ASSESSMENTS IN SUPPORT OF THE DUTCH POSITION ON HDV CO_2 LEGISLATION

Authors: Maarten Verbeek, Stephan van Zyl, Emiel van Eijk, Robin Vermeulen, René van Gijlswijk, Hilde Huismans, Richard Smokers

Client: Dutch Ministry of Infrastructure and Water management

Richard Smokers

richard.smokers@tno.nl

www.tno.nl

Issues:

- Reduction potential in ICEVs
- Required reduction at HDV fleet level
- Potential for ZE HDVs
- Considerations on modalities

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CO_2 REDUCING TECHNOLOGIES

Engine
Improved turbocharging and EGR
Friction reduction + improved water and oil pumps
Improved lubricants
Waste heat recovery
Downspeeding (combined with DCT optimization)
10% Engine downsizing

Transmission
Reduced losses (lubricants, design)
Transition from manual to AMT

Aerodynamics
Roof spoiler plus side flaps
Side and underbody panel at truck chassis
Aerodynamic mud flaps
Rear/side view cameras instead of mirrors
Redesign, longer and rounded vehicle front
Side and underbody panels at trailer chassis
Boat tail short, additional

Tyres
Low rolling resistance tyres on truck/tractor
Low rolling resistance tyres on truck/tractor + trailer
Tyre pressure monitoring system (TPMS) on truck
Tyre pressure monitoring system (TPMS) on truck and trailer
Automated tyre inflation system (ATIS) on truck
Automated tyre inflation system (ATIS) on truck and trailer
Wide base single tyres

Auxiliaries
Electric hydraulic power steering
LED lighting
Air compressor
Cooling fan

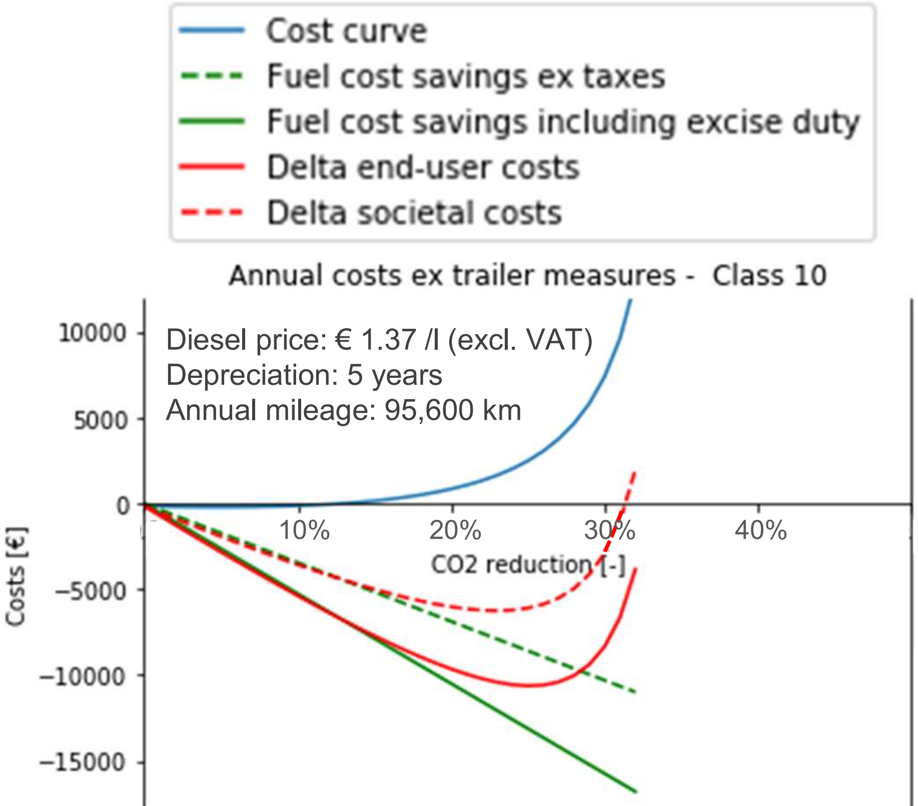
Mass
5% Mass reduction (truck/tractor)
10% Mass reduction (truck/tractor)

Hybridisation
48V system with starter/generator
Full electric hybrid

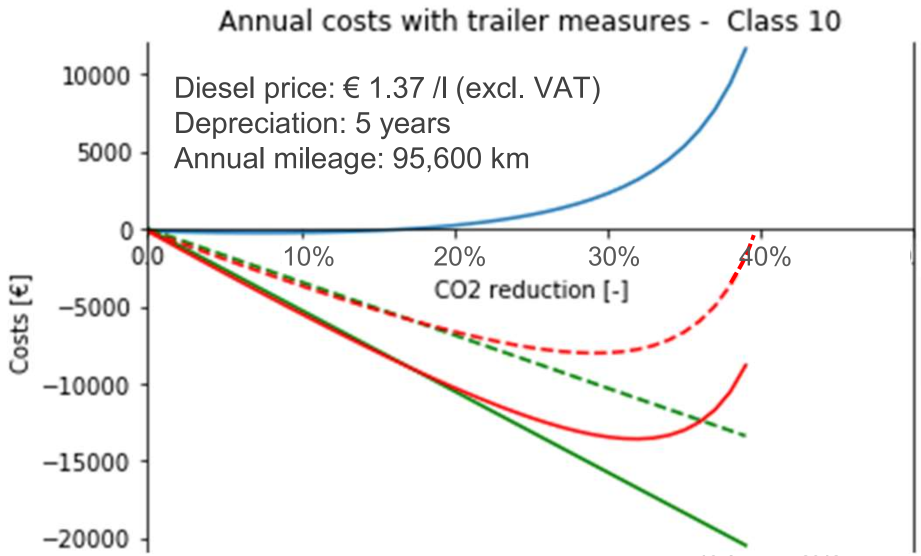
Trailer-related measures

COST-EFFECTIVE CO_2 REDUCTION POTENTIAL UP TO 30 - 40%

- Fuel cost savings exceed additional vehicle costs
- 30% reduction potential available from vehicle-related measures
- About 10% additional potential from measures related to build-up / trailers



- **source cost curves: TNO in-house assessment**
  - expected costs in 2030
  - **annuity** with 4% discount rate
- diesel price based on EU reference scenario

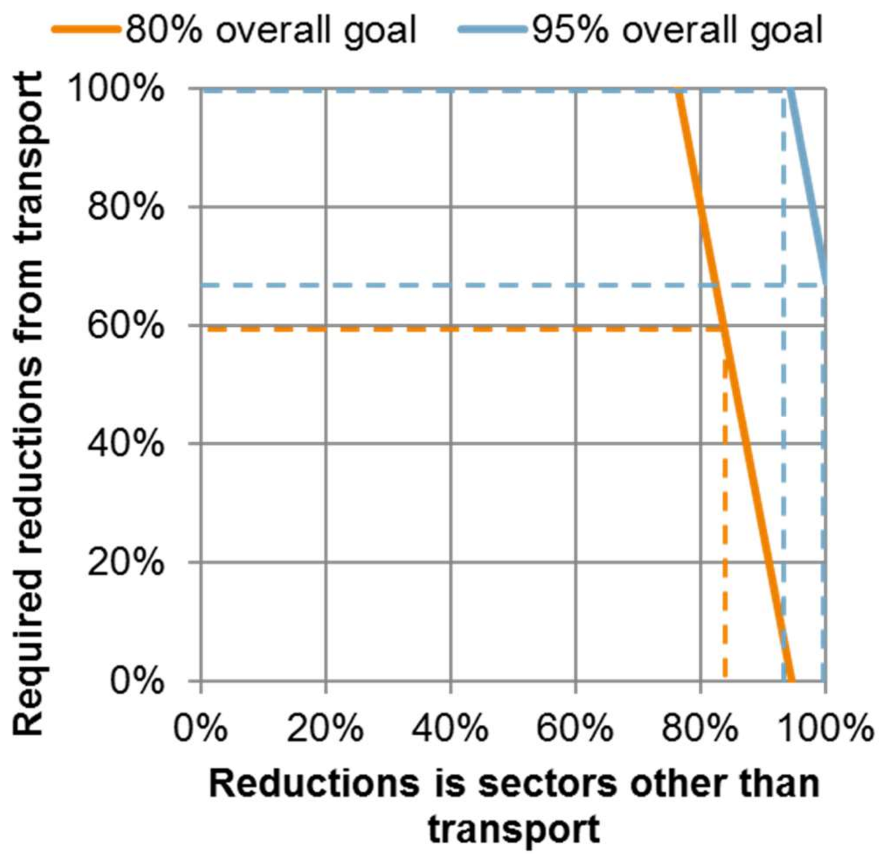


COP21 1.5 ˚C GOAL LIMITS ROOM FOR BURDEN SHARING BETWEEN SECTORS

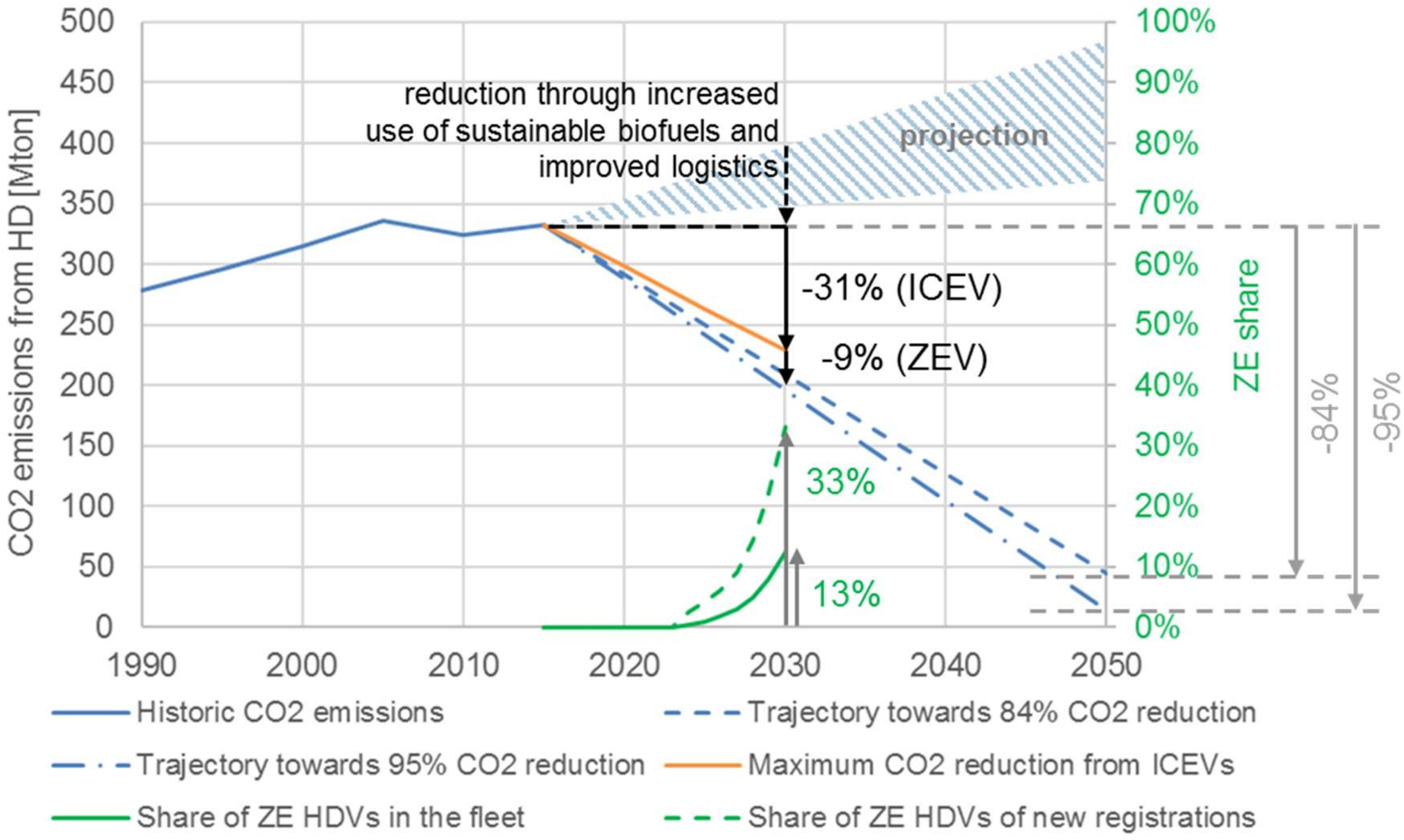
- 1.5 ˚C goal of COP21 Paris agreement requires overall GHG emission reduction of 95% compared to 1990 for Western countries

- Bandwidth for transport sector goal:
  - 67% - if other sectors reduce 100%
  - 100% - if other sectors reduce 94%

- To increase certainty of meeting the target all sectors should strive for 95%



BY 2030 FULL POTENTIAL OF ICEVs + ADDITIONAL SHARE OF ZE HDVs NEEDED



Assuming aviation and shipping also reduce 95%...

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FEASIBILITY OF LARGE SHARE OF ZE HDVs DEPENDS ON LOT OF FACTORS

SUPPLY

DEMAND

- Technology readiness
- Availability of attractive products
- Cost competitiveness
  - battery price development
  - price of diesel and electricity (incl. cost of (fast) chargers)
- Availability of charging infrastructure => EU AFID + national measures
- Sustainability strategies of logistics sector
- Effective policies applying to both truck manufacturers and end users
  - Stringent CO_2 target
  - ZEV requirements
  - National and municipal policies
    - Urban access restrictions: e.g. Dutch Green Deal Zero Emission City Logistics

THERE'S A LOT HAPPENING wrt ZE HDVs

ZE VEHICLES

- Commercial availability of electric buses
  - e.g. Solaris, Optare, BYD, VDL, ADL, Van Hool, Volvo, Dennis
- Small OEMs offer battery electric trucks commercially
  - e.g. GINAF (rigid truck), EMOSS (rigid truck and tractor)
- Many OEMs are developing and testing battery electric trucks
  - BYD, Daimler, MAN, VDL (DAF based), Fuso, Tesla, Nicola
- Volvo and Scania test catenary trucks
- Toyota develops a hydrogen truck

CHARGING

- Rollout of ultra-fast charging (@ 350 kW) networks across EU (>10,000 charging points) announced by E.ON and two other consortia
  - backed by several large OEMs
  - would reduce charging time of 900 kWh long-haul truck to 2.5 hours
- Tesla has announced the deployment of 1 MW chargers

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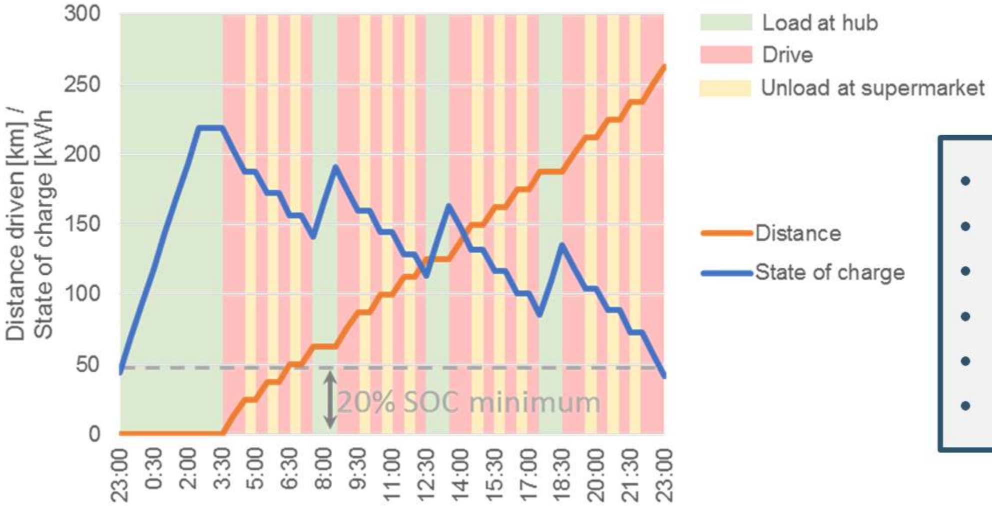
- **Perspective on technical and economic feasibility is rapidly improving**

CASE: SUPERMARKET SUPPLY

RIGID TRUCK (2350 KG PAYLOAD)

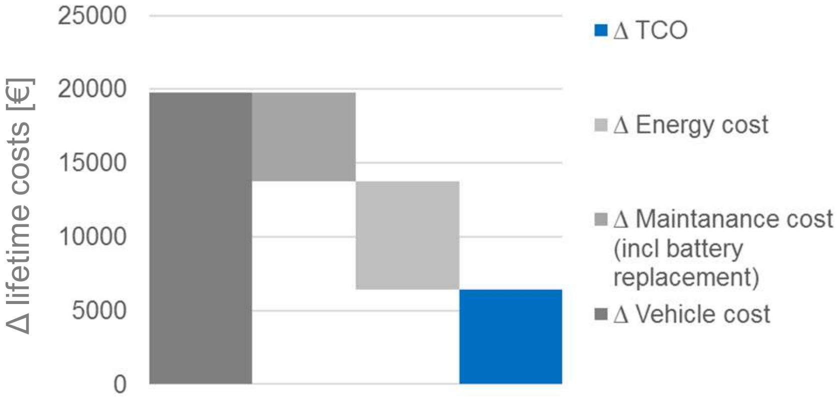


- A smaller battery and faster charging would further improve the business case

- Average speed of 25 km/h
- Drive 10.5 hours per day (= 263 km/day)
- 630,000 km in 8 years lifetime
- Charger: 50 kW
- Required battery: 219 kWh (incl. max. 80% DoD)
- Energy use: 1.4 kWh/km (incl. mass penalty)

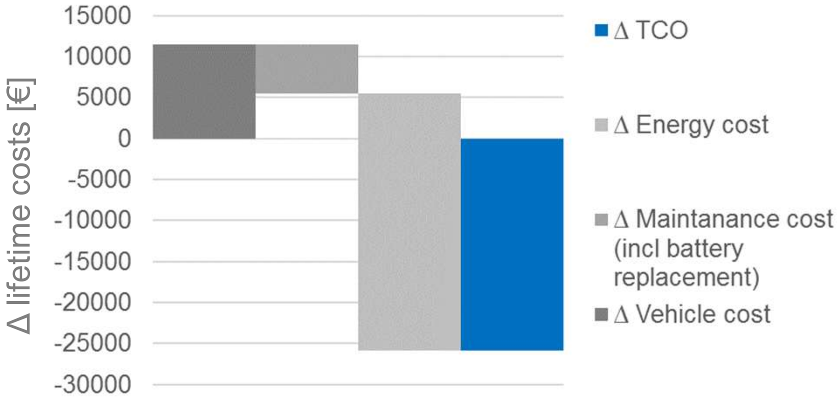
2025

- Electricity price: 0.35 €/kWh
- Diesel price: 1.27 €/l



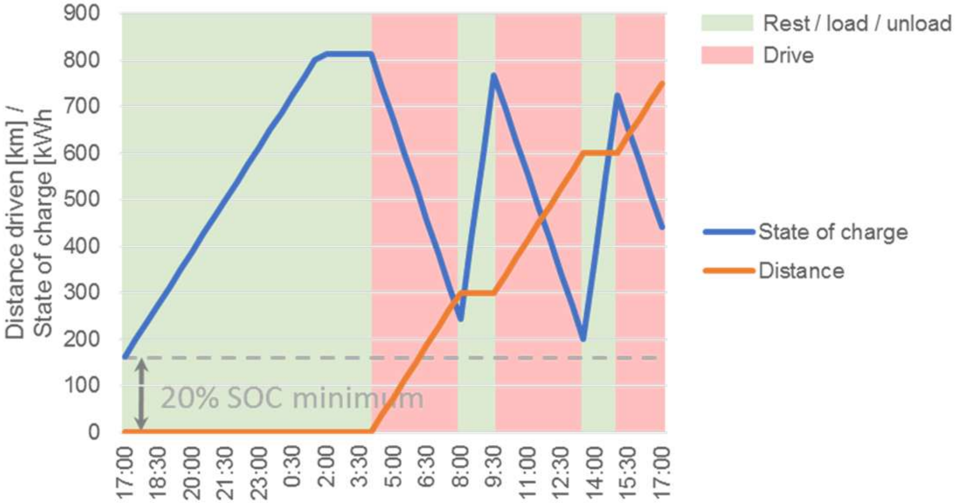
2030

- Electricity price: 0.36 €/kWh
- Diesel price: 1.37 €/l



CASE: LONG HAUL

TRACTOR-TRAILER (24.270 KG PAYLOAD)

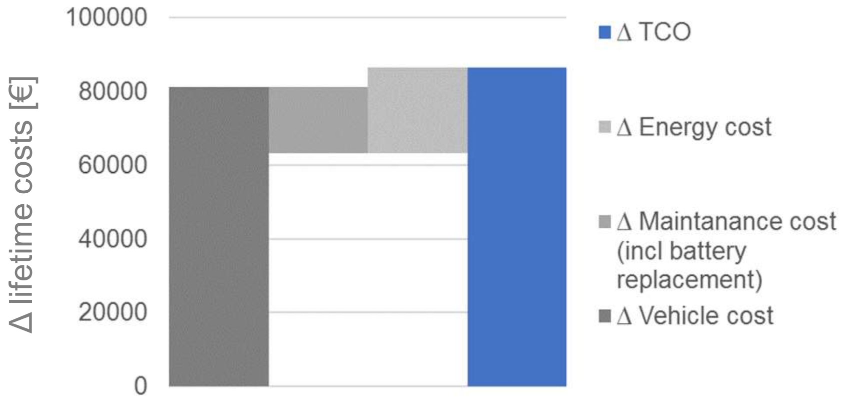


- Average speed of 75 km/h
- Drive 10 hours per day (=750 km/day)
- 1.8 mln km in 8 years lifetime
- Overnight charger: 75 kW
- Fast charger during rest: 350 kW
- Required battery: 813 kWh (incl. 80% max. DoD)
- Energy use: 1.5 kWh/km (incl. mass penalty)

› A smaller battery and faster charging would further improve the business case

2025

- Electricity price: 0.35 €/kWh
- Diesel price: 1.27 €/l



2030

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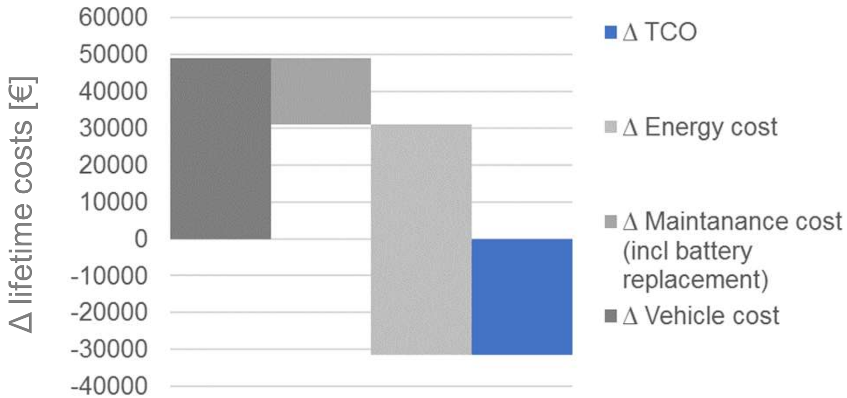
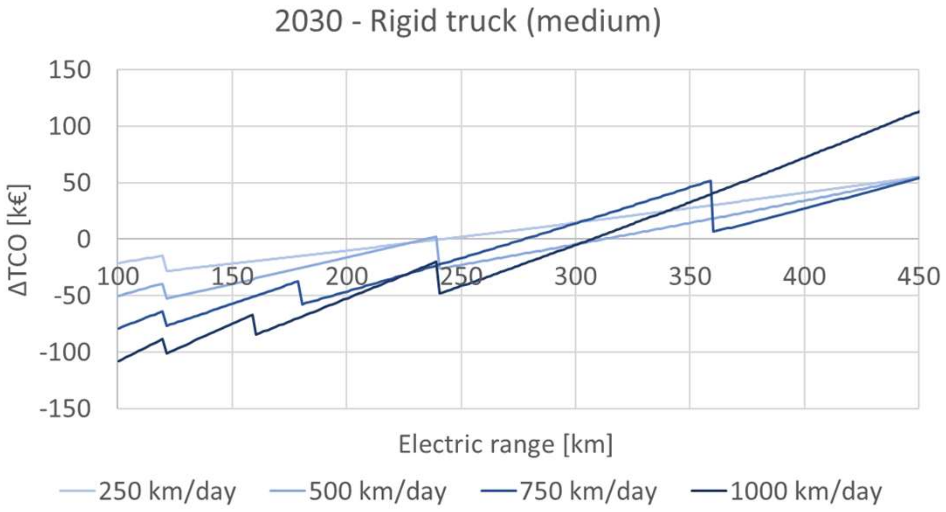


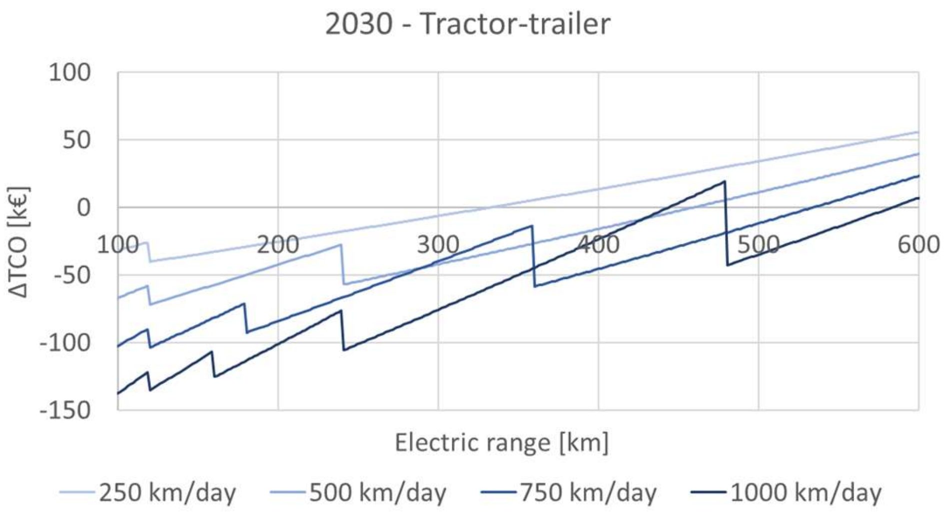
DEPENDENCE ON RANGE AND MILEAGE

- Including cost of battery replacement

Assumption battery life:
- 5000 cycles in 2030

- Using a smaller battery and a combination of overnight and opportunity charging improves business case, because of lower battery price and higher payload





CONCLUSIONS

- Battery-electric HDVs expected to be technically and economically feasible:
  - by 2025 for a limited number of segments
  - by 2030 for many types of use
- However, this would require:
  - sufficient and sufficiently fast chargers
  - electricity prices (incl. infrastructure cost) at acceptable levels
    - depends on occupation of chargers (> 30%)

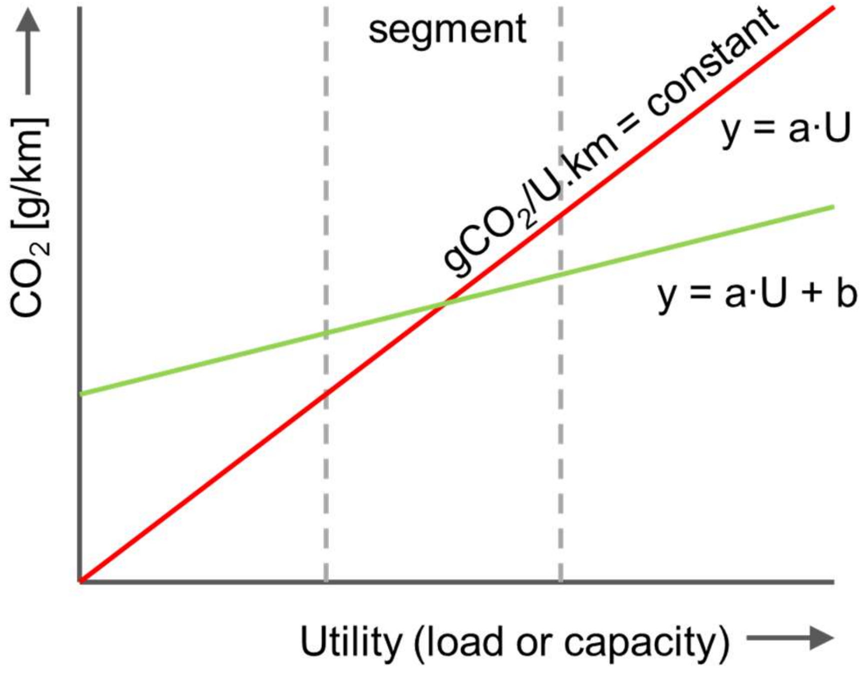
- Allowing higher vehicle masses will improve business case and could lead to quicker uptake of ZE HDVs

ISSUES

- The metric
  - g/km vs. g/ton.km or g/m^3.km
- Options for specific promotion / requiring of ZEVs
- Mileage weighting i.r.t. sales weighted targets and/or exchanging ZEV credits

THE METRIC

- Options:
  - g/km
  - g/ton.km or g/m³.km
    - based on load or capacity?



- **g/km is preferred**
  - if necessary use utility-based target function to differentiate target within segment
- **arguments against g/ton.km or g/m³.km**
  - using actual load or capacity is difficult / not feasible
  - using default load or capacity makes g/ton.km or g/m³.km equivalent to g/km
  - implicitly makes load or capacity a utility parameter but with a utility-based target function that is way too steep

OPTIONS FOR PROMOTING ZE HDVs

- Need for specific promotion of ZEVs depends on:
  - overall CO_2 target for 2030 and need to accelerate transition to ZE mobility
  - stringency of CO_2 standards for HDVs

- How could CO_2 legislation be structured to incentivise ZE HDVs?
  - Zero rating
  - Super credits
    - Could be considered for 2025
  - ZEV credits
    - e.g. allowing ZEV credits earned in non-regulated segments to compensate deficits in regulated segments
  - ZEV mandate
  - A flexible ZEV mandate

The "technology neutrality" mantra may need reconsideration in the light of the (urgency of the) transition towards climate-neutral mobility.

AWARDING / REQUIRING ZEVs

- **ZEV credits for ZEVs sold in categories that are not yet regulated**
  - Stimulates action in non-regulated segments

- **A flexible ZEV mandate**
  - Target for ZEV share combined with a bonus and/or malus
    - **bonus:** gives away extra CO_2 reduction associated with extra ZEVs
    - **malus:** makes the overall target for an OEM more stringent

- **A hard ZEV mandate**
  - Minimum required ZEV share
  - Only for regulated categories or also including non-regulated categories?

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ISSUES wrt AWARDING / REQUIRING ZEVs

- **Some options require**
  - certification & monitoring of non-regulated categories
  - lifetime mileage weighting => *see further on*

- **How to deal with partial-ZEVs?**
  - Share of ZE kms is critical factor
    - Will strongly depend on powertrain configuration and application
  - Data to be based on monitoring vehicles in normal operation
    - *Moving towards certification & regulation based on on-board monitoring (OBM) could be considered…*

REQUIRING ZEVs

- **What minimum share / target to be set for 2025/2030?**
  - Balance between what is needed in view of transition and what is (considered) technically and economically feasible
  - Is primarily a political choice
  - Exact number difficult to motivate scientifically at this stage
    - **The perspective w.r.t. technical and economical feasibility of ZE trucks is rapidly improving**
    - Be careful not fix ZE targets for the next 12-17 years based on outdated facts / assumptions

MILEAGE WEIGHTING irt AVERAGING OVER SEGMENTS or ZEV CREDITS

- Different truck categories have very different annual / lifetime mileage
  - **Lifetime mileage weighting** relevant when CO_2 credits or ZEV credits can be used to off-set emissions from ICEVs in other categories, e.g.:

ZEV credits of 1 (p)ZEV in category *y* =

$(target_y – emission_{(p)ZEV}) \times avg\_mileage_y$

OR

$(avg\_emission\_of\_ICEVs_y – emission_{(p)ZEV}) \times avg\_mileage_y$

If ZEV credits can be gained in non-regulated categories. Requires monitoring.

- **Exchange grammes, not g/km**

Typical lifetime mileages:

- 4-5 litre: 650.000 km
- 7-9 litre: 850.000 km
- 11-13 litre: 1.200.000 – 1.800.000 km

CONTACT INFORMATION

Dr.ir. Richard Smokers
Principal Advisor
Sustainable Transport & Logistics

TNO innovation for life

Anna van Buerenplein 1
2595 DA Den Haag
The Netherlands

T +31 88 866 8628

richard.smokers@tno.nl