2050 scenario analysis using the EU CTI 2050 Roadmap Tool

TRANSPORT sector documentation

October 2018
Content

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- Priorization of levers
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Structure of the ECF EU CTI 2050 Roadmap model

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- Demography

Technologies, Energy & Resources
- Food production
- Energy requirements by sector: Transport, Buildings, Manufacturing
- Energy supply
- Impact on resources: Land, Fossil fuels

Trans-boundary effects, Trade, & Flows
- Outside the EU
Structure of the ECF EU CTI 2050 Roadmap model

- **Climate & Technological Transitions**
  - Economy
    - Economy evolution
  - Transport
  - Energy requirements by sector
    - Buildings
      - Residential (Commercial)
      - Heating technologies
      - Appliance efficiencies
    - Manufacturing
      - Product Design
      - Materials production
  - EU & rest of world
    - Demography
    - Dynamics with rest of world

- **Energy & Resources**
  - Food production
    - Livestock
    - Crops
  - Impact on resources
    - Land
      - Land allocation
      - Forests & grasslands
      - Bioenergy crops
  - Energy requirements by sector
    - Transport
      - Passenger
      - Commercial
      - Transport Technologies
    - Buildings
      - Residential (Commercial)
      - Heating technologies
      - Appliance efficiencies
  - Energy supply
    - Technologies
      - Electricity production
      - Heat production
      - Transport & Distribution
      - Storage
    - Materials
      - Minerals (location based)
      - Fossil fuel reserves

- **Trans-boundary effects, Trade, & Flows**
  - Outside EU
    - Food
    - Energy
    - GHG
    - Materials & resources
4 ambition levels are used as boundaries to create scenarios. Any value can be chosen in between.

<table>
<thead>
<tr>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
</table>
| **Current development** scenario (existing legal obligations)  
No additional effort  
« BAU scenario » | **Increased ambition** compared to BAU  
No breakthrough, but more extensive use of existing technologies | **Ambitious**: Significant effort requiring extensive changes in the system, leveraging best practices available today  
Typically reaching –85% | **Transformational**: Max potential based on transformational changes but reflecting technical or physical constraints |
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General calculation logic of transport modules (both passenger & freight)

1. **Transport activity per mode**
   - Eg: [kms] for cars
   - [pkms] for train

2. **Technology share**
   - Eg: [%] of BEV
   - [%] of Diesel

3. **Energy consumption**
   - Eg: [(MJ/km)] for BEV cars
   - [(MJ/pkm)] for diesel trains

4. **Emission intensity (TTW)**
   - Eg: [(gCO2/MJ)] for electricity
   - [(gCO2/MJ)] for diesel

5. **Need for infrastructure**
   - Eg: [# of BEVs] for charging stations

6. **Energy demand**
   - Eg: [PJ] of electricity for BEV cars
   - [PJ] of diesel for trains

7. **Infrastructure O&M & new infrastructures**
   - Eg: [# of charging stations]

8. **# Vehicles & vehicle sales**
   - Eg: [# of cars & new cars per technology]
   - [# of trains & new trains per technology]

9. **Costs**
   - Eg: [EUR/vehicle] for cars & trains
   - [EUR/#] for charging stations
   - [EUR/PJ] of electricity/diesel

10. **Total costs of system**
    - Eg: [EUR] for new vehicle acquisition
    - [EUR] for O&M of vehicles
    - [EUR] for fuels

11. **CO2 emissions**
    - Eg: [MtCO2] for BEV cars
    - [MtCO2] for Diesel trains
The avoid/reduce-shift-improve approach is used to structure the levers used to reduce transport energy demand and GHG emissions

- **Avoid** vehicle activity by:
  - reducing transport demand
  - increasing vehicle occupancy/load factor
- **Further reduce** the number of vehicles needed by:
  - increasing the utilization rate of vehicles
  - increasing the mileage lifetime of vehicles
- **Shift** to more efficient/environmentally friendly modes (e.g. active modes or public transport)
- **Improve** efficiency of transport by:
  - making more efficient new vehicles
  - shifting to more efficient fuels and technologies
In practice, we use 8 types of levers

<table>
<thead>
<tr>
<th>Lever type</th>
<th>Granularity of the levers for the user</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freight: total demand</td>
</tr>
<tr>
<td>2. Occupancy/load factor [passenger/vehicle] or [ton/vehicle]</td>
<td>Passenger: occupancy for LDV &amp; bus</td>
</tr>
<tr>
<td></td>
<td>Freight: load factor for trucks</td>
</tr>
<tr>
<td></td>
<td>Freight: utilization rate for trucks</td>
</tr>
<tr>
<td>4. Modal share [%/mode]</td>
<td>Passenger: modal share for LDV, 2W, Bus</td>
</tr>
<tr>
<td></td>
<td>- LEV share</td>
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<tr>
<td></td>
<td>Freight: - ZEV share</td>
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<tr>
<td></td>
<td>- LEV share</td>
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<tr>
<td></td>
<td>Passenger &amp; freight together: short-haul flights electrification &amp; shipping</td>
</tr>
<tr>
<td></td>
<td>electrification</td>
</tr>
<tr>
<td>8. Lifetime of vehicles [total km/vehicle]</td>
<td>Passenger: total kms travelled over vehicle lifetime</td>
</tr>
<tr>
<td></td>
<td>Freight: total kms travelled over vehicle lifetime</td>
</tr>
</tbody>
</table>
**Scope of the analysis**

**Modes for passenger transport:**
- Light duty vehicles (LDV)
- 2-wheels (2W)
- Bus
- Rail
- Airplane

**Types of vehicles/trip:**
- **Airplanes:**
  - Intra-EU
  - Extra-EU
- **HDV:**
  - Light
  - Medium
  - Heavy
- **LDV, 2W, bus, rail, ships:**
  - No further categorization

**Modes for freight:**
- Heavy Duty Vehicles (HDV)
- Rail
- Aviation
- Inland Waterways (IWW)
- Marine

**Technologies:**
- **LDV, 2W & Bus:**
  - Internal Combustion Engines (ICE)
  - Battery Electric Vehicles (BEV)
  - Fuel Cell Electric Vehicles (FCEV)
  - Plug-in Hybrid Electric Vehicles (PHEV)
- **Rail:**
  - ICE
  - Catenary Electric (CE)
- **Airplane:**
  - ICE
  - BEV
- **HDV:**
  - Internal Combustion Engines (ICE)
  - Battery Electric Vehicles (BEV)
  - Fuel Cell Electric Vehicles (FCEV)
  - Plug-in Hybrid Electric Vehicles (PHEV)
  - Catenary Electric Vehicles (CEV)

**Ships:**
- ICE
- BEV

**Types of fuels:**
- Diesel (for ICE & PHEV)
- Gasoline (for ICE & PHEV)
- Gas (for ICE & PHEV)
- Electricity (for BEV, PHEV, CE)
- Hydrogen (for FCEV)
- Aviation gasoline (for ICE planes)

**Source of fuels:**
- Conventional fossil fuel
- Biofuel (1G & 2G)
- E-fuel / PtX

**+ infrastructures:**
- EV charging stations,
- E-highways,
- Hydrogen charging stations

**+ costs (yet to be added):**
- Fuel costs,
- CAPEX for new vehicles and new infrastructures,
- OPEX for existing vehicles and infrastructures.
Projection trajectories until 2050

- Different types of curves are used

- Starting time and duration parameters are also used
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Calculation sequence of levers for the computation of energy and emissions in transport

1. **Transport demand**
   - [pkm] & [tkm]
   - This lever determines the total transport demand

2. **Modal share**
   - [%/mode]
   - This lever determines the share of transport demand for each transport mode
   - Multiplied by the transport demand, this results in the total transport demand for each mode in [pkm] or [tkm]

3. **Occupancy & Utilization rate**
   - [pkm/vkm] & [vkm/veh]
   - Occupancy lever determines the number person per vehicles and allows to translate [pkm] to [vkm] for cars and buses
   - Utilization rate determines the number of kilometers per vehicle each year and allows to compute the number of vehicles needed to answer the demand

4. **Technology share**
   - [%]
   - This lever determines the share of each technology in each mode

5. **Energy efficiency**
   - This lever sets the energy consumption for each mode & each technology. This allows to translate transport demand into energy consumption

6. **Biofuels**
   - [% fuel]
   - This lever sets the share of biofuels in the different types of remaining fuels

7. **E-fuels**
   - [% of “non-bio”fuel]
   - This lever sets the share of e-fuels in the different types of remaining non bio-fuels
Calculation sequence of modal share sub-levers

1. Modal share – LDV [%]
   - This lever determines the share of LDV in total transport demand

2. Modal share – 2W [%]
   - This lever determines the share of 2W in remaining transport demand (total – LDV)

3. Modal share – Bus [%]
   - This lever determines the share of Bus in remaining transport demand (total – LDV – 2W)
Calculation sequence of technology sub-levers

1. **Technology share – ZEV [%]**
   This lever determines the share of Zero Emission Vehicles (either Battery Electric Vehicles or Fuel Cell Electric Vehicles) into the total vehicle fleet.

2. **Share of FCEV in ZEV [%]**
   This lever determines the share of Fuel Cell Electric Vehicles into the ZEV fleet.

3. **Technology share – LEV [%]**
   This lever determines the share of Low Emission Vehicles (mainly Plug-in Hybrid Electric Vehicles) into the remaining non-ZEV vehicle fleet.
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## Summary of ambition levels for passenger transport

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<tr>
<th>Lever</th>
<th>Curve shape</th>
<th>2015 situation for EU28</th>
<th>2050 ambition for EU28+CH</th>
<th>Sources</th>
</tr>
</thead>
</table>
| Passenger – transport demand                   | L           | 12000 pkm/capita for land transport  
2400 pkm/capita for aviation of which 1200 are intra-EU | Level 0: +24% for land transport  
+84% for aviation  
Level 2: +0% for land transport  
+0% for aviation  
Level 3: -17% for land transport  
-23% for aviation | Level 0 aligned with PRIMES REF16  
Level 3 considers demand decrease coherent with NegaWatt scenarios |
| Passenger – Modal share                         | L           | Car: 78%  
2W: 4%  
Bus: 9%  
Rail: 9%  
Level 0: Car: 61%  
2W: 3%  
Bus: 17%  
Rail: 19%  
Level 2: Car: 55%  
2W: 2%  
Bus: 25%  
Rail: 18%  
Level 3 | Level 0 aligned with PRIMES REF16  
Level 3 aligned with proximity mobility scenario of [V.Kaufmann & E.Ravalet, 2016] for France |
| Passenger - Occupancy                          | L           | Car: 1,6 p/v  
2W: 1,1 p/v  
Bus: 18,8 p/v  
Level 0: Car: 2,3 p/v  
2W: 1,1 p/v  
Bus: 24,4 p/v  
Level 2: Car: 2,6 p/v  
2W: 1,1 p/v  
Bus: 27,3 p/v  
Level 3 | Level 0 aligned with PRIMES REF16  
Level 3 for cars aligned with most optimistic scenario of [TRANSvisions, 2009] for urban transport. |
| Passenger – Utilization rate                   | L           | Car: 12000 vkm/v  
2W: 3200 vkm/v  
Bus: 42000 vkm/v  
Level 0: Car: -20%  
2W: -15%  
Bus: -22%  
Rail: -30%  
Rail: -30%  
Rail: -25%  
Real: -22%  
Level 2: Car: +400%  
2W: +10%  
Bus: +30%  
Level 3: Car: +900%  
2W: +15%  
Bus: +45%  | Level 3 for cars aligned with disruption scenario of [RethinkX, 2017] |
| Passenger – Energy efficiency (fleet average)  | L           | Car: 3 MJ/vkm  
2W: 17 MJ/vkm  
Bus: 0,3 MJ/kpm  
Air: 2 MJ/kpm  
Level 0: Car: -20%  
2W: -15%  
Bus: -22%  
Rail: -30%  
Real: -25%  
Real: -40%  
Real: -22%  
Level 2: Car: +400%  
2W: +10%  
Bus: +30%  
Level 3: Car: +900%  
2W: +15%  
Bus: +45%  | Level 0 aligned with Belgium Low carbon (Climact, 2013)  
Level 3 based on T&E, IEA, UIC, Sustainable aviation |
| Passenger – Technology share (in new sales for cars & buses, and in total fleet for trains & planes) | S           | Car: 3% LEV, 0,1% ZEV  
Bus: 0,5% LEV, 0,3% ZEV  
Train: 50% ZEV  
Air: 0% LEV + ZEV  
Level 0: Car: 8% LEV, 9% ZEV  
Bus: 0% LEV + ZEV  
Train: 50% ZEV  
Air: 0% LEV + ZEV  
Level 2: Car: 22% LEV, 69% ZEV  
Bus: 50% LEV + ZEV  
Train: 50% ZEV  
Air: 0% LEV + ZEV  
Level 3: Car: 100% ZEV  
Bus: 100% ZEV  
Train: 100% ZEV  | Level 3 for cars aligned with most optimistic scenario of Fueling Europe’s Future 2 |
| Passenger – Lifetime of vehicles               | L           | Car: 180000 km  
Bus: 400000 km  
Train: 30 years  
Air: 30 years  
Level 0: Car: +350%  
Bus: +20%  
Train: +20%  
Air: +20%  
Level 2: Car: +700%  
Bus: +30%  
Train: +30%  
Air: +30%  | Level 3 for cars aligned with disruption scenario of [RethinkX, 2017] |
| Passenger & Freight – Fuel mix                | L           | Biofuels: 5% of transport liquid or gas fuel demand  
E-fuels: 0% of transport liquid or gas fuel demand  
Level 0: Biofuels: 7% of transport liquid or gas fuel demand  
E-fuels: 0% of transport liquid or gas fuel demand  
Level 2: Biofuels: 65% of transport liquid or gas fuel demand  
E-fuels: 42% of transport liquid or gas fuel demand  
Level 3: Biofuels: 100% of transport liquid or gas fuel demand  
E-fuels: 60% of transport liquid or gas fuel demand | The transport sector defines a certain amount of biofuels demand which is either produced in the AFOLU Sector or imported |
Land transport demand: Ambition levels

Rationale for the levels:
- **Level 0**: Aligned with EURef 2016 scenario
- **Level 3**: based on the Négawatt scénario for France
Land transport demand: Ambition levels

Level 2 is ambitious but realistic:

- It is a status quo scenario and therefore does not require significant change compared to today
- In EU, those country already have lower demand per capita: NL, ES, BG, CZ, etc.

Level 3 requires some additional efforts and changes such as:

- Strong urban policy for “proximobility”
- Change in behaviour to switch to active modes (bike, walk)

But is still realistic:

- Some EU countries already have lower demand: SK, RO, PL, MT, LV, HR
Rationale for the levels:

- **Level 0**: Aligned with EURef 2016 scenario
- **Level 3**: based on the observation that the most rapid and efficient way to reduce aviation emissions is to change behaviors and significantly reduce aviation demand [Bows-Larkin, 2015]
Air transport demand: Ambition levels

Level 2 is ambitious but realistic:
- It is a status quo scenario and therefore does not require significant change compared to today

Level 3 requires some additional efforts and changes such as:
- Less long-range travels, and behaviour change on travelling
- More Video-conference for international meetings
- High carbon price on aviation
Modal share: Ambition levels

Rationale for the levels:

- **Level 0**: Aligned with EURef 2016 scenario
- **Level 3**: Based on the Proximobility scenario of [V. Kaufmann & E. Ravalet, 2016] for France

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2050 - Level 0</th>
<th>2050 - Level 2</th>
<th>2050 - Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>78%</td>
<td>75%</td>
<td>61%</td>
<td>55%</td>
</tr>
<tr>
<td>2W</td>
<td>9%</td>
<td>9%</td>
<td>12%</td>
<td>17%</td>
</tr>
<tr>
<td>Bus</td>
<td>9%</td>
<td>4%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Rail</td>
<td>9%</td>
<td>12%</td>
<td>19%</td>
<td>18%</td>
</tr>
</tbody>
</table>

18.5% for trains, 7.5% for metro & tram

*Rail = metro & tram + train
Modal share: Ambition levels

Level 2 is ambitious but realistic:
- Some countries already reach a 15% bus share in 2015 (BG, CZ, SK) or even more
- Train share already reaches 17% in 2015 in Switzerland and Japan
- Metro + tram share already reaches more than 5% in some EU countries in 2015 (CZ, AT, RO)

Level 3 requires some additional efforts and changes, in line with the [V.Kaufmann & E.Ravalet, 2016] proximobility scenario for France:
- Strong urban planning policies**
- Decrease in long-range transport demand
- Shift to TGV “because of the quality of the time” it allows

** “In territorial terms, this scenario is characterized by the development of concentrated decentralization. Suburban areas will be less dispersed and reach critical mass in terms of population.”

<table>
<thead>
<tr>
<th>Year</th>
<th>Car 2015</th>
<th>Rail 2015</th>
<th>2W 2015</th>
<th>Bus 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>78%</td>
<td>9%</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>2050 - Level 0</td>
<td>75%</td>
<td>12%</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>2050 - Level 2</td>
<td>61%</td>
<td>19%</td>
<td>3%</td>
<td>17%</td>
</tr>
<tr>
<td>2050 - Level 3</td>
<td>55%</td>
<td>18%</td>
<td>2%</td>
<td>25%</td>
</tr>
</tbody>
</table>
Technology share: Ambition levels

Rationale for the levels:

- **Level 0**: Aligned with EURref 2016 scenario
- **Level 3**: Aligned on Fuelling’s Europe Future 2 most optimistic scenario for new car sales
Technology share: Ambition levels for cars

Example of national/local objectives for LDVs [SLoCaT, 2018]:

- Norway: after 2025, all new LDV should be ZEV
- The Netherlands: ban new petrol & diesel cars by 2030
- Germany: only ZEV LDVs will be approved for use in 2030

Manufacturers objectives:

- Volvo: by 2020, 10% of EV
- Honda: by 2030, 2/3 of new sales are EV (PHEV, BEV, etc.)
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  **Freight transport**
  Other assumptions
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## Summary of ambition levels for freight

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<th>Curve shape</th>
<th>2015 situation for EU28</th>
<th>2050 ambition for EU28+CH</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight – transport demand</td>
<td>L</td>
<td>3400 Btkm/year</td>
<td>Level 0: +1,16%/year</td>
<td>Level 0: aligned on PRIMES REF16 Level 3: NegaWatt scenarios</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Level 2: +0%/year</td>
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<td></td>
<td></td>
<td></td>
<td>Level 3: -0,7%/year</td>
<td></td>
</tr>
<tr>
<td>Freight – Modal share</td>
<td>L</td>
<td>Road: 50%</td>
<td>Road: Road: 51%</td>
<td>Level 0 aligned with PRIMES REF16 Level 3 aligned with EC White paper modal shift ambition Level 3 based on NégaWatt scenarios</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rail: 11%</td>
<td>Rail: 11%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>IWW: 4,9%</td>
<td>IWW: 4,9%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Sea: 33%</td>
<td>Sea: 33%</td>
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<tr>
<td></td>
<td></td>
<td>Air: 0,1%</td>
<td>Air: 0,1%</td>
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<td>Road: 41%</td>
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<td></td>
<td>Rail: 20,4%</td>
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<td></td>
<td>IWW: 4,4%</td>
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<td></td>
<td>Sea: 34,4%</td>
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<td></td>
<td>Air: 0,1%</td>
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<td></td>
<td></td>
<td></td>
<td>Road: 35%</td>
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<td></td>
<td>Rail: 23%</td>
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<td></td>
<td>IWW: 4,9%</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Sea: 37%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Air: 0,1%</td>
<td></td>
</tr>
<tr>
<td>Freight – Load factor</td>
<td>L</td>
<td>Road: 10,8 tkm/vkm</td>
<td>Road: Status quo compared to 2015</td>
<td>Level 2: T&amp;E estimate Level 3: IEA estimate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Road: +10%</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Road: +15%</td>
<td></td>
</tr>
<tr>
<td>Freight – Utilization rate</td>
<td>L</td>
<td>Road: 68500 vkm/year</td>
<td>Status quo compared to 2015</td>
<td>Climact work in the context of the EU Calculator</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Road: +7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Road: +10%</td>
<td></td>
</tr>
<tr>
<td>Freight – Energy efficiency (fleet average)</td>
<td>L</td>
<td>Light truck: 3MJ/km</td>
<td>Truck: -10%</td>
<td>Level 0 aligned with Belgium Low carbon (Climact, 2013) Level 3 based on T&amp;E, IEA, UIC, Sustainable aviation, DNV-GL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium truck: 6 MJ/vkm</td>
<td>Boat: -5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heavy truck: 12 MJ/vkm</td>
<td>Road: -10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boat: 0,3 MJ/tkm</td>
<td>Air: -20%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rail: 0,15 MJ/tkm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air: 20 MJ/tkm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight – Technology share (in new sales for trucks, and in total fleet for boats &amp; planes)</td>
<td>S</td>
<td>Truck: 0,04% LEV, 0,3% ZEV</td>
<td>Truck: 26% LEV+ZEV</td>
<td>Level 3: T&amp;E reports, DNV-GL for boats and expert interviews</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boat: 0% LEV + ZEV</td>
<td>Boat: 0% LEV+ZEV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air: 0% LEV + ZEV</td>
<td>Air: 0% LEV+ZEV</td>
<td></td>
</tr>
<tr>
<td>Freight – Lifetime of vehicles</td>
<td>L</td>
<td>Truck: 400000km</td>
<td>Status quo compared to 2015</td>
<td>Climact work in the context of the EU Calculator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boat, train, aircraft: 25 years</td>
<td>All vehicles: +20%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>All vehicles: +30%</td>
<td></td>
</tr>
</tbody>
</table>
Content

Project context
Modelling approach
Priorization of levers

Ambition levels & main assumptions
  Passenger transport
  Freight transport
  Other assumptions

Bibliography
Aviation – Direct emissions mitigation logic & ambition levels

**Passenger aviation:**
Situation in 2015: 2380 km/capita (50% intra-EU, 50% extra-EU)
2050, Level 0: +1.8% every year (same proportion of intra/extra EU than in 2015)
2050, Level 3: -0.9% every year (same proportion of intra/extra EU than in 2015)

**Freight aviation:**
0.1% of intra-EU freight modal share (constant for all scenarios)
Extra-EU freight aviation represents 94% of freight aviation demand

1. **Aviation demand** [pkm] & [tkm]
   - Situation in 2015: 2 MJ/pkm & 19 MJ/tkm
   - 2050, Level 0: 20% improvement compared to 2015
   - 2050, Level 3: 40% improvement compared to 2015

3. **Electrification** [% of short hauls]
   - Situation in 2015: 0%
   - 2050, Level 0: 0% electrification
   - 2050, Level 3: 10% of all intra-EU flight

4. **Biofuels** [% kerozene]
   - Situation in 2015: 0%
   - 2050, Level 0: 0% of bio-kerozene
   - 2050, Level 3: 100% of bio-kerozene

5. **E-fuels** [% of “non-bio”kerozene]
   - Situation in 2015: 0%
   - 2050, Level 0: 0% e-kerozene
   - 2050, Level 3: 100% e-fuels in “non-bio”kerozene

**This includes technical/design (e.g. Light-weight materials, aerodynamics, etc.) & operational improvement (e.g. shorter routes, bigger planes)**

Starting year: 2040 or after because of R&D process

Starting year: 2030 or after because of long fuel registration process
Navigation– Direct emissions mitigation logic & ambition levels

**Passenger navigation:**
Inland Waterways passenger navigation is kept constant at 2010 level: 40 [Bpkm]

**Freight navigation:**
Situation in 2015: 38% of EU freight modal share
2050, Level 0: 38% of EU freight modal share
2050, Level 3: 42% of EU freight modal share

**Navigation demand**
[pkm] & [tkm]

2 **Energy efficiency**
Situation in 2015: 0,45 MJ/tkm for IWW* & 0,23 MJ/tkm for maritime
2050, Level 0: 5% improvement compared to 2015
2050, Level 3: 40% improvement compared to 2015

3 **Electrification**
[%,] Situation in 2015: 0%
2050, Level 0: 0% electrification
2050, Level 3: 30% of all SSS* and 15% of all LSS*

4 **Biofuels**
[%, navigation gasoline]
Situation in 2015: 0%
2050, Level 0: 0% of navigation gasoline
2050, Level 3: 100% of navigation gasoline

5 **E-fuels**
[%, of “non-bio” navigation gasoline]
Situation in 2015: 0%
2050, Level 0: 0% of navigation gasoline
2050, Level 3: 100% efuels in non-bio navigation gasoline

This includes technical/design & operational improvement

IWW: Inland Waterway ; SSS: Short Sea Shipping ; LSS: Long Sea Shipping
## Decarbonizing freight shipping

<table>
<thead>
<tr>
<th>Type of measures</th>
<th>Main measures</th>
<th>Decarbonization potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technological</td>
<td>Light materials</td>
<td>0-10% fuel saving</td>
</tr>
<tr>
<td></td>
<td>slender design</td>
<td>10-15% fuel saving</td>
</tr>
<tr>
<td></td>
<td>less friction</td>
<td>1-25% fuel saving</td>
</tr>
<tr>
<td></td>
<td>waste heat recovery</td>
<td>0-4% fuel saving</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>4-15% fuel saving</td>
</tr>
<tr>
<td>Operational</td>
<td>Lower speed</td>
<td>0-60% CO2 emissions reduction potential</td>
</tr>
<tr>
<td></td>
<td>ship size</td>
<td>0-30% CO2 emissions reduction potential</td>
</tr>
<tr>
<td></td>
<td>ship-port interface</td>
<td>1% CO2 emissions reduction potential</td>
</tr>
<tr>
<td>Alternative fuels/energy</td>
<td>Sustainable biofuels, hydrogen, ammonia, electric ships, wind assistance</td>
<td>0 – 100% CO2 emissions reduction potential</td>
</tr>
</tbody>
</table>

Comment: Those potentials can’t be added without considering the interactions between measures

## Infrastructure assumptions

<table>
<thead>
<tr>
<th>Infrastructure development</th>
<th>Unit</th>
<th>Source</th>
<th>#/1000 veh</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDV - Number of private charging stations per BEV (residential or at workplace)</td>
<td>#/1000 veh</td>
<td>Fuelling Europes Future 2</td>
<td>1000</td>
</tr>
<tr>
<td>LDV - Number of public charging stations per BEV (in parkings)</td>
<td>#/1000 veh</td>
<td>Fuelling Europes Future 2</td>
<td>200</td>
</tr>
<tr>
<td>LDV - Number of fast charging stations per BEV</td>
<td>#/1000 veh</td>
<td>Fuelling Europes Future 2</td>
<td>3</td>
</tr>
<tr>
<td>LDV - Number of FCEV charging stations per FCEV</td>
<td>#/1000 veh</td>
<td>Fuelling Europes Future 2</td>
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</tr>
<tr>
<td>HDV - Number of fast charging stations per BEV</td>
<td>#/1000 veh</td>
<td>Fuelling Europes Future 2</td>
<td>17</td>
</tr>
<tr>
<td>HDV - Number of depot station per BEV</td>
<td>#/1000 veh</td>
<td>Fuelling Europes Future 2</td>
<td>1000</td>
</tr>
<tr>
<td>HDV - Number of FCEV charging stations per FCEV</td>
<td>#/1000 veh</td>
<td>Fuelling Europes Future 2</td>
<td>2</td>
</tr>
<tr>
<td>HDV - km of e-highways per PH-ERS trucks</td>
<td># km/1000 veh</td>
<td>Fuelling Europes Future 2</td>
<td>3</td>
</tr>
</tbody>
</table>
Content

- Project context
- Modelling approach
- Priorization of levers
- Ambition levels & main assumptions

Bibliography
Bibliography

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