ETH zürich

Center for Sustainable Future Mobility (CSFM)

Analyzing the cost competitiveness of low-carbon drive-technologies for European road-freight

Bessie Noll[1], Santiago del Val[1], Tobias S. Schmidt[1,3], Bjarne Steffen[2,3]
[1]Energy and Technology Policy Group, ETH Zurich; [2]Climate Finance Group, ETH Zurich; [3]Institute of Science, Technology and Policy, ETH Zurich

1 Introduction

- Road-freight represents a critically difficult-to-abate sector that requires immediate decarbonization in order to meet ambitious European transport-sector emissions reductions targets.
- A number of **low- or zero-carbon drive-technologies** are available, though it is unclear if they are cost competitive in different road-freight application segments.
- **Policy intervention will be required** to accelerate the road-freight transport transition. To support European policy-makers, the relative cost competitiveness between commercial vehicles of varying alternative drive-technologies is examined through a **total cost of ownership (TCO) framework** guided by the following questions:
  1) Which key TCO parameters drive cost competitiveness?
  2) In which geographic and application specific contexts are which policy tools most effective in enabling the road-freight transport transition?

2 Framework and Method

- A framework to characterize the road-freight sector is introduced. Three dimensions characterize and differentiate this framework—**drive-technology, application and geography**.
- **5 drive-technologies** (see Fig 3 legend) compete in **3 representative application segments** (Fig 1), and **10 European countries** (Fig 3).
- Cost competitiveness is evaluated through the **total cost of ownership (TCO) equation**, which offers a faire assessment of cost effectiveness of alternative drive-technology vehicles over their complete lifetime (Eqn 1).

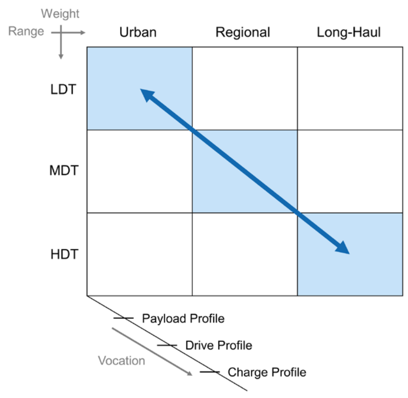

Fig 1. The application matrix characterizes the road-freight landscape along the weight, range and vocation dimensions.

$$TOC_{t,a,g} = \frac{\left(CAPEX_{t,a} - SUB_{t,a,g} - \frac{SV_{t,a}}{(1+i_g)^N}\right) \cdot CRF + \frac{1}{N_{a,g}} \sum_{n=1}^{N} \frac{OPEX_{t,a,g}}{(1+i_g)^n}}{AKT_{a,g}} \quad (1)$$

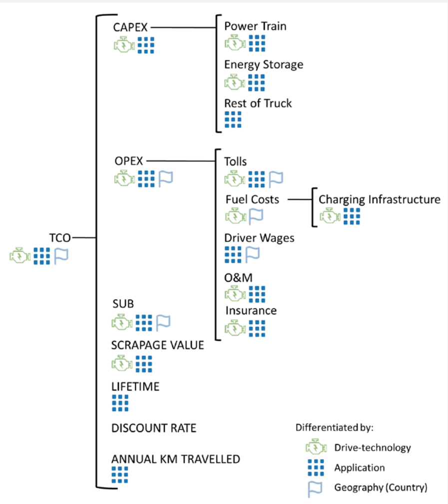

Fig 2. TCO dimensional parameter tree.

- The TCO equation is broken into sub-parameters along each of the three framework dimensions to analyze influential cost drivers as well as to understand better where and in what way policy efforts can be focused (Fig 2).
- **Database** of TCO cost parameters is **compiled**.
- A **stochastic Monte Carlo simulation** model is employed to introduce uncertainty of cost parameters.

References

1. Wu, G., Inderbitzin, A. & Bening, C. Total cost of ownership of electric vehicles compared to conventional vehicles: A probabilistic analysis and projection across market segments. Energy Policy 80, 196–214 (2015).
2. Palmer, K., Tate, J. E., Wadud, Z. & Nellthorp, J. Total cost of ownership and market share for hybrid and electric vehicles in the UK, US and Japan. Appl. Energy 209, 108–119 (2018).

4 Results and discussion

- Results from the **CAPEX alone** show zero-carbon drive technologies to be **not yet competitive**.
- FCETs are uneconomical in all segments due to high fuel cell system costs and BETs are uneconomical in the HDT-LongHaul segment where the large required energy storage drives up the cost.
- Results from the country-specific TCO comparison, however, show high competitiveness of low- or zero-carbon drive-technologies (baring FCETs) in the LDT-Urban and MDT-Regional segments, but also surprisingly in the HDT-LongHaul segment for countries that exhibit targeted policy measures.
- **Switzerland stands as an anomaly**. FCETs and BETs are competitive in the MDT and HDT segments. This is due to their unique tolling policy.
- **Germany and Norway** have similarly **enabled BET competitiveness in the HDT segment** through a combination of tolls, fuel costs, and CAPEX subsidy policies.

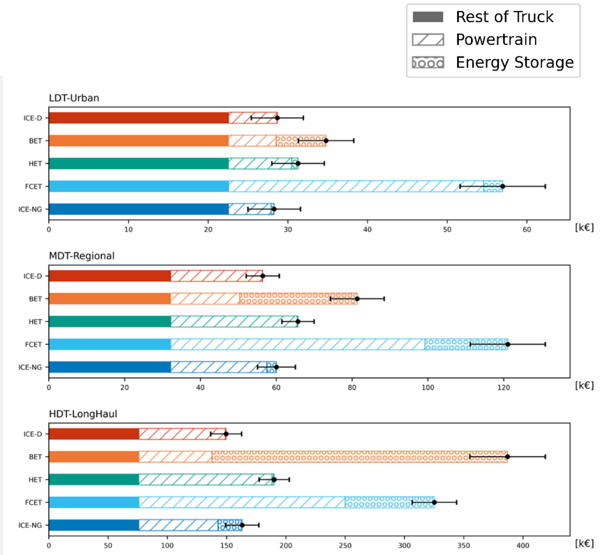

Fig 3. CAPEX results for 5 drive-technologies in 3 application segments.

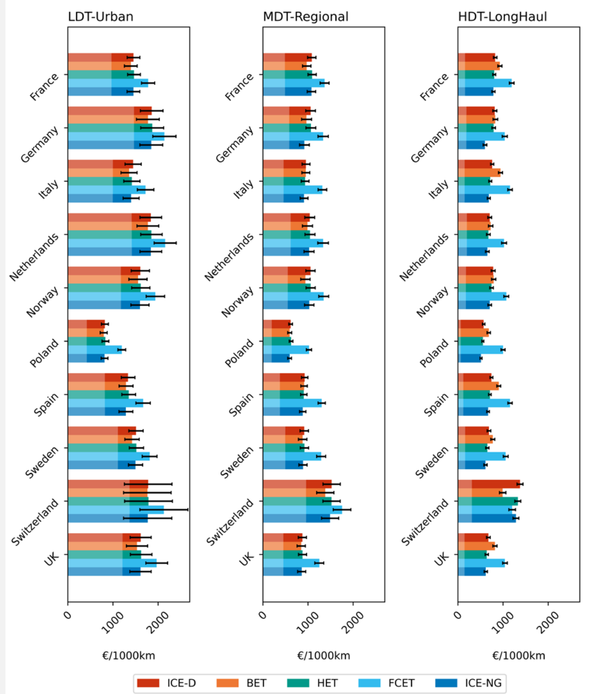

Fig 4. TCO results for 5 drive-technologies in 3 application segments and 10 European countries.

5 Conclusion

- **Cost competitiveness for low- or zero-emission drive-technologies** in certain application segments and European countries is **exhibited already today**.
- Policy instruments that target **OPEX parameters** are considerably more effective than instruments that target CAPEX parameters in enabling competitiveness of zero-emission commercial vehicles.
- Policy makers may employ an **appropriate mix of key influencing parameters** to ensure greater reach, efficiency, and flexibility of policy design.
- Future research may explore specific policy design tools for key influential TCO parameters as well as dynamic modeling approaches to incorporate expected cost reductions of certain drive-technology components.

Partner: amag SIEMENS

CSFM