Techno-economic analysis of long-haul battery-electric trucks in Europe

Hussein Basma, Ph.D.
International Council on Clean Transportation

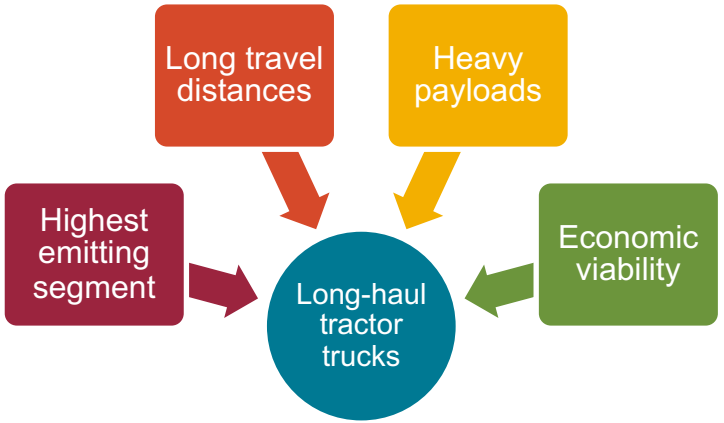
A3PS Eco-Mobility Conference - 18.November.2021
Vienna, Austria

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
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

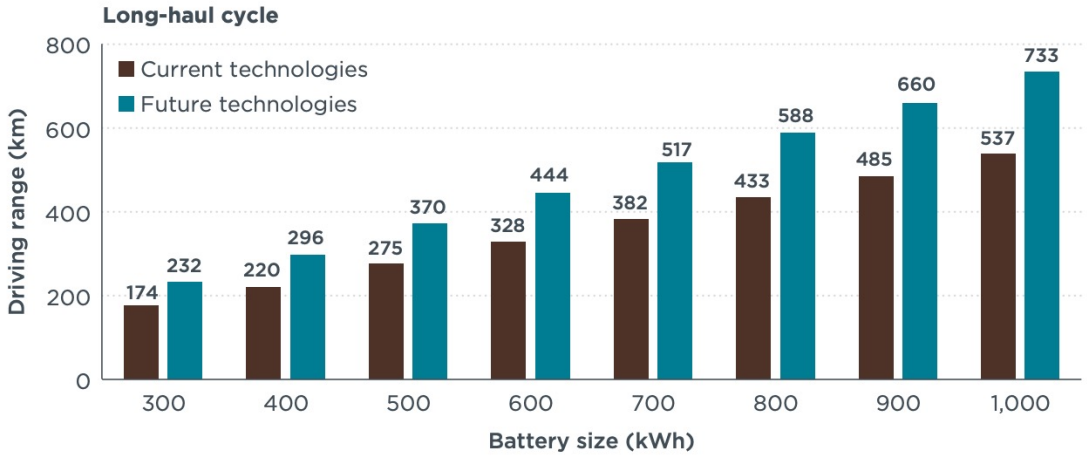
Outline

- Technology analysis
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Technology analysis: 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.

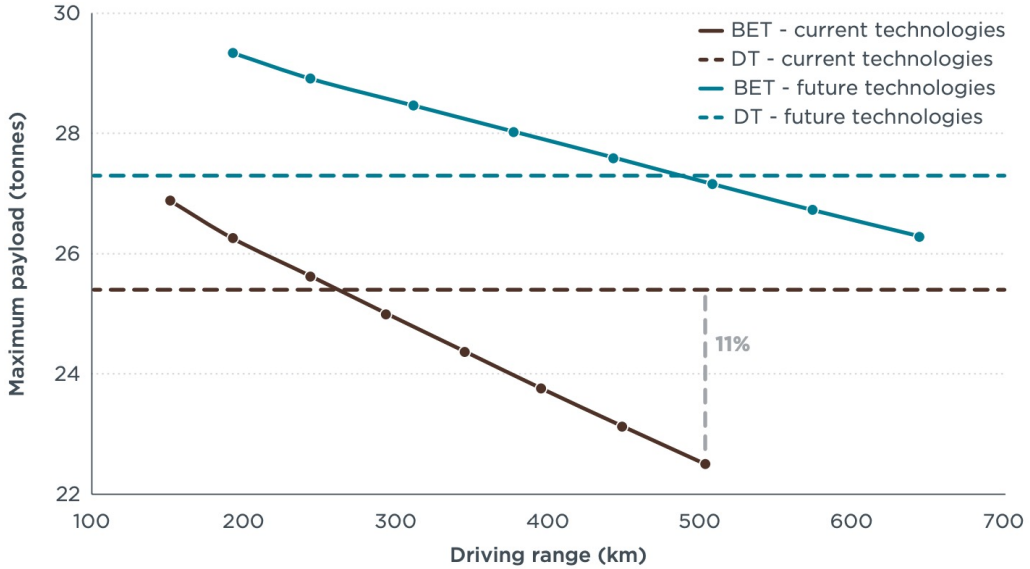
icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Technology analysis
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

Technology analysis: payload penalty

- 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, electric truck would not result in any payload penalty.



Maximum tractor-trailer payload as function of driving range.

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Technology analysis
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Economic analysis: methodology

- 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
- Assesss 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

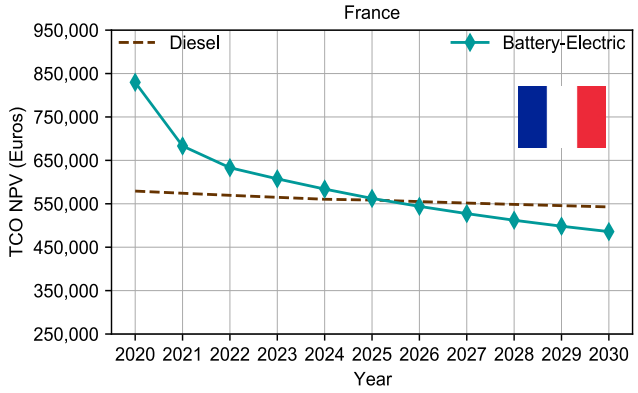
Outline

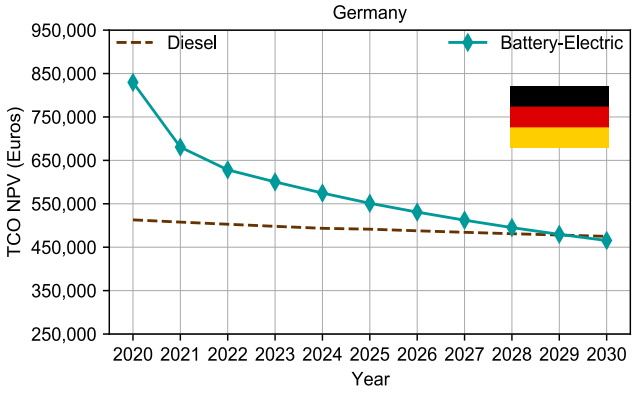
- Technology analysis
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

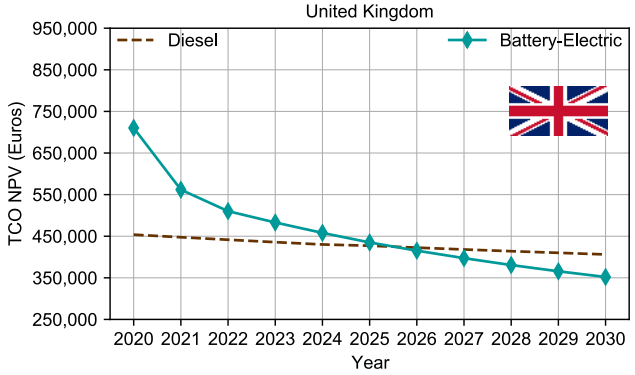
icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

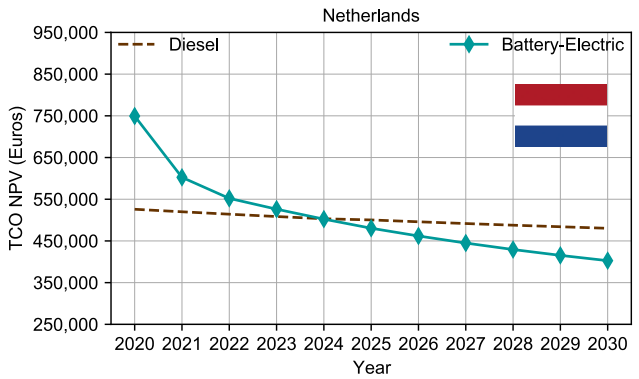
Total cost of ownership under fixed energy prices 2020-2030

- 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

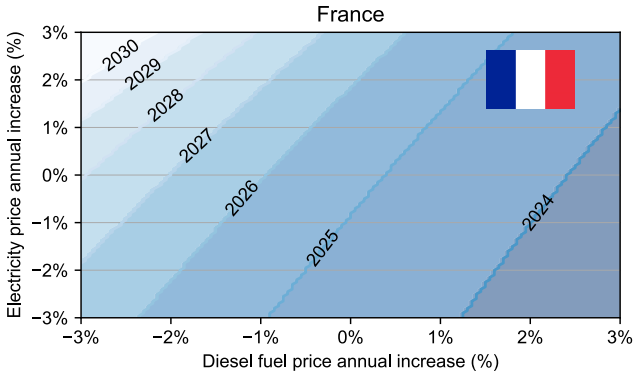
Outline

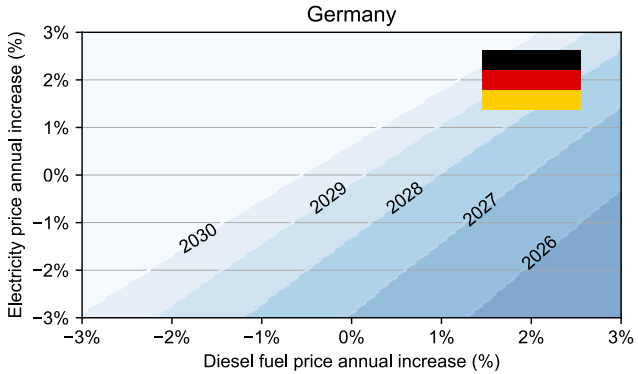
- Technology analysis
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

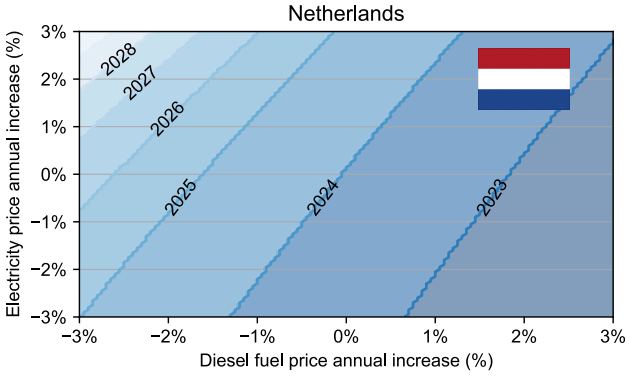
icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

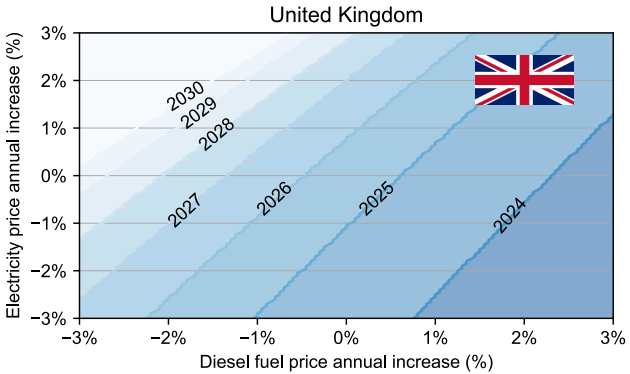
Total cost of ownership under variable energy prices 2020-2030

- Significant impact on the year electric trucks achieve TCO parity with diesel trucks.
- TCO parity will be achieved during this decade in the Netherlands and France under any electricity and diesel fuel prices projection scenario.









icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

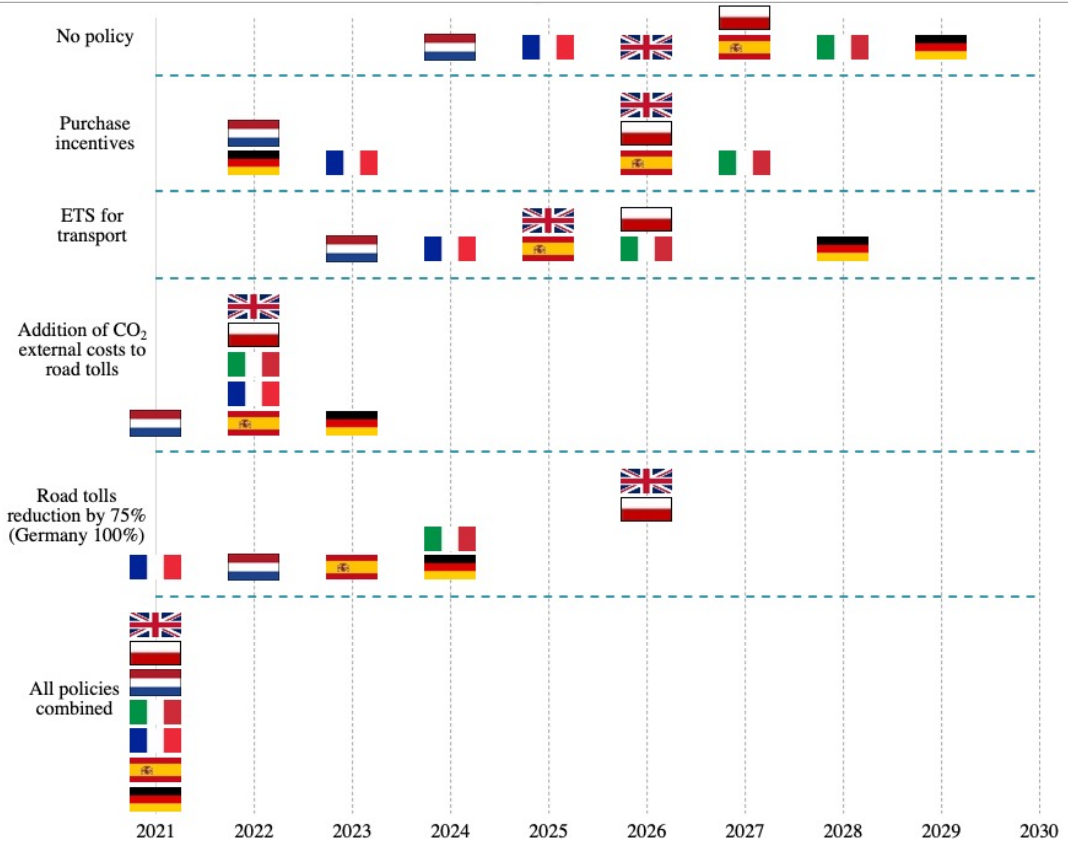
- Technology analysis
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Economic analysis: policy implications

Set of policy interventions

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



icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Technology analysis
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Economic analysis: parity year under current policy interventions

- Under current policy interventions implemented in each country, battery-electric trucks achieve TCO parity today in Germany, France, and the Netherlands.
- High purchase incentives in Germany reaching € 450,000 per truck. France (€ 50,000), Netherlands (40% of cost difference with diesel truck).
- 100% road tolls waiver for electric trucks in Germany

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Outline

- Technology analysis
  - Energy efficiency
  - Payload capacity
- Total cost of ownership
  - Methods
  - Total cost of ownership at fixed energy prices
  - Total cost of ownership at variable energy prices
  - Impact of policy scenarios
  - Currently adopted policies
- Summary

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

Summary

- Long-haul tractor trucks can be run using battery-electric powertrains, with a 700-kWh battery enough to cover more than 90% of the use cases in the EU by 2030.
- Battery-electric powertrains witness a minimum payload penalty today relative to diesel trucks, a penalty that will diminish in the near future with battery energy density improvement.
- Battery-electric long-haul trucks are already cost competitive today with their diesel counterparts in several EU member states without the need for any additional policies.
- Regulatory support can reduce the cost gap between battery-electric and diesel tractor trucks. Policies such as implementing the Eurovignette directive can have a significant impact on costs of battery-electric trucks.

Questions

Hussein Basma
h.basma@theicct.org
International Council on Clean Transportation

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION