TECHNOLOGICAL SCENARIOS FOR THE DECARBONIZATION OF ROAD TRANSPORT

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ERTRAC
(European Road Transport Research Advisory Council)
ERTRAC CO₂ STUDY

Decarbonisation is one of the main challenges for road transport. The objective, based on the EU Transport White Paper, is: by 2050, the overall CO₂ (tank-to-wheel, TTW) emissions should be reduced by more than 60%, based on 1990 emissions. But within a context of significantly increasing transport needs and road traffic. Therefore, this ambitious target can only be reached by using all reduction opportunities in the transport system: more efficient vehicles, better traffic conditions and technologies to reduce traffic.

In its CO₂ study, ERTRAC collected all technologies that could be relevant by 2050 and did an experts assessment of the CO₂ saving potentials (TTW), for the different types of vehicles in different use-cases (urban, rural and highway). Note: the study focused only on CO₂ emission reduction and the social and economic effects were not addressed. Using the experts assessment, which includes a range with pessimistic and optimistic values, and applying several scenarios for the market deployment of the different vehicles powertrain technologies, the EU Joint Research Centre JRC made calculations of the CO₂ effect on the overall European fleet under real world driving conditions (TTW).

The database of the CO₂ measures and the calculation results are available in the study, published at the TRA 2018 Conference. All scenarios show clearly that electrification is the main leverage to reduce CO₂ (TTW), and only the fleet mix scenarios with high level of electrified vehicles show a chance to reach the policy objective. This means that an ambition innovation program is needed to support electromobility to improve from today technological level into a stage where all the customer needs are met e.g. range, charging, costs.

Another important message from the study is that even within the highly electrified scenarios, there will still be a significant need for chemical energy carriers, especially for long distance trips and heavy duty transport. Because the usage of these vehicles require much more energy than electric vehicles in urban use, even in highly electrified scenarios we will still face that around 50% of the overall energy need from road transport rely on chemical energy carriers.

Therefore, Europe needs to strengthen its activities in producing renewable energies: not only electricity but also renewable fuels like synthetic fuels, sustainable biofuels or hydrogen. Knowing that the production of renewable fuels in the quantities required will be challenging, considering also the needs from other transport modes and sectors, a further improvement of the combustion engines and of the road traffic conditions are key issues to be addressed by the European Research and Innovation policy.
There is a need to significantly reduce transport CO₂ whilst demand is projected to increase.

To reach the overall European CO₂ targets for transport, a system approach is needed.
**KEY QUESTIONS**

1. Which technologies can support the **decarbonisation** (TTW)?
2. How large is the **specific effect**?
3. What could be the **fleet impact on CO₂**?
4. **How much energy** and which **energy** is still needed for road transport: **electricity**? **alternative fuels** (Btx, Ptx, H₂)?
5. What are the **research needs**?

[How much energy](out of ERTRAC scope): Are we able to produce this energy in a **renewable** or CO₂ **neutral way**?

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**Agreements ERTRAC CO₂ Evaluation Group**

- **Only technical measures** are addressed
- **Fleet calculation** is done by simulation tool “**DIONE**” by JRC
- **Effects** are based on **reduction factors** (WLTP, RDE etc.)
- **Ranges** (optimistic and pessimistic approach)
- **3 main types of measures**:
  - **Type A**: “**better vehicle**” (powertrain, aerodynamics, weight,...)
  - **Type B**: “**better traffic conditions**” ("green traffic light,...)
  - **Type C**: “**traffic reduction technologies**” (load optimization,...)
CO2-MEASURE SHEET

- Expert assessment for the specific potential of each measure.
- Optimistic / pessimistic range for all measures.
- Three areas: Urban, rural and highway.
- Efficiency potential depending on categories:
  - Two-wheelers and small/medium size cars
  - Large cars, SUV's and light commercial vehicles
  - Medium Duty Trucks and City Busses
  - Heavy Duty Trucks and Coaches

Projected Fleet Composition in 2050

Fleet mix similar to today (DIONE Baseline)

Passenger Cars are dominating the fleet 2050
Powertrain Scenarios 2050

General assumptions for all scenarios:

- **100% zero emission (TTW) in urban areas** (“White Paper Transport, EU”)
  
  2Wheelers, Passenger Cars, Commercial Vehicles and Buses:
  
  ➔ BEV, PHEV (e-mode) or FCEV

- **Architectures for HDT Long Haul:**
  
  ➔ Advanced ICE, PHEV and/or FCEV

- **3 different scenarios:**
  
  Highly Electrified (HE)
  Highly Electrified incl. Hydrogen (HE-H)
  Partly electrified (PE)

- **1 Additional scenario** (not in line with “White Paper Transport, EU”)
  
  Low emission ICES still allowed in urban areas: Mixed scenario (MIX)

Projected Fleet Activity by Vehicles 2050

(Vehicle km, DIONE Baseline)

- Rising activity with rising vehicle size
Powertrain Scenarios 2050 (stock): 4 Scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Small and Medium Car, 2W</th>
<th>Large Car, SUV</th>
<th>LCV, Delivery Van</th>
<th>City Bus</th>
<th>Medium Duty Truck</th>
<th>HDV, Coach</th>
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<tbody>
<tr>
<td>DSL MHEV</td>
<td>0/0/0/50%</td>
<td></td>
<td></td>
<td>0/0/0/15%</td>
<td>40/40/60/60%</td>
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<tr>
<td>GSL MHEV</td>
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<tr>
<td>DSL PHEV</td>
<td>40/20/60/60%</td>
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<td>60/30/70/70%</td>
<td>40/20/20/20%</td>
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<tr>
<td>BEV</td>
<td>100/100/75%/37.5%</td>
<td>50/50/40/20%</td>
<td>60/40/40/20%</td>
<td>100/50/100/50%</td>
<td>40/40/30/15%</td>
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<tr>
<td>FCEV</td>
<td>0 / 25/ 0 / 0%</td>
<td>0 / 40/ 0 / 0%</td>
<td>0 / 50/ 0 / 0%</td>
<td>0 /30/ 0 / 0%</td>
<td>0 /30/ 0 / 0%</td>
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<tr>
<td>CNG/LNG</td>
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<td>20/10/20/20%</td>
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Powertrain Scenarios 2050 (stock): Highly Electrified Scenario (HE)

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<thead>
<tr>
<th>Scenario</th>
<th>Small / med. PC 2 wheeler</th>
<th>Large PC / Large SUV</th>
<th>LCV / Delivery Van</th>
<th>City Bus</th>
<th>Medium Duty Truck</th>
<th>Heavy Duty Truck Coach</th>
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<tr>
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<td>BEV 100%</td>
<td>PHEV 50%</td>
<td>PHEV 40%</td>
<td>BEV 100%</td>
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30th International AVL Conference “Engine & Environment”, June 7th - 8th, 2018, Graz, Austria
Powertrain Scenarios 2050 (stock):
Highly Electrified Scenario incl. Hydrogen (HE-H)

Powertrain Scenarios 2050 (stock):
Partly Electrified Scenario (PE)
Powertrain Scenarios 2050 (stock): Mixed Scenario (MIX)

2050 Fleet Activity by Powertrain

* Remark PHEV: First 50 km of driving-cycle always in electric mode
Conclusions:
1. The change of the fleet mix has the most important effect.
   
   Remark: R&I is needed to develop the functionality of electrified vehicles and to create customer acceptance (Range, Charging, Costs, ...)

2. The partial electrified and mixed scenario without further efficiency measures will not achieve the CO2-Targets.

Conclusion:
1. In combination with all efficiency measures also scenarios with lower electrification can achieve the CO2-reduction.

   Remark: economical/societal impact is not considered!

2. With lower electrification the influence of efficiency measures is more important.

3. The “Mix Scenario” only offers a critical chance to achieve the CO2 targets (TTW)

4. With lower electrification or lower system efficiency the need for decarbonized fuels is becoming more important (Well to wheel, WTW)
We are able to reduce the TTW CO₂ emissions in the order of 60% vs. 1990 baseline. (Social or economical impact not considered!)

Huge investment in R&I is needed to improve the functionality of e-mobility! (costs, range, charging, ...)

Electricity has to become zero carbon!

Fossil transport fuels have to be replaced by renewable PtX, Biofuels or Hydrogen!

Are we able to produce these energy carriers in a renewable way?

Conclusion:

1. Even in scenarios with high electrification more than ~ 50% of total energy demand is for chemical energy carrier (Fuels, Gas, Hydrogen).
2. Improvement of combustion engine efficiency is important even in highly electrified scenarios.

Question (out of ERTRAC scope):
“Are we able to produce these energy carriers in a renewable way?”

MAIN OUTCOME 2050:

If we put together all technical measures ... (fleet + efficiency)

For the electrification of the fleet ...

Well to Wheel:

With - lower electrification - lower efficiency improvements

We are able to reduce the TTW CO₂ emissions in the order of 60% vs. 1990 baseline. (Social or economical impact not considered!)

Huge investment in R&I is needed to improve the functionality of e-mobility! (costs, range, charging, ...)

Electricity has to become zero carbon!

Fossil transport fuels have to be replaced by renewable PtX, Biofuels or Hydrogen!

“Are we able to produce these energy carriers in a renewable way?”
ERTRAC CO2 Evaluation Group*

* Each Member of ERTRAC Executive Group nominated specific experts

<table>
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<tr>
<th>Category</th>
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<td>Volkswagen (cars)</td>
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<td>Staffan Lundgren</td>
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<td>BMW</td>
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<td>CO2 assessment for the fleet</td>
<td>Christian Thiel</td>
<td>JRC</td>
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