Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation

Pathways for decarbonizing the transport sector

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EU Roadmap for moving towards a competitive low-carbon economy:

GHG EMISSIONS AND TARGETS FOR THE TRANSPORT SECTOR

- 28% of the EU GHG emissions
- 84% of these emissions from road transport
- road transport emissions mainly caused by passenger cars (61%) and by heavy duty trucks & buses (26%)

### GHG reductions compared to 1990

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>-7%</td>
<td>-40 to -44%</td>
<td>-79 to -82%</td>
</tr>
<tr>
<td><strong>By Sector</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>-7%</td>
<td>-54 to -68%</td>
<td>-93 to -99%</td>
</tr>
<tr>
<td>Industry</td>
<td>-20%</td>
<td>-34 to -40%</td>
<td>-83 to -87%</td>
</tr>
<tr>
<td><strong>Transport</strong> (incl. aviation, excl. maritime)</td>
<td>+30%</td>
<td>+20 to -12%</td>
<td>-54 to -67%</td>
</tr>
<tr>
<td>Residential and services</td>
<td>-12%</td>
<td>-37 to -53%</td>
<td>-88 to -91%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>-20%</td>
<td>-36 to -37%</td>
<td>-42 to -49%</td>
</tr>
<tr>
<td>Other non-CO2 emissions</td>
<td>-30%</td>
<td>-72 to -73%</td>
<td>-70 to -78%</td>
</tr>
</tbody>
</table>
REFERENCE SCENARIO FAILS TO MEET GHG TARGETS BY FAR

Source: based on EU Reference Scenario EU28 for transport
3 Main Strategies to Decarbonize Transport

1. Shift to more efficient transport modes

2. Diffusion of low/zero-emission technologies

3. Alternative fuels: bio & synthetic fuels
## Measures and Policies to Enable the Transition

### Modal Shift
- **Financial measures** like smart pricing, road infrastructure or congestion charges in cities,
- Measures to **improve the infrastructure** of public transport, cycling and walking pathways,
- Measures to **improve the accessibility and the use of multi-modal transport, bike-, car- and ridesharing services** by better applying digital technologies and
- **Regulatory measures** like lower speed limits for passenger cars, prioritised traffic flows of non-motorised modes and public transport on crossings and high parking fees

### Low emission technologies & fuels
- **Stricter fuel efficiency or CO₂ standards** until 2030 and beyond
- **Subsidies for electric vehicles** in early market phases
- Vehicle **registration taxes based** on bonus-malus systems related to emissions
- Increased **energy taxation** for conventional fuels, **reduced fuel tax** for electricity, biofuels, hydrogen and renewable synthetic fuels
- Spreading **road charges based on CO₂ emissions**
- **Banning** fossil-fuel based cars from entry into cities
- Regulating a general **phase-out of pure ICE vehicles** at least for passenger cars
PATHWAYS

- many new entrant
- heterogeneous actors
- active consumers
- coordination, digitalisation, open platforms
- regulatory opening
- challenges to incumbents

- local resources
- national differentiation
- resistance to big infrastructure
- experimentation & diversity (but weak spillovers)
- winner-takes-all digitalisation

clear shared vision -
EU in guiding role -
strong coordination between member states -
durable and stable policy framework -
buy-in of (large) stakeholders -

low transitional risks -
strong role for incumbents -
regulatory capture -
large-scale projects & balance sheets -
### Pathway Interpretations for Transport

#### Diversification

"Mobility as a service" system with new business models, shared and increasingly autonomous vehicles for freight and passengers.

Range of various technologies and policies adapted across EU countries.

#### Directed Vision

Joint infrastructure and policy decisions across EU countries. Strong electrification of road transport with trolley truck infrastructure and phase-out of pure ICE vehicles. Biofuels mainly used for non-road modes.

#### Localisation

Strong role of car-sharing, public transport, walking and cycling for local mobility. Technologies differ between countries. Decentral roof-top PV installation incentivizes electric car purchases for households. Biomass as local resource is part of the decarbonization strategy.

#### National Champions

National development of new technologies and policies. Low- and zero-emission technologies diffuse relatively slowly. Biofuels adopted on a large scale, also for road transport. Low changes in modal split and car ownership.
**Methodology: Modelling Approach**

ASTRA - Assessment of Transport Strategies
[www.astra-model.eu](http://www.astra-model.eu)

Main characteristics:

- System Dynamics - Vensim® software
- 1995 to 2050
- EU28 + CH/NO
- Modular structure
- Simulation of single policy measures and bundles
- Technology diffusion based on an adapted total cost of ownership approach
## Pathway Model Assumptions

<table>
<thead>
<tr>
<th></th>
<th>Diversification</th>
<th>Directed Vision</th>
<th>Localization</th>
<th>National Champions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trolley truck infrastructure</td>
<td>DE, NL, DK, FI, SE, NO</td>
<td>Trolley trucks in most countries (wo islands)</td>
<td>-</td>
<td>DE, DK, FI, SE, NO</td>
</tr>
<tr>
<td>Measures for FCEV diffusion</td>
<td>Different levels</td>
<td>in countries wo trolley trucks →UK, IE, CY, MT</td>
<td>Different levels</td>
<td>Very low, selected countries only</td>
</tr>
<tr>
<td>Measures for CNG/LNG diffusion</td>
<td>Different levels</td>
<td>Very low, selected countries only</td>
<td>Different levels</td>
<td>Selected countries only</td>
</tr>
<tr>
<td>Biofuel share</td>
<td>Different levels low to high</td>
<td>Low for road modes, very high for aviation</td>
<td>Different levels low to high</td>
<td>Very high in all countries also for road modes</td>
</tr>
<tr>
<td>Phase-out ICE vehicles</td>
<td>Urban buses, cars &amp; LDV in selected countries 2030-40</td>
<td>Urban buses in 2030, cars &amp; LDV in 2035</td>
<td>Urban buses in 2030 for EU15/NO/CH, cars/LDV in selected countries in 2035/40</td>
<td>Urban buses in 2030 for EU15/NO/CH, in 2040 for EU13</td>
</tr>
<tr>
<td>Autonomous driving</td>
<td>Scenario „World of mobility services“</td>
<td></td>
<td>Scenario „World of car ownership“</td>
<td></td>
</tr>
<tr>
<td>Car sharing, active modes</td>
<td>Variations of levels for several parameters, e.g. highest level of improvement of public transport in Directed Vision, lowest diffusion of car sharing in National Champions, highest level of e-bike penetration in Localization.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Policies to push a transition to a decarbonized transport sector</td>
<td>Strict efficiency standards for vehicles of all road modes, measures to increase costs for conventional vehicles while decreasing them for low-emission vehicles (vehicle registration tax and fuel tax based on emissions, R&amp;D and subsidies for new technologies), deployment of charging stations and alternative fuelling infrastructure, measures for non-road modes, in particular increased electrification for railways and emission standards for aircrafts and ships</td>
<td></td>
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</table>
RESULTS: GHG EMISSIONS IN Mt CO₂

EU target 2030 (-8%): 922
EU target 2050 (-60%): 335
Pathway target 2050 (-65%): 300
RESULTS: MODAL SHIFT & ACTIVITY

Passenger land transport

Transport demand in Mio. passenger kilometers (pkm)

Modal split based on pkm origin country

![Graph showing transport demand and modal split](image-url)
RESULTS: FLEET COMPOSITION

CARs

2015 Base year

Diversification

Directed Vision

Localisation

National Champions

Diesel

Gasoline

LPG

CNG

FCEV

PHEV

BEV

Trucks

2015 Base year

Diversification

Directed Vision

Localisation

National Champions

Diesel

CNG

LNG

FCEV

PHEV

BEV

Trolley

Fraunhofer
RESULTS:
FINAL ENERGY DEMAND IN TWh
RESULTS: BIOFUEL DEMAND IN TWh

- Biodiesel
- Bioethanol
- Biomethane
- Biokerosene

Year: 2015, 2020, 2030, 2040, 2050

Diversification, Directed Vision, Localisation, National Champions
RESULTS:
LINK TO THE ELECTRICITY SECTOR

Annual consumption for EU28 in TWh

- Flexibility potential due to production in times of electricity oversupply and option for reconversion
- Lower overall efficiency
### Conclusions

- **GHG reduction of -65% is possible.**
  - Decarbonizing transport by -65% is possible.
  - Efficiency improvements contribute, but are by far not sufficient.
  - Really strong measures are required to enable the transition, the sooner the better.

- **Several pathways exist, strategies have to be combined.**
  - Three main strategies have to be combined:
    - Shift to more efficient transport modes (public transport and active modes for passengers, railway & ships for freight, multi-modal transport) important, but limited due to infrastructure capacity, additional efforts for logistics, behavior change required.
    - Diffusion of low/zero-emission vehicles for road transport contributes substantially: BEV/PHEV soon competitive prices – range anxieties to be resolved, FCEV/Trolley trucks as options for freight to be further evaluated
    - Alternative fuels play an important role, in particular for non-road modes – to be covered either by biomass or by synthetic PtX-fuels

- **All pathways require strong measures soon.**
  - Research & discussions on the best policy & technology mix is required, overall efficiency, financial, social & ecological impacts to be considered
  - Investments for infrastructure & production capacities needed
  - Trigger transition with technology-independent measures first
Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation

Thank you!

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RESULTS: FLEET COMPOSITION

BUSES

LDV

Fraunhofer ISI
**Results:**

**Modal Shift & Activity**

Freight land transport

<table>
<thead>
<tr>
<th>Year</th>
<th>IWW</th>
<th>Maritime</th>
<th>Train</th>
<th>Truck</th>
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<tbody>
<tr>
<td>2015</td>
<td>4.4%</td>
<td>33.3%</td>
<td>11.3%</td>
<td>51.1%</td>
</tr>
<tr>
<td>2030</td>
<td>4.0%</td>
<td>34.3%</td>
<td>12.3%</td>
<td>49.5%</td>
</tr>
<tr>
<td>2050</td>
<td>3.8%</td>
<td>35.9%</td>
<td>11.4%</td>
<td>48.9%</td>
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<tr>
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Modal split based on tkm origin country