iceland
Source: IHS Markit (Feb 2023); BCG
Along the four core value chain elements, the industry currently contributes ~€75B to Europe’s GDP in 2022

Total GDP contribution in Europe in 2022 (in B€)

- **Suppliers**: €29B (39%) GDP is associated with suppliers, including firms like ZF, Continental, and Knorr-Bremse.
- **OEMs**: €29B (39%) GDP is associated with OEMs, including firms like Daimler Truck, Scania, and MAN.
- **ZEV infrastructure**: >€1B (~1%) GDP is associated with ZEV infrastructure, including firms like ABB, sennder, and Milence.
- **MHDT-related utilities**: €16B (21%) GDP is associated with refining of diesel and generation of electricity, including firms like Shell and E.ON.

1. Incl. (after) sales of motor vehicle parts and accessories
2. OEMs generate value via ICE, production value add (e.g., assembly, tooling), and nonproduction elements (e.g., SG&A and R&D), including (after) sales and maintenance
3. Base including infrastructure, connected and platform services, transport solutions, and resale, reuse, and recycling

Source: Eurostat; BCG
In 2022, ~577K jobs are associated with Europe’s MHDT industry

Total number of jobs in Europe in 2022 (in K)

- **577K** jobs in Europe associated with 4 clusters along the value chain...
  - ... of which **235K** (41%) jobs are associated with suppliers,\(^1\) including firms like ZF, Continental, and Knorr-Bremse
  - ... of which **244K** (42%) jobs are associated with OEMs,\(^2\) including firms like Daimler Truck, Scania, and MAN
  - ... of which < **11K** (2%) jobs are associated with ZEV infrastructure,\(^3\) including firms like ABB, sennder, and Milence
  - ... of which **87K** (15%) jobs are associated with refining of diesel and generation of electricity, including firms like Shell and EON

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1. Incl. (after) sales of motor vehicle parts and accessories
2. OEMs generate value via ICE, production value add (e.g., assembly, tooling), and nonproduction elements (e.g., SG&A and R&D), including (after) sales and maintenance
3. Base including infrastructure, connected and platform services, transport solutions, and resale, reuse, and recycling

Source: Eurostat; BCG
EU net exports totaled 33K units to small markets in 2022—CN and US dominated by domestic players

MHDT trade flows

1. Excluding component business (suppliers and OEMs)
Note: EU 27 + UK, Switzerland, Norway and Iceland; new trucks only
Source: IHS Markit (May 2023); World Bank; BCG
European OEMs operate and produce locally in key regions, trade with low relevance for European GDP

Global footprint of selected European MHDT OEMs

Daimler Truck
Volvo Trucks
TRATON
PACCAR
...

Note: Logos indicate own brands as well as associates (equity stakes) and alliances for MDT
Source: BCG
MHDTs responsible for ~ 4% of Europe’s GHG emissions

EU-27 GHG emissions by sector\(^1\) (2019\(^2\))

1. Excludes the sector “Land use, land-use change, and forestry” (-6.9%)  
2. Most recent available study

Note: GHG = greenhouse gas

Source: European Environmental Agency (EEA), April 2021; BCG
Three major trends will drastically shape current market landscape

**Focus**

**Electrification**
Gradual replacement of ICE drivetrain with BEV and H\(_2\) drivetrains
ZEV powertrain the next big change in MHDT sector

**Digitalization**
Increased relevance of digitalized controls and fleet monitoring
Push for telematics and fleet management systems

**Autonomous vehicles**
Increased activity and value potential in MHDT highly automated driving development
New highly automated driving vehicle concepts

Source: BCG
Market perspective shows an expected rise to 55% ZEV in '30 and 77% ZEV in '35

1. H₂ includes both H₂ ICE and FCEV  2. ICE contains diesel and xNG  3. Weighted by respective share of each type in overall sales

Note: TCO = total cost of ownership; H₂ = hydrogen; BEV = battery electric vehicle; ICE = internal combustion engine

Source: BCG market model
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Shift to ZEV for MHDT mainly driven by four factors

**A. Regulation: MHDT CO₂ standards tightening further**
- EU set goal to reach climate neutrality by ’50, addressing high-polluting sectors in particular
- CO₂ reduction targets for MHDT in ’30 to increase from 30% to ~45% based on EU Commission proposal
- Call for additional intensification of CO₂-reduction targets to reach 100% by ’35 (T&E case)

**B. Infrastructure ramp-up**
- AFIR² sets legally binding nat’l and EU-wide targets for deployment of alternative fuels infrastructure
- Complete charging infra. coverage of TEN-T³ core network to be completed by ’30
- Major players to invest in buildup of truck charging infrastructure (e.g., €500M by Milence, comprising Volvo, Daimler, and Traton)

**C. TCO shift toward ZEV**
- TCO for electric trucks to outperform diesel around ’25/’26 in Europe
- BEV cost to decrease by over 40% until ’35 (vs. ’22), while range and charging capabilities improve

**D. OEMs prepare for ZEV**
- ZEVs offered/announced by major OEMs—33 BEV models to be offered by European OEMs by ’25
- EU OEMs, incl. Daimler Truck, Scania, and MAN set objectives to achieve 100% ZEV sales by ’40
- Partnerships among OEMs formed to manage high R&D costs (e.g., e-mobility JV between Traton and Hino)

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1. Compared to 2019 levels
2. Alternative Fuel Infrastructure Regulation
3. Trans-European Transport Network outlines strategic connections linking the most important nodes in Europe

Source: Company websites; EU Commission; T&E; BCG
Regulation: With higher CO₂ standards, ZEV adoption could reach 97% by 2035

These cases are the base for the GDP and employment impact analysis in the next chapter

**Base case:**
Proposed EU Commission CO₂ standards

EU targets mandate base level of average new fleet emissions

- ZEV adoption
- CO₂ reduction

Tightened CO₂ emissions standards as proposed by the EU Commission in Feb. 2023 (approval pending—expected in 2024)

Case below current market perspective, used as minimum scenario for future adoption

**T&E case:**
Elevated CO₂ standards (beyond EU Commission)

Stricter regulations to become CO₂ champion

Elevated CO₂ emissions standards leading to 97% ZEV adoption by 2035 across truck segments

Case assumes higher adoption than current market perspective beyond 2030, making ZEV more attractive

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1. Not covering unregulated MHDT segments (e.g., vocational, noncertified)
2. Incl. unregulated MHDT (under EU Commission)

Note: CO₂ reduction consists of both ZEV adoption, efficiency improvements of ICE MDHT, supercredits (until 2024), and benchmarked-based crediting systems (from 2025)

Source: T&E; BCG
Infrastructure: Mandatory deployment targets established via Alternative Fuel Infrastructure (AFIR) Regulation for road transport

EU Green Deal regulation to deploy alternative fuel infrastructure

European Green Deal: ambitious new law agreed to deploy sufficient alternative fuel infrastructure (AFIR)

- Every 60 km along the TEN-T core network, MHDT charging pools of at least 3,600 kW must be installed by 2030
- Four recharging points in each safe and secure parking lot by 2030
- H₂ refueling infrastructure must be deployed by 2030 in all urban nodes and every 200 km along the TEN-T core network

TEN-T¹ core network corridors

<table>
<thead>
<tr>
<th>Network corridors</th>
<th>km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltic-Adriatic</td>
<td>2,410</td>
</tr>
<tr>
<td>North Sea-Baltic</td>
<td>3,800</td>
</tr>
<tr>
<td>Mediterraneo</td>
<td>5,390</td>
</tr>
<tr>
<td>Orient-East Mediterraneo</td>
<td>4,360</td>
</tr>
<tr>
<td>Scandinavia-Mediterranean</td>
<td>5,610</td>
</tr>
<tr>
<td>Rhine-Alpine</td>
<td>1,690</td>
</tr>
<tr>
<td>Atlantic</td>
<td>4,240</td>
</tr>
<tr>
<td>North Sea-Mediterranean</td>
<td>2,260</td>
</tr>
<tr>
<td>Rhine-Danube</td>
<td>4,540</td>
</tr>
</tbody>
</table>

- TEN-T¹ core network outlines strategic connections linking the most important nodes; expected to be completed by 2030
- Nine core network corridors (CNCs) identified to streamline development

1. TEN-T = Trans-European Transport Network
Note: Map only covers 9 strategic corridors of TEN-T—not exhaustive
Source: EU commission; T&E; BCG

Illustrative

Shift to ZEV along adoption scenarios
TCO parity for ICE and BEV expected in 2025/26

Example HDT: Key assumptions on critical cost drivers

**General (for all technologies):**
- Annual mileage: 120,000 km
- Driver cost: €50,000 p.a.

**Powertrain costs:**
- Batteries (€/kWh): 2023, 2030, 2035
  - 2023: 226
  - 2030: 112
  - 2035: 112
- FC (€/kW): 2023, 2030, 2035
  - 2023: 130
  - 2030: 70
  - 2035: 60

**Fuel sources (excl. VAT):**
- Diesel (€/l): 2023, 2030, 2035
  - 2023: 1.31
  - 2030: 1.74
  - 2035: 2.25
- Electricity (€/kWh): 2023, 2030, 2035
  - 2023: 0.28
  - 2030: 0.23
  - 2035: 0.20
- Hydrogen (€/kg): 2023, 2030, 2035
  - 2023: 11.50
  - 2030: 7.00
  - 2035: 7.00

**Total cost of ownership on HDT €/km**

1. Avg. price between Western and Eastern Europe
2. Price without surcharge, assuming up to 100% surcharge for public fast-charging services, leading to an end-customer price of up to 0.56€/kWh

Note: Energy costs assumptions: 2023 actuals; from 2025-28, return to pre-crisis levels by extrapolating historical growth rates with 2019 as the starting point

Source: BCG analysis
OEMs introduce first ZEV trucks in portfolio and announce further commitments

European OEMs offer first ZEV trucks ...

Portfolio in 2022—not exhaustive

1. 2022 new truck registrations for EU-27, UK, Norway, Iceland, and Switzerland
2. Announcements of Daimler, Scania, and MAN
Source: IHS; ACEA; company websites; BCG

Shift to ZEV along adoption scenarios

... and communicate objectives for 2030 and beyond

Selected statements of OEMs

Objectives to achieve 100% ZEV sales by 2040

1. 70% of new EU ZEV sales by 2030
2. 60% of new sales ZEV by 2030
3. > 50% of new sales ZEV by 2030
4. 50% of EU new sales ZEV by 2030
OEMs are adapting their business models with partnerships emerging to manage high investments and R&D costs

- **ISUZU and Cummins**
  - FCEV collaboration
  - Agreement to create a prototype MD battery electric truck
  - Battery electric truck to be introduced in North America
  - First zero-emission solution of partnership formed in May 2019

- **Daimler, Volvo, TRATON**
  - Milence charging network
  - 3 largest players agreed on developing & operating a charging network
  - Agreement is basis for a JV starting operations in 2022
  - Plan is to install 1,700 charging points within 5 years

- **Daimler and Volvo**
  - FCEV JV cellcentric
  - Volvo Group acquired 50% of existing Daimler Truck Fuel Cell
  - Ambition is to become a leading global manufacturer of fuel cells
  - Focus is on development of fuel-cell systems for use in HDT

- **TRATON and Hino**
  - E-mobility JV
  - Hino and TRATON drive sustainable transport with e-mobility JV
  - Focus is on BEV, FCEV, and EV platform development
  - Activities will be launched in Sweden first and then Japan

- **IVECO, FPT, Nikola**
  - FCEV and BEV JV
  - IVECO, FPT, and Nikola JV to achieve zero-emission transport
  - Nikola provides fuel-cell and advanced-technology expertise
  - IVECO contributes eng. and manuf. knowledge to industrialize ZEVs

1. High-performance charging points
Source: Company webpages; Reuters; BCG

**Update:** Iveco fully acquires JV with Nikola on BEV and H2 trucks to effectively buy out Nikola from European markets—yet ties remain (May 9, 2023)
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### Overall positive GDP and employment development along MHDT value chain in Europe 2035 versus 2022

**Supplier**
- **GDP**: +3B, +6B
- **Jobs**: +1K, +3K

**OEM**
- **GDP**: +2B, +3B
- **Jobs**: -18K, -35K

**ZEV infrastructure**
- **GDP**: +0.3B, +0.6B
- **Jobs**: +3K, +6K

**MHDT-related utilities\(^1\)**
- **GDP**: +11B, +22B
- **Jobs**: +25K, +55K

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1. Assuming share of renewables from total electricity production ~ 88% in Europe in 2035
   Note: Assuming no strategic changes to current OEM business model

Source: BCG

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<table>
<thead>
<tr>
<th>Case</th>
<th>GDP Change</th>
<th>Jobs Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base case</strong></td>
<td>+3B, +6B</td>
<td>+1K, +3K</td>
</tr>
<tr>
<td><strong>T&amp;E case</strong></td>
<td>+2B, +3B</td>
<td>-18K, -35K</td>
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</table>

Note: Assuming no strategic changes to current OEM business model

**GDP and employment increase driven by shift from foreign-sourced fossil fuels to domestically produced electricity**
Depending on ZEV adoption rates, changes along MHDT value chain impact EU economy to different extents.

Change in vehicle components, ...

... infrastructure, and utilities due to ZEV

New/omitted components lead to redistribution of value creation and labor requirements in the industry.

1. As a majority of the fleet remains ICE until 2035, no substantial change for filling stations associated with MHDT transition in considered time frame.

Source: BCG
Shift to ZEV has potential to create up to €32B in GDP and 30K additional jobs in Europe by 2035 versus 2022

Deep dive A

GDP (B€)

Supplier

OEM

ZEV infrastructure

MHDT-related utilities

Total

Deep dive B

Jobs (in K)

Note: Size of circles indicative; assuming no strategic changes to current OEM business model

Source: BCG
Deep dive A (1/3): GDP increase of up to ~ €32B in Europe by 2035 possible, driven by significant uptake in energy sector

**Base case:** Current EU commission proposal

**GDP (€)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Suppliers</th>
<th>OEMs</th>
<th>ZEV Infra.</th>
<th>MHDT-related utilities</th>
<th>2035</th>
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<tr>
<td>2022</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>12</td>
<td>75</td>
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<tr>
<td>2035</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>91</td>
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</tbody>
</table>

- **+3.1B** Higher GDP contribution from suppliers in Europe from 2022 to 2035, due to increased value generated via battery production
- **+1.4B** Marginally increased GDP at OEM associated with shift to ZEVs, driven primarily by production of battery module and pack
- **+0.3B** GDP increase based on new charging infrastructure hardware
- **+11.7B** Additional GDP created based on energy mix driven by shift from fossil fuels to (renewable) electricity produced primarily in Europe

**T&E case:** Increased CO₂ regulations

**GDP (€ bn)**

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<td>2022</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>22</td>
<td>75</td>
</tr>
<tr>
<td>2035</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>107</td>
</tr>
</tbody>
</table>

- **+32** GDP increase based on new charging infrastructure hardware
- **+6.3B** Higher GDP contribution from suppliers in Europe from 2022 to 2035, due to increased value generated via battery production
- **+2.8B** Marginally increased GDP at OEM associated with shift to ZEVs, driven primarily by production of battery module and pack
- **+0.6B** GDP increase based on new charging infrastructure hardware
- **+22.5B** Additional GDP created based on energy mix driven by shift from fossil fuels to (renewable) electricity produced primarily in Europe

1. Assuming share of renewables from total electricity production ~ 88% in Europe in 2035
Note: Production volumes adjusted for cyclicality; assuming no strategic changes to current OEM business model
Source: BCG
Deep dive A (2/3): New GDP driven by increase in shift to (renewable) electricity and battery cell production; phaseout of ICE with dampening effect

1. Incl. core vehicle components and (after) sales of motor vehicle parts and accessories  
2. Production value add (e.g., assembly, tooling) and nonproduction elements (e.g., SG&A, R&D), incl. (after) sales and maintenance  
3. Incl. connected and platform services, transport solutions, resale, reuse, and recycling  
4. Assuming share of renewables of ~88% in Europe in 2035

Note: Size of circles indicative
Source: BCG

Impact of ZEV shift on European economy

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Deep dive A (3/3): GDP contribution highly dependent on shift to domestically produced electricity and battery cells

- **OEMs**
  - High-value battery module and pack production enough to balance loss of €3.8B in GDP from ICE production

- **ZEV infrastructure**
  - Truck charging infrastructure required to run increasing ZEV fleet in 2035 creates €0.6B in additional GDP from ZEV infrastructure

- **Suppliers**
  - Up to €6.3B add. GDP, as increase in battery cell production overcompensates ICE losses
  - Supplier GDP highly dependent on domestic value add of ZEV components (esp. battery cell prod.) in Europe

- **MHDT-related utilities**
  - Majority of up to €22B net GDP contribution from MHDT-related utilities driven by shift from foreign-sourced diesel to domestically produced electricity

Source: BCG
Deep dive B (1/3): Shift to new energy sources drives job creation until 2035 in both scenarios, overcompensating job losses at OEMs

**Base case:**
Current EU commission proposal

**T&E case:**
Increased CO₂ regulations

### Jobs (in K)

<table>
<thead>
<tr>
<th>Year</th>
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<th>ZEV Infra.</th>
<th>MHDT-related utilities</th>
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</thead>
<tbody>
<tr>
<td>2022</td>
<td>577</td>
<td>2</td>
<td>-18</td>
<td>3</td>
<td>589</td>
</tr>
<tr>
<td>2035</td>
<td>607</td>
<td>3</td>
<td>-35</td>
<td>6</td>
<td>607</td>
</tr>
</tbody>
</table>

1. Assuming no further changes in business model
2. Assuming share of renewables from total electricity production ~ 88% in Europe in 2035

**Impact of ZEV shift on European economy**

**Base case:**
Current EU commission proposal

- **+1.6K** Additional jobs at suppliers based on increased battery production needs in Europe
- **-17.7K** Jobs lost at OEM; increase in production of battery modules and packs cannot offset losses from ICE
- **+3.2K** Job increase driven by new charging infrastructure hardware
- **+25.1K** Job increase based on energy mix driven by shift from fossil fuels to (renewable) electricity produced primarily in Europe

**T&E case:**
Increased CO₂ regulations

- **+3.4K**
- **-35.1K**
- **+6.2K**
- **+55.2K**

Note: Production volumes adjusted for cyclicality; assuming no strategic changes to current OEM business model

Source: BCG
Deep dive B (2/3): Job reduction due to shift from ICE overcompensated by new demands in MHDT-related utilities; major shift across value chain steps

Employment (in K)

1. Incl. core vehicle components and (after) sales of motor vehicle parts and accessories  
2. Production value add (e.g., assembly, tooling) and nonproduction elements (e.g., SG&A, R&D), incl. (after) sales and maintenance  
3. Incl. connected and platform services, transport solutions, resale, reuse, and recycling  
4. Assuming share of renewables of ~88% in Europe in 2035

Note: Size of circles indicative  
Source: BCG
Deep dive B (3/3): High value add of electricity production main driver for net employment gain, overcompensating losses from phaseout of ICE

- **Phaseout of ICEs leads to ~ 42K lost jobs until 2035**
- **Due to reduced number of parts and lower production complexity, battery and module can only replace ~ 16% of lost jobs at OEM**

**Manufacturers**

- **No employment reductions from diesel infrastructure** (i.e., filling stations)—will continue operations to cater to ICE vehicles, comprising major share of truck fleet by 2035
- **~ 6K additional employees for** charging infrastructure hardware required to enable widespread ZEV usage

**Suppliers**

- **Net employment gain based on production of BEV and H₂ components**
- **Battery cell represents key driver of employment gains, compensating over 60% of lost ICE-related jobs**

**MHDT-related utilities**

- **Job increase due to electricity production overcompensates losses from reduced diesel need required to run smaller ICE fleet in ’35**
- **Higher domestic value add of (renewable) energy production versus fossil fuels main driver for net job increase**

Source: BCG
Agenda

1. Current state of the European truck industry
2. Shift to ZEV and underlying key drivers
3. Impact of ZEV shift on European economy until 2035
4. Supporting the shift to zero emissions
5. Outlook: Emerging competition from new non-European ZEV players
Various challenges across value chain to support shift to zero emissions

**Supplier**
- Battery cell ramp-up
  - 2022: 228
  - 2035: 230
  - Additional required annual production (in GWh)
  - 2022: 228
  - 2035: 230
  - Loss in employees (in K)

**OEM**
- Net loss of ~14% jobs, additional reskilling required
  - 2022: 244
  - 2035: 209
  - Add. required production (in GWh)

**Service provider**
- Setup of 200K charging points
  - 2022: 184
  - 2035: 185
  - Add. required charging points (in K)

**Utilities**
- Rising electricity consumption
  - 2022: 162
  - 2035: 163
  - Add. required electricity (TWh)

1. Average gigafactory 45 GWh
Source: RWTH Aachen Battery Atlas 2022; annual reports; International Trade Association; BCG
Supplier (1/2): ZEV shift brings new economic opportunities to suppliers; battery cell production being the main driver

1. Excludes buses, coaches, and LDVs
2. EDU = electrical drive unit

Note: 2035 figures based on ZEV adoption in T&E case

Source: BCG
Supplier (2/2): Besides securing 230 GWh battery capacity in 2035, strengthening cell production key for resilient battery supply & contrib. to EU economy

2035: Battery key value-add lever to support MHDT industry

<table>
<thead>
<tr>
<th>Share of battery production costs</th>
<th>Base scenario: Europe securing major share of cell production</th>
<th>Trailblazer scenario: Europe becoming battery champion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total domestic value add</td>
<td>~ 47%</td>
<td>~ 72%</td>
</tr>
<tr>
<td>Battery module and pack¹</td>
<td>- 85%</td>
<td>- 95%</td>
</tr>
<tr>
<td>Cell production</td>
<td>- 60%</td>
<td>- 95%</td>
</tr>
<tr>
<td>Raw materials</td>
<td>4%</td>
<td>- 18%</td>
</tr>
</tbody>
</table>

- **Scenario used in study—figures for T&E case**

1. Share of battery production costs is based on the total cost of production, including battery module and pack, cell production, and raw materials.

2. **Existing policies**

- **Net-Zero Industry Act**: Content requirements for batteries to enforce local production
- **Critical Raw Mat. Act**: Proposed in March 2023 to address shortages and supplier concentration
- **Framework to secure sustainable supply of critical raw mat.**: Supported by battery regulation’s recycling and recovery requirements
- **Taxes on import of battery**: To increase attractiveness of local battery production
- **Local sourcing requirements**: For obtaining government contracts or licenses

3. **Incentives**

- **New tech support**: Country-specific schemes in comb. with Temporary Crisis and Transition Framework and Green Deal Industrial Plan
- **Addl. tax incentives, subsidies, and grants**: To attract investment in battery infrastructure
- **Grants to R&D activities**: For innovative raw material exploration and processing
- **Support for accelerated build of battery recycling infrastructure**

4. **Value add in Europe**

- **Total domestic value add**
- **Add. supplier GDP 2022 vs. 2035** +€7B
- **Add. supplier jobs 2022 vs. 2035** +16K
- **Change from base case**
- **Existing policies**
- **Addl. policy levers to support trailblazer scenario**
- **Value add in Europe**

1. Battery mod. & pack covered by OEM, effects shown only for cell prod. & raw mat. at supplier
2. State aid valued at €837M granted to Spain for supporting battery prod. with loans & grants; Northvolt with support of ~ €500M in Germany
3. Assumptions for sensitivity demo
4. Source: Expert interviews; BCG

Supporting the shift to zero emissions
OEMs (1/2): While GDP grows, job losses from ICE phaseout cannot be replaced fully by new ZEV parts

Note: 2035 figures based on ZEV adoption in T&E case; assuming no strategic changes to current OEM business model

Source: BCG
### Supporting the shift to zero emissions

**OEMs (2/2): Structural changes create need for reskilling labor force**

2035: 35K employees in major job families affected

<table>
<thead>
<tr>
<th>ICE</th>
<th>ZEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICE engine planner</td>
<td>Battery mod./pack production planner &amp; staff</td>
</tr>
<tr>
<td>ICE engine staff</td>
<td>High voltage production staff</td>
</tr>
<tr>
<td>ICE engine developer</td>
<td>Batterie mgmt. developer</td>
</tr>
<tr>
<td>Machine/tooling operator</td>
<td>(Vehicle) concept developer</td>
</tr>
<tr>
<td>Power unit developer</td>
<td>(Vehicle) feature developer</td>
</tr>
<tr>
<td>ICE engine planner</td>
<td>(Vehicle) battery mod./pack developer</td>
</tr>
</tbody>
</table>

**Policies**

**Incentives**
- Green reskilling as part of Green Deal Industrial Plan—e.g., via Erasmus+ initiative (€1.1B), European Skills Agenda
- Social investment and skills window (SISW)—support of supply and demand of skills (e.g., students, learners, and SMEs)
- Recovery and resilience facility (RRF) support with grants and loans for development of skills to support green and digital transition
- (National) location-based reskilling program supporting OEMs shift to ZEV and green production based on new job profiles

**General trends affecting ICE jobs**
- (Early) retirement schemes
- Remote and flexible work
- Demographic shifts

---

Note: Same applies to suppliers and utilities with significant changes in job demands and profiles taking place

Source: BCG
Infrastructure (1/2): Economic growth driven by buildup in charging infrastructure

1. Incl. connected and platform services, transport solutions, and resale, reuse, and recycling

Note: 2035 figures based on ZEV adoption in T&E scenario. Source: BCG
Infrastructure (2/2): Net ramp-up of charging infrastructure critical for capacity-driven road transport industry

2035: Fast growing number of charging points forecasted

Policies

Regulations
- AFIR\(^1\) requiring at least 3,600 kW MHDT charging pools to be installed every 60 km along TEN-T core network by 2030, supporting major buildup of charging infrastructure in Europe

Incentives
- Subsidies and grants to support charging infrastructure providers and SMEs regarding setup of fleet charging options
- Support setup of electricity grid as fundamental basis of infrastructure rollout (including light vehicles)

1. Alternative fuel infrastructure regulation
Note: Assuming high-speed charger share of 70% for public charging points; CAGR = compound annual growth rate
Source: BCG
Utilities (1/2): GDP and jobs created by new energy needs; main driver electricity due to high value share in Europe

Deep dive: Affordable electricity prices

<table>
<thead>
<tr>
<th>Year</th>
<th>Diesel (B€)</th>
<th>Electricity (B€)</th>
<th>H₂ (B€)</th>
<th>Total (B€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022</td>
<td>16</td>
<td>-4</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>2035</td>
<td>21</td>
<td>5</td>
<td></td>
<td>26</td>
</tr>
</tbody>
</table>

Supporting the shift to zero emissions

Diesel GDP loss due to shrinking diesel fleet and lower consumption

€4 B GDP

GDP contribution by electricity, driven by high value add in Europe

€21 B GDP

Jobs (in K)

<table>
<thead>
<tr>
<th>Year</th>
<th>Diesel (in K)</th>
<th>Electricity (in K)</th>
<th>H₂ (in K)</th>
<th>Total (in K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022</td>
<td>88</td>
<td>-31</td>
<td></td>
<td>57</td>
</tr>
<tr>
<td>2035</td>
<td>143</td>
<td>72</td>
<td></td>
<td>215</td>
</tr>
</tbody>
</table>

Note: 2035 figures based on ZEV adoption in T&E case
Source: BCG
Utilities (2/2): Contribution from electricity consumption reliant on affordable energy prices and value add versus diesel

2035: Sensitivity of TCO to energy prices

<table>
<thead>
<tr>
<th>2035 diesel prices</th>
<th>2035 electricity prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower prices (e.g., incentives)</td>
<td>Lower prices (e.g., incentives)</td>
</tr>
<tr>
<td>No change in TCO advantage</td>
<td>No TCO advantage</td>
</tr>
<tr>
<td>High/medium TCO advantage</td>
<td>Medium/low TCO advantage</td>
</tr>
<tr>
<td>High TCO advantage</td>
<td>No change in TCO advantage</td>
</tr>
</tbody>
</table>

Policies

**Regulations**
- **Net Zero Industry Act**: Strengthen manufacturing capacity of net-zero technologies, overcoming barriers to scaling up
- **REPowerEU Plan**: Decarbonizing the industry by accelerating the switch to electrification and providing affordable energy

**Incentives**
- **Partial toll reductions**: Subsidies for BEVs, e.g., no road tolls in scale-up phase
- **Green subsidies**: No/lower cost for access to grid of renewable electricity
- **Wholesale prices**: Access to large scale electricity prices for smaller fleets

Source: BCG
EU already with substantial mechanisms in place to support shift to ZEV

<table>
<thead>
<tr>
<th>Regulations</th>
<th>Incentives</th>
</tr>
</thead>
<tbody>
<tr>
<td>- CO₂ reduction targets</td>
<td>- CO₂ emissions reduction targets of 15% by 2025 and 30% by 2030(^1); case for stricter targets awaiting final approval</td>
</tr>
<tr>
<td>- Manufacturing ecosystem</td>
<td>- Net Zero Industry Act to strengthening net-zero technology products, setting enabling conditions for batteries and energy with 40% domestic production benchmark by 2030</td>
</tr>
<tr>
<td>- Battery supply</td>
<td>- Critical Raw Materials Act addresses shortages for critical and strategic raw materials sets a 40% target for the local processing of these materials by 2030</td>
</tr>
<tr>
<td>- Infrastructure</td>
<td>- Alternative Fuels Infrastructure Regulation with complete TEN-T network coverage to be achieved by ’30 with MHDT charging pools at least 3,600 kW to be installed every 60 km</td>
</tr>
<tr>
<td>- Energy</td>
<td>- REPowEU Plan diversifies EU energy supply by investing in renewables and securing affordable energy supplies</td>
</tr>
</tbody>
</table>

| Purchase subsidies | | |
|---------------------|----------------------| |
| - National level subsidies (e.g., Germany and Austria up to 80% of price delta to ICE truck; NL 45%) | - Partial toll reductions on natl. level (e.g., Germany €0/km until 2023, afterward reduced until 2040) |
| - CO₂ pricing | - CO₂ price on transport fuels increasing diesel prices and thus relative TCO adv. of ZEVs |
| - Tech funding | - New tech support via e.g., NextGen EU (€800B), Horizon Europe R&D program (€40B) |
| - Skills funding | - Green reskilling as part of Green Deal Industrial Plan—e.g., via Erasmus+ initiative (€1.1B), European Skills Agenda; social investment and skills window (SISW) |

1. Relative to 2019 level; stricter CO₂ standards revised for MHDts based on EU commission case (Feb. 2023) of 45% by ’30 & 65% by ’35, applicable to trucks (> 5 t), city buses, long-distance buses (> 7.5 t), trailers; final approval still pending; additional targets set on national level

Source: BCG

Not exhaustive

Common incentive along the value chain
Agenda

1. Current state of the European truck industry
2. Shift to ZEV and underlying key drivers
3. Impact of ZEV shift on European economy until 2035
4. Supporting the shift to zero emissions
5. Outlook: Emerging competition from new non-European ZEV players
Global trend toward ZEV challenges traditional market structures, offering new players opportunities to enter into the European truck industry

A

Technology shift is enabler for market disruption

Shifts in technology and business model open up opportunities for new players in the market, incl. non-European truck manufacturers

B

Exports are starting point for new players, moving toward localization

Depending on home-market cost structure, localization becomes crucial for long-term dominance for non-European players, but requires minimum volume of ~ 5-10K vehicles p.a.

C

Three scenarios for the rise of non-European players foreseen

Overall impact of non-European ZEV players on GDP and employment depends upon the concrete scenario, esp. number of entrants, localization degree, etc.

Source: BCG
ZEV shift is accelerating fast, impacting traditional MHDT OEMs

**Market trends**
Core MHDT market is tougher, growth shifts to Asia, rules of the game being redefined

- MHDT market maturing, limited growth in Europe
- Temporary volume shocks due to COVID and semiconductors
- New valuations emphasize the transition

**Technological development**
Rapid tech development forces large investments and redefinition of industrial operations

- New powertrain technologies accelerating
- Digital solutions gaining speed
- Autonomous vehicles maturing

**External forces**
Sustainability and environment top of the agenda, through both push and pull forces, accelerating the shift

- Push from regulations and standards
- Geopolitical implications
- Sustainability and climate pull from customers

**Value drivers and business models**
Profit pools shift toward new business models, where the right to win is not as given for traditional OEMs

- New ZEV competition—often driven by new entrants from US & CN
- Value pools are shifting toward new technologies
- Customer landscape is changing

Source: BCG
New ZEV competition expected mainly from new market entrants

Potential candidates for entry into European MHDT market

<table>
<thead>
<tr>
<th>Company</th>
<th>HQ</th>
<th>xEV portfolio</th>
<th>Highlights of what is known</th>
<th>Year established</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYD</td>
<td>China</td>
<td>🚕</td>
<td>Preorders from UK, Netherlands, and Norway, no delivery date disclosed</td>
<td>2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>🚕</td>
<td>Developed electric and hydrogen truck eligible for European market, recently sold European stake to IVECO</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>🚕</td>
<td>Main BEV presence currently in the US</td>
<td>2015</td>
</tr>
<tr>
<td></td>
<td></td>
<td>🚕</td>
<td>Main BEV presence currently in the US</td>
<td>2020</td>
</tr>
<tr>
<td></td>
<td></td>
<td>🚕</td>
<td>Currently in production but only available to North American market as of yet</td>
<td>2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>🚕</td>
<td>Presented MHDT designed to enter European market at IAA in 2022</td>
<td>2003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>🚕</td>
<td>Developed native NEV-truck aiming for US and Chinese markets</td>
<td>2002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>🚕</td>
<td>Hyundai expands its hydrogen fueled truck fleet in Europe</td>
<td>1967</td>
</tr>
<tr>
<td>Tevva</td>
<td>UK</td>
<td>🚕</td>
<td>Tevva started in UK, recently expanding into mainland Europe</td>
<td>2012</td>
</tr>
<tr>
<td>Volta</td>
<td>Sweden</td>
<td>🚕</td>
<td>Production partnership with Steyr, supplying Schenker with ~1,500 trucks</td>
<td>2017</td>
</tr>
<tr>
<td>einride</td>
<td>Sweden</td>
<td>🚕</td>
<td>Partnered with Scania to deliver 110 trucks primarily for Swedish market</td>
<td>2016</td>
</tr>
<tr>
<td>Quantum</td>
<td>Europe</td>
<td>🚕</td>
<td>Partnerships with NEUMAN &amp; ESSER in Germany, and Ballard Power Systems in Canada</td>
<td>2019</td>
</tr>
</tbody>
</table>

Not exhaustive

---

1. BYD founded in 1995 as battery manufacturer, entered automobile business in 2003  
2. Announced H2 MHDT offering for Europe in 2020

Source: Press releases
Emerging competition from ZEV trend

Exports are typically starting point for new players, moving toward localization

1. Under IRA subsidies, US likely to be in lower range of scenario
2. Tesla Semi likely to fall under 16% tariff being categorized as road tractor

Note: HCC = high-cost country, LCC = low-cost country
Source: BCG
Localization requires minimum volume of 5-10K units p.a. to reach efficient production levels

Typical scale curve for MHDT production

Production cost significantly declines per vehicle until 5-10K units per year

If respective volume is in sight, players typically shift to local assembly (CKD) and start to localize supply chain

Source: BCG
Reasons and barriers for entering the European market

Key reasons to enter European market

Supply shortage: European incumbents do not fulfill high ZEV demand, attracting new players to fill the gap

Technological advantage: New players entering with advanced offering (e.g., range, performance) outperforming incumbents

Supply chain advantage: New players may have access to potential scarce resources than incumbent OEMs

Cost advantage: Potentially lower cost structure besides tariffs and logistics cost of new players

Potential lead market: Current regulation could make Europe front-runner for BEV truck market (versus USA)

Key barriers to European market entry

Development effort: Homologation and product adaptations needed to fulfill European needs

Low-margin market: Overall low margins realized in recent years in Europe

Trade barriers: Tariffs (also if lowered) may make imports (temporarily required to establish brand) less attractive

Service/aftermarket network: Need to offer dense network of workshops and spare part supply

Sales network and customer relations: Long-standing customer relations limit market potential for new players

Investments at risk: High investments needed to establish market presence but limited guarantee to succeed

1. Brand stickiness in MHDT market lower than in light vehicle market due to focus on TCO
Source: BCG
Three scenarios considered for non-European player market entry

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Fully localized production</th>
<th>Local assembly with partial local sourcing</th>
<th>Import-based competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defend</td>
<td>Two players establish in market and transition to fully localized production from import-only model. Peak import to be expected around 2030. Long-term only limited vehicle import to Europe</td>
<td>Two players established in market and transition toward local production with CKD model. Long-term only little whole vehicle import to Europe</td>
<td>No entrant can achieve sufficient market share to establish local production: Also in medium- to long-term only imports at relatively low levels</td>
</tr>
<tr>
<td>Mkt shr. ’35¹</td>
<td>-11% (thereof 1% vehicle import)</td>
<td>-8% (thereof 1% vehicle import)</td>
<td>-3% (all vehicle import)</td>
</tr>
<tr>
<td>Localization approach</td>
<td>After achieving sufficient market share (2-3%), start to localize assembly and supply chain to achieve similar cost structure as incumbents, targeting full localization</td>
<td>After achieving sufficient market share (2-3%), start to localize assembly and partially also supply chain (50% of incumbent OEM levels). Limited further growth prevents from full localization</td>
<td>No localization, full import</td>
</tr>
<tr>
<td>Peak (2028)</td>
<td>-1.6</td>
<td>Peak (2029)</td>
<td>-1.8</td>
</tr>
<tr>
<td>2035</td>
<td>-0.4</td>
<td>2035</td>
<td>-1.4</td>
</tr>
</tbody>
</table>

1. Assuming upper range in following analyses for more prominent results 2. In high adoption case versus 2022

Source: BCG
Underlying foundations and assumptions for market entry scenarios

GDP and employment effect of scenarios calculated against base scenario, i.e., no competition from abroad

Underlying base is the current BCG market perspective (see chapter 1), which showcases a median trajectory between the two regulatory scenarios (Base case and T&E case)

Start of local assembly derived from truck production scale curve (see section 5B) and transition period toward full local assembly assumed to take 5-7 years

Number of entrants estimated based on today’s potential entrants and competitive dynamics in European truck market (saturated, low-margin, BEV technology already available, etc.)

Focus of GDP and employment calculations is on OEMs and suppliers. ZEV infrastructure and MHDT-related utilities assumed stable with/without new entrants

Source: BCG
Fully localized production (1/2): New player market share of 11% in 2035, assuming two fully localized new entrants

Emerging competition from ZEV trend

Few new players enter market with import model first

Two players can establish in market and transition to fully localized production when volume of ~5K units p.a. is in reach

Leaving limited window of opportunity for additional competition through import (only 1% market share long-term)
Fully localized production (2/2): Intermediate dip in GDP and employment during “import peak” with recovery after

### Fully localized production

<table>
<thead>
<tr>
<th>Share of total market</th>
<th>Domestic OEMs</th>
<th>Imported (non-EU OEMs)</th>
<th>Localized (non-EU OEMs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMULATION</td>
<td>Based on BCG market perspective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic OEMs</th>
<th>Imported (non-EU OEMs)</th>
<th>Localized (non-EU OEMs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2028</td>
<td>0.1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>2029</td>
<td>1%</td>
<td>0.3%</td>
<td>2%</td>
</tr>
<tr>
<td>2030</td>
<td>1%</td>
<td>0.7%</td>
<td>3%</td>
</tr>
<tr>
<td>2031</td>
<td>3%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>2032</td>
<td>2%</td>
<td>0.7%</td>
<td>5%</td>
</tr>
<tr>
<td>2033</td>
<td>7%</td>
<td>0.3%</td>
<td>3%</td>
</tr>
<tr>
<td>2034</td>
<td>8%</td>
<td>0.2%</td>
<td>3%</td>
</tr>
<tr>
<td>2035</td>
<td>9%</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>

**GDP decrease during import peak temporary up to 1.6B**

- 2028: -1.6B
- 2035: -0.4B

**Employment losses throughout import phase up to 11.3K**

- 2028: -11.3K
- 2035: -1.6K

Source: IHS Automotive; BCG
Local assembly w. partial local sourcing (1/2): New player market share of 7% expected in 2035, w. partial localization

Emerging competition from ZEV trend

Few new players enter market with import model first

Two players can get established in market and partially transition toward local production, however they don’t fully localize. Localization of supply chain reaches 50% of incumbent’s level

Vehicle import very low in long term, as new players and incumbents leave little room

Source: IHS Automotive; BCG
Local assembly w. partial local sourcing (2/2): Substantial decline in GDP and jobs if supply chain is not localized

### Local assembly with partial local sourcing

#### Based on BCG market perspective

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP (€B)</th>
<th>Jobs (in K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2029</td>
<td>-1.8B</td>
<td>-12.3K</td>
</tr>
<tr>
<td>2035</td>
<td>-1.4B</td>
<td>-7.4K</td>
</tr>
</tbody>
</table>

#### Share of total market

- **Domestic OEMs**
- **Imported (non-EU OEMs)**
- **Partially localized (non-EU OEMs)**

<table>
<thead>
<tr>
<th>Year</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
<th>2031</th>
<th>2032</th>
<th>2033</th>
<th>2034</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022</td>
<td>-0.1</td>
<td>0.3</td>
<td>-0.6</td>
<td>-0.8</td>
<td>-1.1</td>
<td>-1.2</td>
<td>-1.2</td>
<td>-1.1</td>
<td>-1.0</td>
<td>-1.0</td>
<td>0.4</td>
<td>0.7</td>
<td>-0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>2023</td>
<td>-0.6</td>
<td>0.4</td>
<td>-0.6</td>
<td>-0.6</td>
<td>-1.2</td>
<td>-1.2</td>
<td>-0.5</td>
<td>-0.4</td>
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Source: IHS Automotive; BCG
Emerging competition from ZEV trend

Few players try to enter market but no player achieves sufficient volume for local production

Limited import of ~3% of the European truck market expected
Import-based competition (2/2): GDP and employment loss grows with ZEV adoption

1. Total value for OEMs and suppliers; loss incurred from share of imported vehicles only

Source: IHS Automotive; BCG
Summary: Highest risk for GDP and employment loss in steady state from new entrants with local assembly and partial local sourcing (scenario II)

I. Under the assumption that new competition cannot be avoided (baseline scenario)

- Peak effect at end of investigated horizon—slightly grow afterward with increasing ZEV adoption

II. Local assembly with partial local sourcing

- Least attractive scenario in terms of 2035 GDP and employment impact (almost no change), as new entrants will create similar value as incumbent OEMs and limit opportunity for pure-import players
- Loss happens mainly at suppliers (GDP: -€1.0B, jobs: -7.4K in 2035), as new players import large share of their components
- As players start with import model first, GDP and job loss is slightly higher during interim period and peaks around 2029 with GDP loss of €1.8B and job loss of 12.3K

III. Import-based competition

- In 2035 expected GDP loss is €1.2B and job loss slightly more pronounced (7.6k) than Scenario II
- In this scenario, competition (3% market share) is only from import without localization, substantial GDP and job loss is expected
- Loss happens on almost equal levels at OEMs and suppliers and grows with ZEV adoption

Most attractive scenario¹ in terms of 2035 GDP and employment impact (almost no change), as new entrants will create similar value as incumbent OEMs and limit opportunity for pure-import players

However, in first years, new players will import entire vehicles before local assembly and sourcing is established. Import expected to peak around 2030, leading to an interim GDP (-€1.6B) and job loss (-11.3K)

Baseline scenario, assuming no new competition

¹. Under the assumption that new competition cannot be avoided (baseline scenario)
². Peak effect at end of investigated horizon—slightly grow afterward with increasing ZEV adoption
Source: BCG
### Potential levers to influence rise of non-European MHDT competition (extract)

**Lever** | Potential impact on new non-European market entrants
--- | ---
**Standards**
Emission targets | Imposing minimum emission standards for MHDT players. Depending on the exact design the lever can incentivize or deter new entrants
Increased technical requirements | With requirements to invest largely to meet local demands, import (III) and semi-localization (II) scenarios can become less likely
**Tariffs / Local content**
Higher tariffs on vehicles | Local production is incentivized by making imports less attractive. Import-only becomes less likely, and new entrants may shorten import phase and ramp-up local production more quickly
Higher tariffs on components | Entire-vehicle import not affected by lever, but CKD production (II) becomes less likely, and players may shorten time for localization of supply chain
Local content requirements | Depending on specifics of regulation, import (III) can be fully suppressed and full localization (I) can be made more attractive
**Subsidies**
Subsidies for development | May speed up ZEV shift in Europe, thus limiting a supply gap, which can make a market entry for new players less attractive
Subsidies, e.g., for local production | Supports semi/full localization in Europe
Customer incentives to push demand | Supports demand for ZEV, which increases adoption and might drive a supply gap, thus attracting new players

Source: BCG
Conclusion: All scenarios for non-European market entry have a negative impact on OEMs and suppliers, though ZEV transition outweighs losses along full value chain

In all scenarios with new entrants, GDP and jobs are lower than in base scenario without new competitors. In worst scenario (II) GDP is €1.4B and jobs 7.4K lower in a steady state for full ZEV adoption in 2035 versus baseline scenario assuming no competition.

If new players cannot be avoided, long-term a scenario with full localization (I) could be most advantageous in terms of GDP and jobs. However, new entrants will start with import model first that leads to an interim peak loss in employment and GDP around 2030 relative to baseline scenario.

Policymakers can influence likelihood of scenarios with protective measures (e.g., MHDT CO₂ standards, import tariffs, local content requirements) or subsidies for local players.

Considering the full value chain, overall positive GDP (+€16B in the lower base and +€32B in the higher T&E case) and job (+16K/+30K) development can be achieved. This positive effect from the transition to ZEV is reduced in all scenarios, but not at risk, with non-European players entering the market.

Source: BCG
Outlook: Roadmap for European MHDT OEMs to secure ZEV leadership as ZEV volumes significantly increase and new players enter the market

- **2022**: Potential new entrants
- **2025**: Most OEMs with “Gen-2” BEV
- **2028**: Every 2nd MHDT sold in EU is a ZEV
- **2030**: Majority of worldwide MHDT sales zero-emission
- **2035**: Accelerate BEV development and production to meet market demand
- **2022-2035**: Strengthen ZEV portfolio to secure market position
- **2022-2035**: Time window to get a cost & performance leading BEV product in the market in prioritized segments (long- & medium-haul)
- **2022**: Increasing CO₂ regulation

Source: BCG 2023 report on the future of CV/heavy road transport; BCG
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Appendix
# EU with broadest set of policies amongst peers promoting shift to ZEV

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<th>Regulations</th>
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<th>ZEV sales targets</th>
<th>R&amp;D support and grants</th>
<th>Economic incentives</th>
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<td>CO(_2) emissions reduction targets of 15% by '25 and 30% by '30; Case for stricter targets waiting for final approval</td>
<td>11 European countries signed the MOU: 30% MHDTs ZEV sales by '30 and 100% by 40(^2)</td>
<td>New tech support via, e.g., NextGen EU (€250B), Horizon Europe R&amp;D program (€40B)</td>
<td>Purchase subsidies: (e.g., Germany and Austria up to 80% of price delta to ICE truck; NL 45%)</td>
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| Skills funding            | Green reskilling as part of Green Deal Industrial Plan—e.g., via Erasmus+ initiative (€1.1B), European Skills Agenda | Green reskilling as part of IRA funding for infrastructure, workforce training/planning & maintenance/charging; funds available through FY '31 |                                                                                       | Subsidies for NEVs (phased out in '22); purchase tax exemption until '23 (10% of purchase tax); now subsidies shifted from national to regional level |
|                           | ✓                                                                                    | ✓                                                                                 | ✓                                                                                      | ✓                                                                                     |
|                           | ✓                                                                                    | ?                                                                                | ?                                                                                      | ?                                                                                    |

| Tech funding              | IRA invests $1B to replace MHDTs with ZEVs; new tech support via, e.g., battery supply chain fund (57B); addl. natl. funds (e.g., NY $500K for ZEV infrastructure) | Four-year pilot program announced—select cities receive support for R&D and demonstration of fuel cell EVs |                                                                                       | No current subsidies for road tolls for HD CVs                                      |
|                           | ✓                                                                                    | ✓                                                                                | ✓                                                                                      | ✓                                                                                     |
|                           | ?                                                                                    | ?                                                                                | ?                                                                                      | ?                                                                                    |

| Usage incentives          | CO\(_2\) price on transport fuels increasing diesel prices and thus relative TCO adv. of ZEVs | Process of infrastructure deployment to start in 2025 and cover all TEN-T roads by 2030 | Process of infrastructure deployment to start in 2025 and cover all TEN-T roads by 2030 | State support to fund the ZEV corridors with EV charging and H\(_2\) refuelling across 23 states |
|                           | ✓                                                                                    | ✓                                                                                 | ✓                                                                                      | ✓                                                                                     |
|                           | ?                                                                                    | ?                                                                                | ?                                                                                      | ?                                                                                    |

| Infra-structure           | No specific ZEV policies beyond '23 but announced commitments                       | CO\(_2\) credit targets for manufacturers as % of their annual sales, Program extended to '23 (18% in '23, 16% in '22, 14% in '21) | Potential reskilling incentives are being discussed                                   | Existing policies                                                                   |
|                           | ✓                                                                                    | ✓                                                                                | ✓                                                                                      | ✓                                                                                     |

1. Relative to 2019 level; stricter CO\(_2\) standards revised for MHDTs based on EU Commission case (Feb. 2023) of 45% by '30 & 65% by '35, applicable to trucks (> 5 t), city buses, long-distance buses (> 7.5 t), trailers; final approval still pending; additional targets set on national level  
2. Nonbinding memorandum of understanding (MOU); Source: BCG
Import tariffs and broad range localization incentives support localized market structure but low tariffs in Europe for ZEV open up market to imports

**Sourcing restrictions**

- **EU**: Requirement to source battery raw materials from eco-certified suppliers
- **US**: 40% of battery raw materials from ‘US or FTA-partners and not from ‘foreign entities of concern’
- **China**: Currently no sourcing restrictions in place

**Subsidies for local production**

- **EU**: EU pledged to mobilise €1tr, to support transition to net-zero over the next decade
- **US**: IRA is a $400bn, fund to support clean energy industries
- **China 2025**: Provides $500bn, to support domestic manufacturing in strategic sectors affecting automotive

**Import tariffs**

- **Truck >5t (GVW)**
  - **16% - 22% ICE ad valorem**
  - **10% ZEV av for BEV and other propulsion**
- **Light vehicles**
  - **10% ad valorem**
  - **2.5% ad valorem**
  - **15% ad valorem**

**Number of harmful measures put in force since ‘21 (#)**

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**International Procurement Instrument threatens to exclude bidders from countries disadvantaging EU-companies in public tenders**

**NAFTA requires 75% North American content to apply for tariff waiver; Buy America requires 40% local content in public tenders**

**Public procurement strong lever due to high share of state-owned companies**

**Note:** Loans and grants considered harmful since only benefitting local producers; ad valorem = payment, rate, or tax calculated according to the price of a product or service, rather than at a fixed rate

Source: World Bank; Global Trade Alert; BCG

Appendix - regulatory overview
Proposed EU commission standards are below projected ZEV adoption 2035 across geographies, whereas progressive T&E case is above.

1. Entails both BEV and H2 HDVs. 2. Not covering unregulated MHDT segments (e.g., vocational, non-certified). 3. Incl. unregulated MHDT (under EU Commission).

Note: EU Commission proposed new CO2 standards for new ZEV sales in Feb.