Long-haul battery-electric trucks in Europe

Hussein Basma, Ph.D.
Felipe Rodríguez, Ph.D.

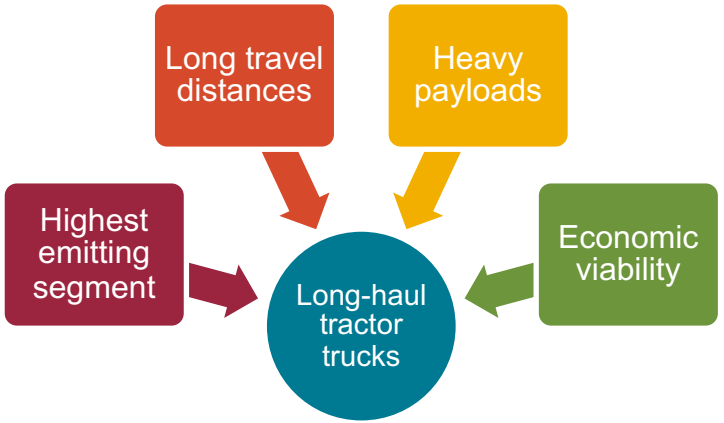
07.February.2022
Berlin, Germany

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Decarbonizing long-haul trucks: importance and challenges

- Tractor-trailers are responsible for over half of the CO_2 emissions from road freight transport.
- Tractor-trailers long travel distances and heavier loads make them the hardest truck segment to decarbonize.
- Uncertainties around the total cost of operation of such tractor trailers, impacting their large-scale deployment.

Most challenging and **most important** segment to **DECARBONIZE**



icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Technology analysis
- Economic analysis (Total cost of ownership)

Battery electric long-haul tractor trailers in Europe: A vehicle technology analysis

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Scope and objectives

1) Estimate the truck energy efficiency and battery sizing needs.

2) Quantify the payload capacity of battery-electric trucks.

WORKING PAPER 2021-29

AUGUST 2021

Battery electric tractor-trailers in the European Union: A vehicle technology analysis

Authors: Hussein Basma, Yannis Beys, Felipe Rodríguez.

Keywords: Battery-electric tractor-trailers, energy consumption, driving range, temperature impact, payload penalty

Introduction

There is a broad consensus on the need to achieve global net-zero CO_2 emissions by 2050 in order to limit the global mean temperature increase to 1.5°C. To achieve this, the European Union (EU) is taking active steps to make these targets legally binding by enshrining them into a European Climate Law (European Commission, 2020), which would create the legal framework to adopt stringent measures to meet the target across sectors.

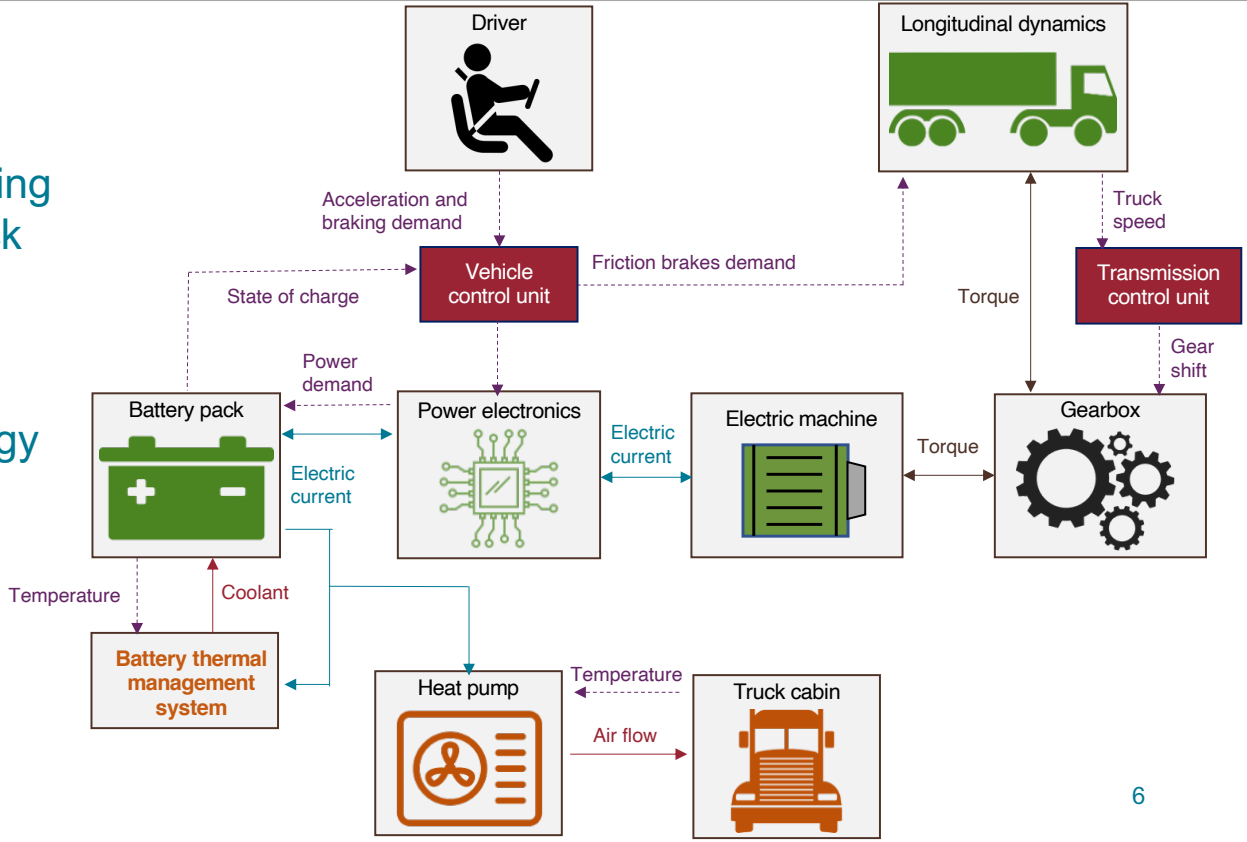
Transport, which represents approximately a quarter of Europe's greenhouse gas emissions, has not seen the same gradual decline in emissions as other sectors have in the past (Delgado & Rodríguez, 2018). In particular, the greenhouse gas emissions of road freight transport went unaddressed for decades. It was not until 2019 that the first CO_2 emission standards for new heavy-duty vehicles (HDV) were adopted in the EU. To set the ambition of the standards, the European Commission studied the potential of

https://theicct.org/publications/eu-tractor-trailers-analysis-aug21

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

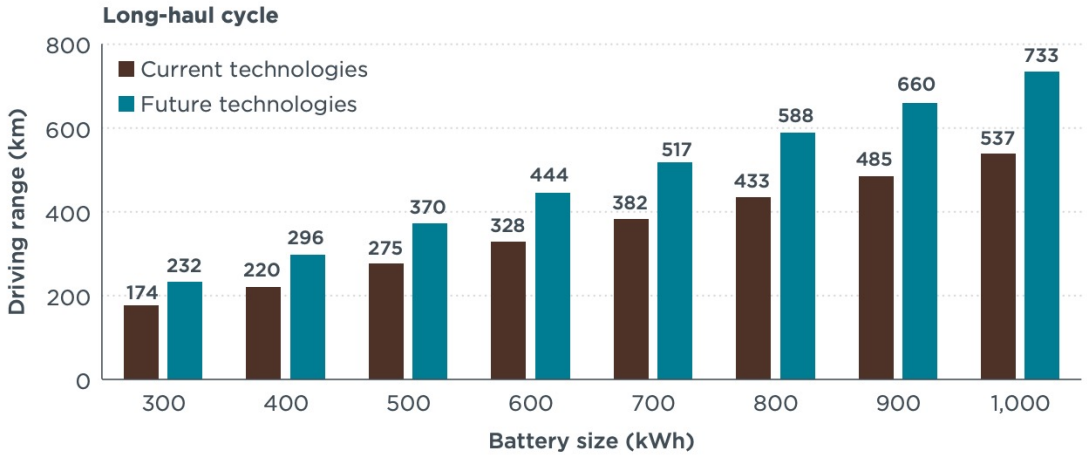
Methods

- Comprehensive vehicle modelling and simulation over typical truck use cases in the EU.
- Powertrain energy needs, and cabin and battery thermal energy needs.



Energy needs and driving range

- 1,000 kWh battery energy capacity is needed to cover a 500 km driving range (90% of truck applications in Europe with 45 mins opportunity charging at 350 kW)
- Improvements in battery energy density and road-load technologies will enable substantially smaller batteries
    - ~ 700 kWh to achieve a 500 km driving range

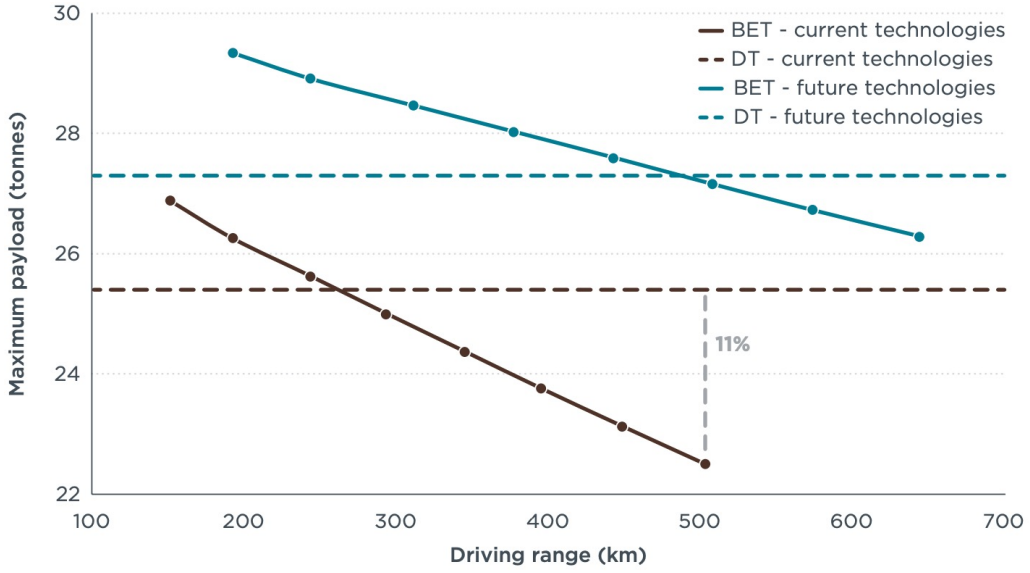


Driving range estimation for current and future technologies over the long-haul drive cycle using the reference payload.

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Payload capacity

- The maximum payload of the battery-electric tractor-trailer is estimated with a gross vehicle weight of 42 tonnes instead of 40 tonnes
- Reduction in electric truck payload capacity with the increase in its driving range
- At a 500 km driving range, payload capacity penalty is 11%.
- With chassis light-weighting and battery energy density increase (0.14 kWh/kg in 2020 to 0.23 kWh/kg in 2030), electric trucks would not result in any payload penalty.



Maximum tractor-trailer payload as function of driving range.

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

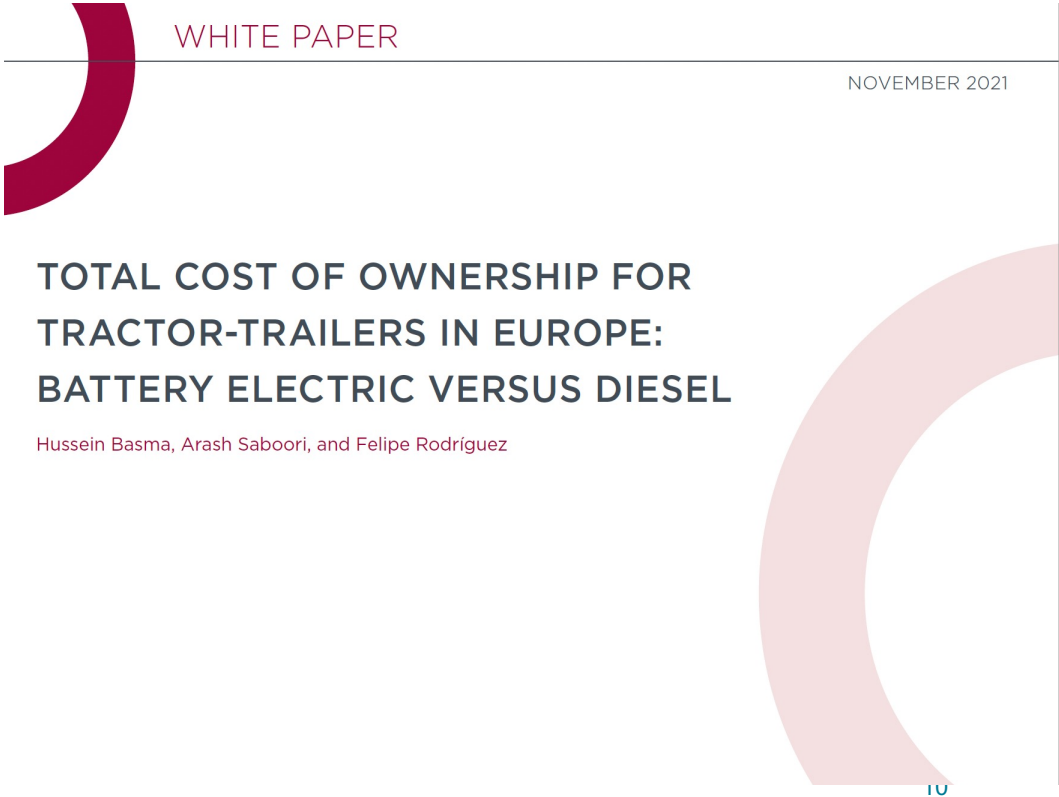
Total cost of ownership of long-haul tractor trailers in Europe: Battery electric VS diesel

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Scope and objectives

1) Quantify and compare the TCO of electric and diesel long-haul tractor trailers in 7 European countries.

2) Assess the impact of policy measures on the TCO parity year of electric and diesel trucks



icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

https://theicct.org/publication/total-cost-of-ownership-for-tractor-trailers-in-europe-battery-electric-versus-diesel/

Methods

- Evaluate costs and TCO parity time relative to diesel trucks
- Comprehensive TCO assessment

Truck retail price	Salvage value
Diesel fuel costs	Electricity costs
Maintenance	Infrastructure
Taxes and levies	Premiums

- Assess impact of policy interventions

=

Bottom-up approach to estimate truck retail price

- Battery
- Chassis
- E-Drive
- Auxiliaries
- Power electronics

+

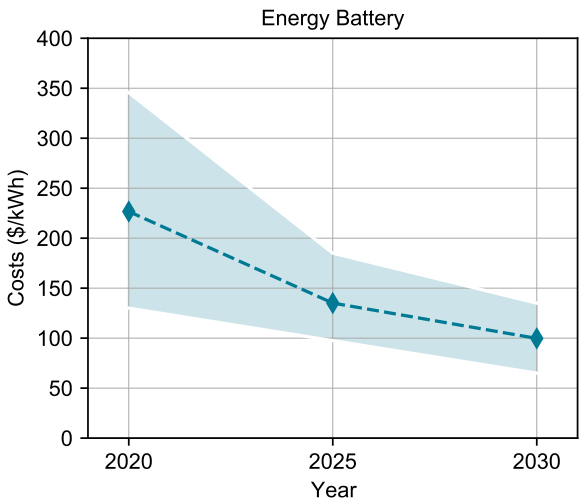
Operational expenses (distance-dependent)

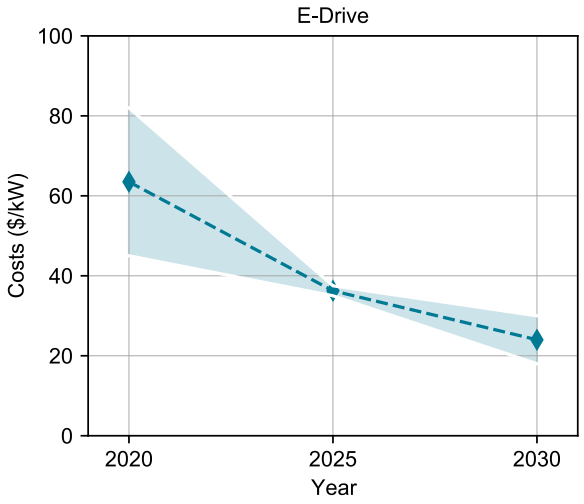
- Annual vehicle kilometers travelled
- Country-specific fuel and electricity prices
- Country-specific taxes and road tolls

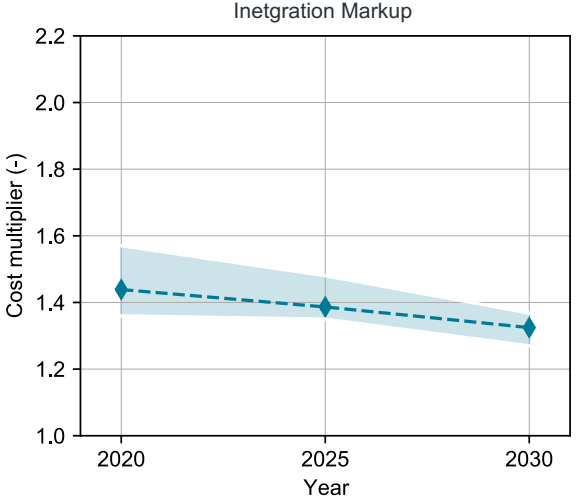
icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Methods

Component direct manufacturing costs forecast between 2020-2030



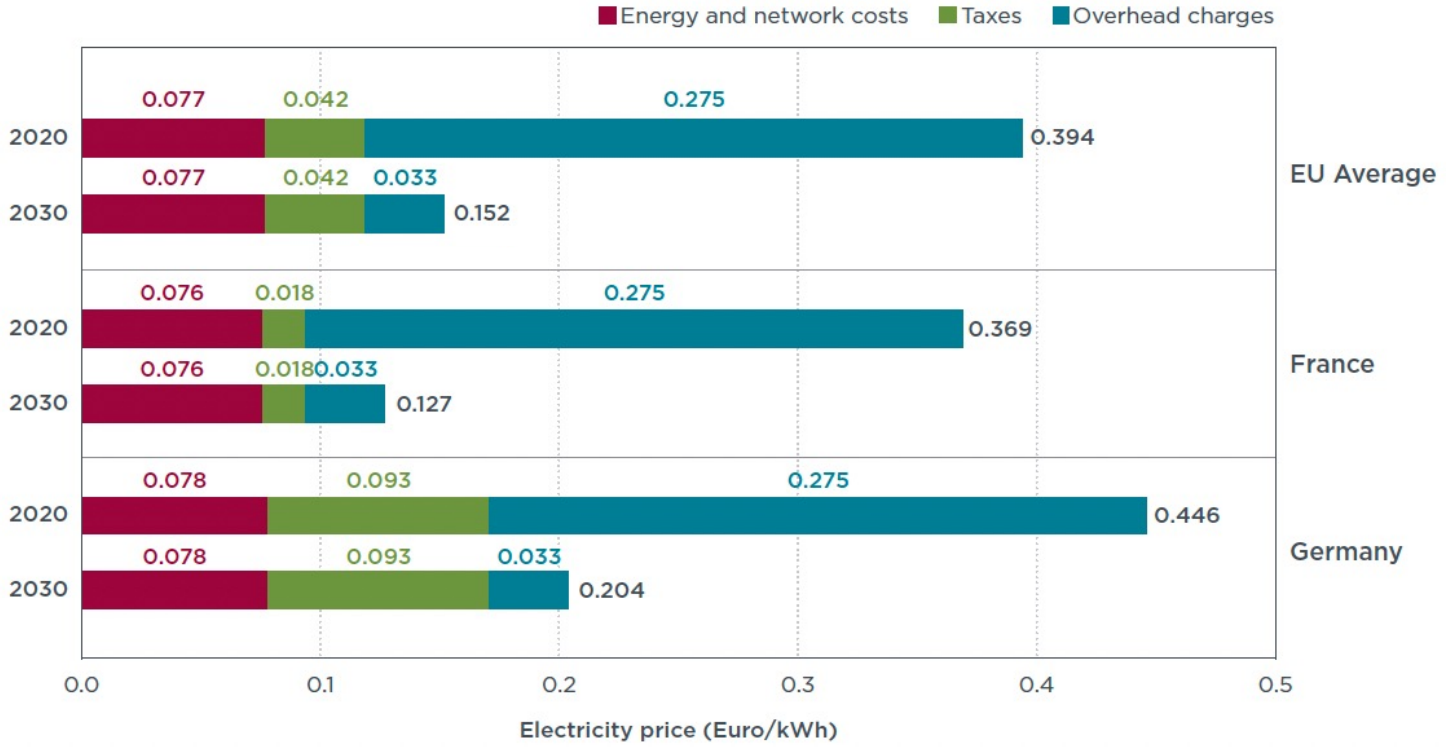




Source: ICCT desk research and Ricardo Strategic Consulting U.S.

Methods

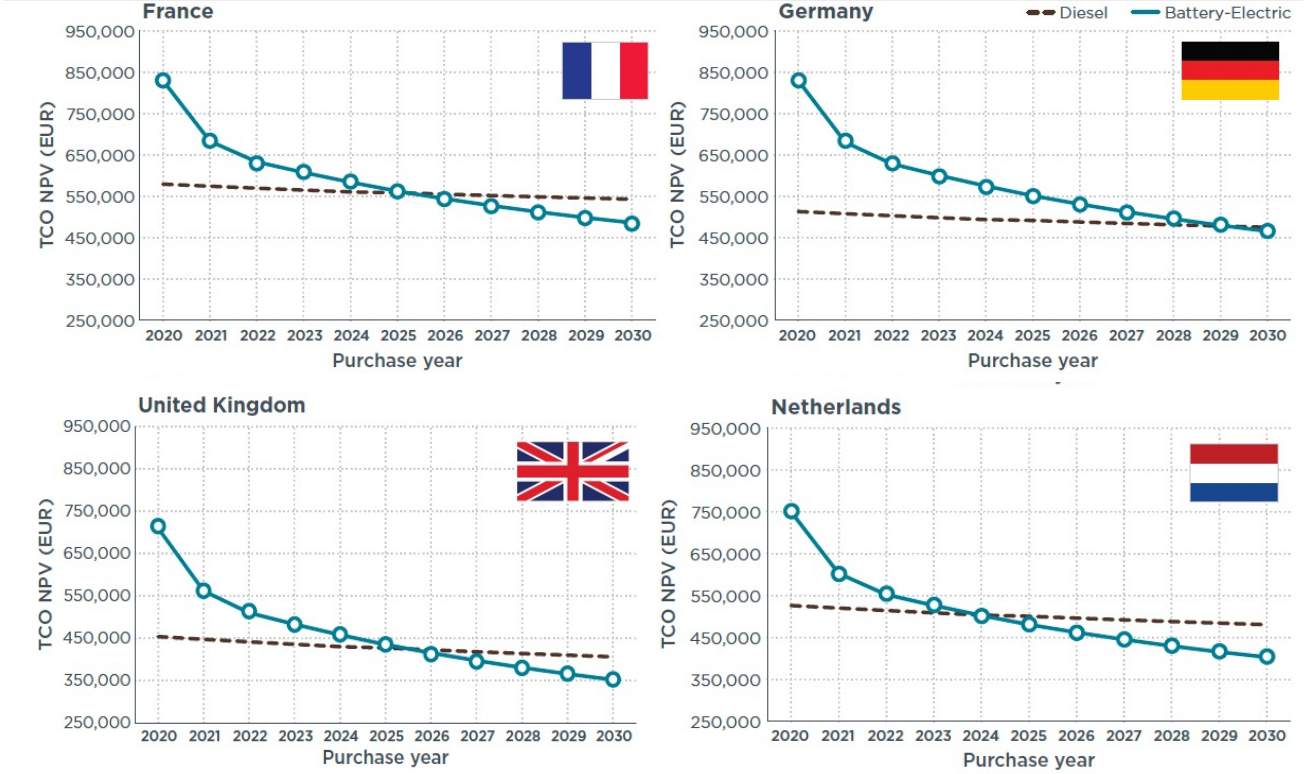
Electricity costs including overheads to account for infrastructure investment



icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Results: fixed energy prices 2020-2030 (No Policies)

- Case of a long-haul tractor-trailer equipped with a battery large enough to cover 500 km on a single charge
- Battery-electric trucks can reach TCO parity with diesel trucks by the mid of the decade:
  - Higher energy efficiency
  - Lower energy costs (depends on diesel and electricity prices)
  - Lower maintenance costs

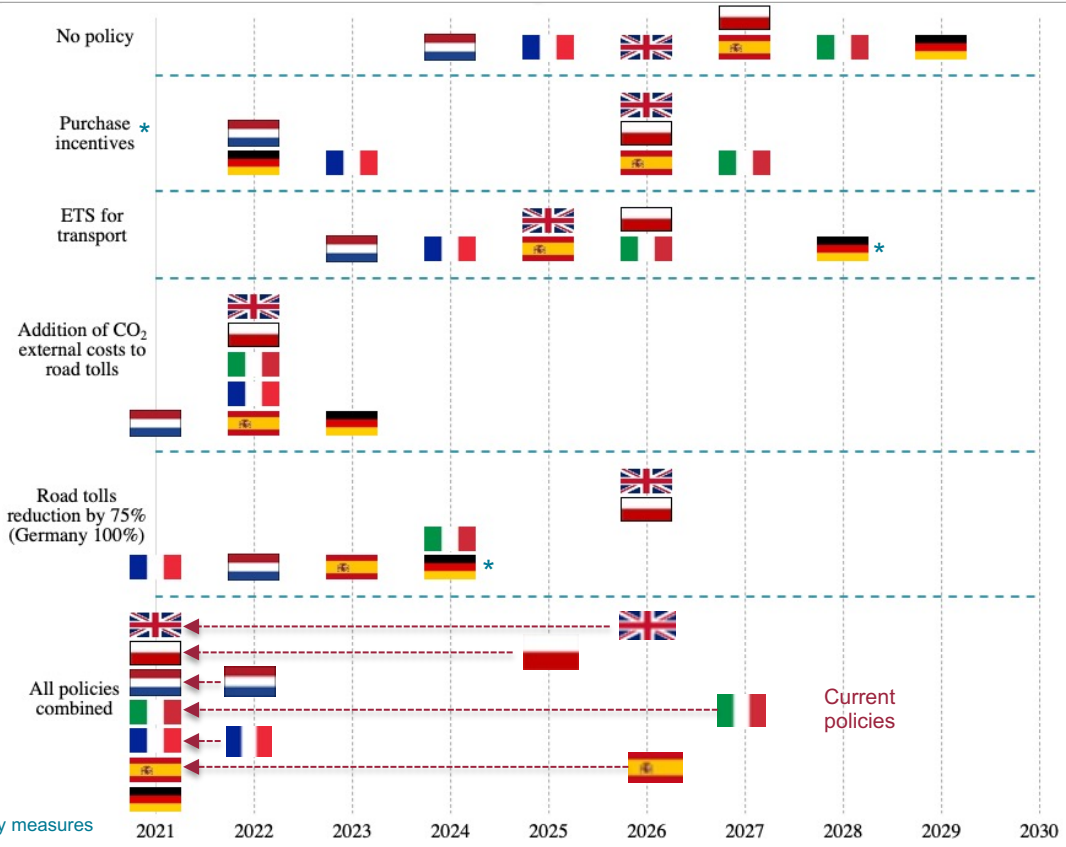


icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Results: impact of policy implications

Set of policy interventions

- Purchase incentives
- Emission Trading System for transport
- Reduce road tolls for electric trucks
- Addition of CO2 external costs to road tolls



* Currently adopted policy measures

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Results: current policy interventions

- Battery-electric trucks operating in Germany, France, and the Netherlands achieve TCO parity today under current policy interventions implemented in these countries.
- Germany offers generous purchase incentives reaching € 450,000 per truck. France offers € 50,000 per truck and the Netherlands covers 40% of price difference with diesel trucks.
- 100% road tolls waiver for electric trucks in Germany.
- National CO_2 prices implemented in Germany including transport.

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Takeaways (1/2)

- The majority of truck applications in the EU can be covered by battery-electric trucks from a technology perspective:
  - Today: ~ battery size of 1,000 kWh
  - By 2030: ~ battery size of 700 kWh due to energy efficiency and battery density improvement

- Battery electric tractor-trailer with 500 km driving range suffer a small payload penalty today, with the potential of having no payload penalty in the future:
  - Today: ~ 11% payload penalty
  - By 2030: No payload penalty

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Takeaways (2/2)

- From a first-user perspective, BETs can achieve TCO parity with diesel tractor-trailers during this decade without any additional policy support:
    - Electric trucks operating in Germany, France, and the Netherlands are already at TCO parity with diesel tractor-trailers.

- Regulatory support can reduce the cost gap between battery-electric and diesel tractor trucks:
    - Implement the Eurovignette directive into national law as expeditiously as possible
    - Extend the European Emissions Trading Systems (ETS) to include transport
    - Purchase premiums for trucks should be limited to incentivize the purchase of zero-emission trucks in the near term and exclude all combustion-powered truck

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Questions

Hussein Basma
h.basma@theicct.org

Felipe Rodríguez
f.rodriguez@theicct.org

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION