Carbon-neutral EU Road Transport 2050

Some insights from a well-to-wheels perspective

Zissis Samaras, Aristotle University, Greece

ERTRAC Annual Conference 2021:
Road Transport research challenges within Horizon Europe - July 2021
ERTRAC CO₂ Evaluation Group

Zissis Samaras
Aristotle University
Academia

Marko Gernuks
Volkswagen(cars)
OEM

Staffan Lundgren
Volvo (trucks)
OEM

Gaetano de-Paola
IFPEN
Cities and Regions

Christophe Petitjean
Valeo
Supplier

Holger Heinfelder
Umweltbundesamt (AT)
Member States

Peter Prenninger
AVL
Research Provider

Stephan Neugebauer
BMW
Chair

Georgios Fontaras
JRC
CO₂ assessment for the fleet

Jette Krause
JRC
CO₂ assessment for the fleet

Marta Yugo
Concave
Energy / CO₂ assessment for the WTT / fuel scenarios

Roland Dauphin
Concave
Energy / CO₂ assessment for the WTT / fuel scenarios

Simon Edwards
Ricardo
Research Provider
European CO₂ targets for transport

To reach the overall European CO₂ targets for transport, a system approach is needed addressing: Vehicle technologies, Traffic modalities, Infrastructure, Energy production.
INITIAL QUESTIONS

1. Which technologies can support net carbon-neutrality in road transport?
2. How large is their specific effect?
3. What could be the fleet and fuel impact?
4. How much energy and which energy is needed for road transport? (electricity? hydrogen? synthetic fuels?)
5. Which energy paths do we have and how much electricity is needed to produce the different energy carriers?
Concept of the study

3 Powertrain Scenarios
Which powertrains could be used in 2050?

Optimistic – Pessimistic ranges
Which efficiency improvements are possible by 2050?

2 Electricity Scenarios:
What will be the CO₂-footprint of electricity production in 2050?
100% Renewable (RES) & 1.5 Tech

4 Fuel Scenarios:
Which fuel production paths could be used in 2050?
Biofuels, e-fuels, Mixed fuels and Limited fossil
Energy flows (Well-To-Wheels)
The concept of total Primary Energy consumption

Well-to-Tank (WTT) reflects the energy expended to produce 1 MJ final “fuel” (biofuel, e-fuel, electricity or H₂) at the point of consumption (pump at the filling station or charging point).

Tank-To-Wheels (TTW) reflects the energy use (only part of the energy in the fuel is used to move the wheels, depending on the efficiency of the powertrain).
**CO₂-Measure sheet of the different type of technical improvements**

- **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 vehicles categories**:
  - Two-wheelers and small/medium size cars
  - Large cars, SUV’s and light commercial vehicles
  - Medium Duty Trucks and City Buses
  - Heavy Duty Trucks and Coaches
3 different powertrain scenarios analysed (corner-points):

- Highly Electrified incl. Electrified Road Systems (HE-ERS)
- Highly Electrified incl. Hydrogen (HE-H)
- Hybrids Scenario (Hyb)
Comparison of different fuel “family” shares being used in the different fuel scenarios (corner-points).

Fuel scenarios have been drafted independently from the powertrains scenarios.

The interactions between these two scenarios are detailed in the WtW study.

Note: (BE)CCS refers to biofuel production routes coupled with CCS (allowing negative emissions)

<table>
<thead>
<tr>
<th>Fuel Scenario</th>
<th>Biofuel/waste</th>
<th>efuel</th>
<th>Fossil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced biofuels</td>
<td>90%</td>
<td>10%</td>
<td>-</td>
</tr>
<tr>
<td>Mixed</td>
<td>50%</td>
<td>50%</td>
<td>-</td>
</tr>
<tr>
<td>efuels</td>
<td>-</td>
<td>100%</td>
<td>-</td>
</tr>
<tr>
<td>Limited fossil</td>
<td>80%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Note: (BE)CCS refers to biofuel production routes coupled with CCS (allowing negative emissions)

- Basis: JEC WTT v5 – 2030 extended towards 2050
- Drop-in fuels compatible with existing powertrains
Results Fleet & Energy scenarios

Well-To-Tank (WTT) → Tank-To-Wheels (TTW)

Biomass / Waste → Electricity Generation
Wind / Solar / Other RES → Electricity Distribution system (grid)

Electricity Generation
2050 EU MIX

Fossil resources

Electricity to vehicle → E-fuel for transport
H₂ for transport
Fossil fuel for transport

CO₂ capture → E-fuel production

Advanced Biofuel production → Ad. Biofuels in transport
CO₂ Compensation / Negative emissions (E.g. BECCS)

Vehicle (TTW – Use)

Net Carbon-neutral Mobility

Remaining CO₂eq (Fossil)
Question 1: How much fuel, hydrogen, or electricity could be required (use) in EU Road Transport by 2050? (TtW, TWh).
Question 1: How much fuel/hydrogen/electricity could be required (use) in EU Road Transport by 2050? (TtW, TWh).

Significant reduction of fleet-average TTW Energy Consumption:
The total TTW energy consumption could range between ~730 and 1900 TWh. A significant reduction is shown in all scenarios considered (20% to 70% savings) in total energy requirement versus 2015.

As a reference, 290 Mtoe consumed in the EU road transp. 2015 <> 2400 TWh.

Fuel: Significant reduction compared to EU road transport sector in 2015.
In the highly electrified scenarios the savings in fuel consumption are up to 95%.
The highest use of fuel (Hybrids-Scenario) varies between 940 and 1510 TWh → 40% to 60% savings

Hydrogen: The use of Hydrogen ranges between 520 and 780 TWh (Highly electrified with H2 scenario).

Electricity: Road Vehicles consume directly up to 20% of total 2015 electricity consumption.
The use of electricity ranges from ~260 up to 1000 TWh (the latter in the highest electrified scenario (HE + ERS scenario) which represents ~20% of total EU-wide electricity consumption in 2015).

Efficiency is paramount (Delta “Optimistic-Pessimistic”)
Technical measures (A,B and C) targeting efficiency improvement

• Vehicle
• Traffic condition
• System improvements

Potential to reduce the energy consumption by ~35-40%, showing the importance of boosting R&D in these areas.
Question 4: How much electricity is needed in the scenarios overall?
Results Fleet & Energy scenarios

Question 4:
How much electricity is needed in the scenarios overall?

The total electricity generated responds to the needs for electricity in the fuel production (WTT) as well as the final use in the directly electrified powertrains (BEVs) or indirectly electrified (ICE with e-fuels / FCHEV with green H2).

Wide variation in total electricity request: Range between 600 TWh up to 4400 TWh (representing from ~20% up to ~140% of total EU-28 electricity consumption in 2019 (3220 TWh).

The limited fossil and advanced biofuel scenario result in the lowest electricity needs (between ~20% to 30% of EU-28 el. Cons. 2019).

The absolute extreme values for electricity request are always linked with the Hybrid Fleet: In combination with e-Fuels the absolute maximum is reached, in combination with “adv. biofuels” or “limited fossil” the absolute minimum is reached.

In the highly electrified scenarios, the electricity demand is towards the lower-end of the different explored scenarios (~35% to 50% of EU28 el. Cons. 2019).

The differences between the electricity scenarios (RES and 1.5TECH) are pretty small.
Results Fleet & Energy scenarios

Question 2: How much energy could be required to reach a net CO$_2$eq neutral road transport in Europe? (WtW, TWh)

What leverage have the different scenarios?
Results Fleet & Energy scenarios

**Question 2:**
How much energy could be required to reach a net CO$_2$eq neutral road transport in Europe? What leverage have the different scenarios? (WtW, TWh, CO$_2$ neutral)

The variation in the WTW Energy demand between

- the fleet scenarios is up to ~3000 TWh
- the optimistic–pessimistic case is up to ~1500 TWh
- the fuel scenarios is about ~1000 TWh
- electricity production scenarios up to ~250 TWh

The share of TTW in the whole WTW energy consumption varies between ~50% up to 90%, increasing with the level of fleet electrification.

---

**DISCLAIMER**

ERTRAC 2050 CO$_2$-Study

**RESULTS**

→ E-Fuels production without 100% renewable electricity is not a reasonable scenario!

→ We mainly focus on the 100% renewable electricity scenario (RES), combined with all fleet and fuel scenarios.
Summary

- The overall **WtW energy demand decreases drastically with fleet electrification**

- The **demand for fuels decreases significantly in all scenarios** (in highly electrified scenarios up to 95%).

- The **energy efficiency measures reduce the energy / fuel consumption in all scenarios in a very significant way**.

- The total **demand for electricity** in road transport will **increase** (energy production + use in vehicle)
  - 20%-30% of total EU28 el. cons. 2019 in advanced biofuels or limited fossil scenarios combined with hybrid fleet.
  - 35%-50% of total EU28 el. cons. 2019 in highly electrified scenarios
  - up to 1.4 times the total EU28 el. cons. 2019 if e-fuels are used along with a hybrid fleet

- The largely **Carbon-Neutral production of electricity** is a prerequisite for “carbon-neutral” road transport in all fleet and fuel scenarios.
Some thoughts

➤ We need a "level playing field" for the assessment of the societal benefit (and impact) of every powertrain technology: i.e. for understood, agreed, comprehensive, perhaps standardised LCA.

➤ More stringent air pollutant emissions standards for combustion-engine vehicles (EURO 7) to keep the IC(of nett-zero efuels)

➤ The digital, virtual world of development presents opportunities to achieve both the transition towards ZeroX road transport and the better refined assessment of the impact.
The ERTRAC Carbon neutrality Study 2050 (WTW) analyses different “extreme” scenarios and compares effects. It does not aim at giving a projection or at describing the way to achieve a carbon neutral road transport.

The study only reflects the views of the contributing authors and is not an official European Commission position.

Results:

- This study explored different corner scenarios based on a static fuel and fleet modelling exercise.
- The analysis does not include dynamic modelling or prediction; the results of the analysis should be considered as estimates for comparative purposes.
- The analysis does not draw conclusions on fuel and electricity availability, competition with other sectors demand, economics, societal acceptance ...
Thank you!