Total Cost of Ownership (TCO) Analysis to Inform E-bus Deployments in Jakarta

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Agenda

1. State of global heavy-duty electrification
2. Fleet level TCO analysis
3. Route level TCO analysis
4. Conclusion

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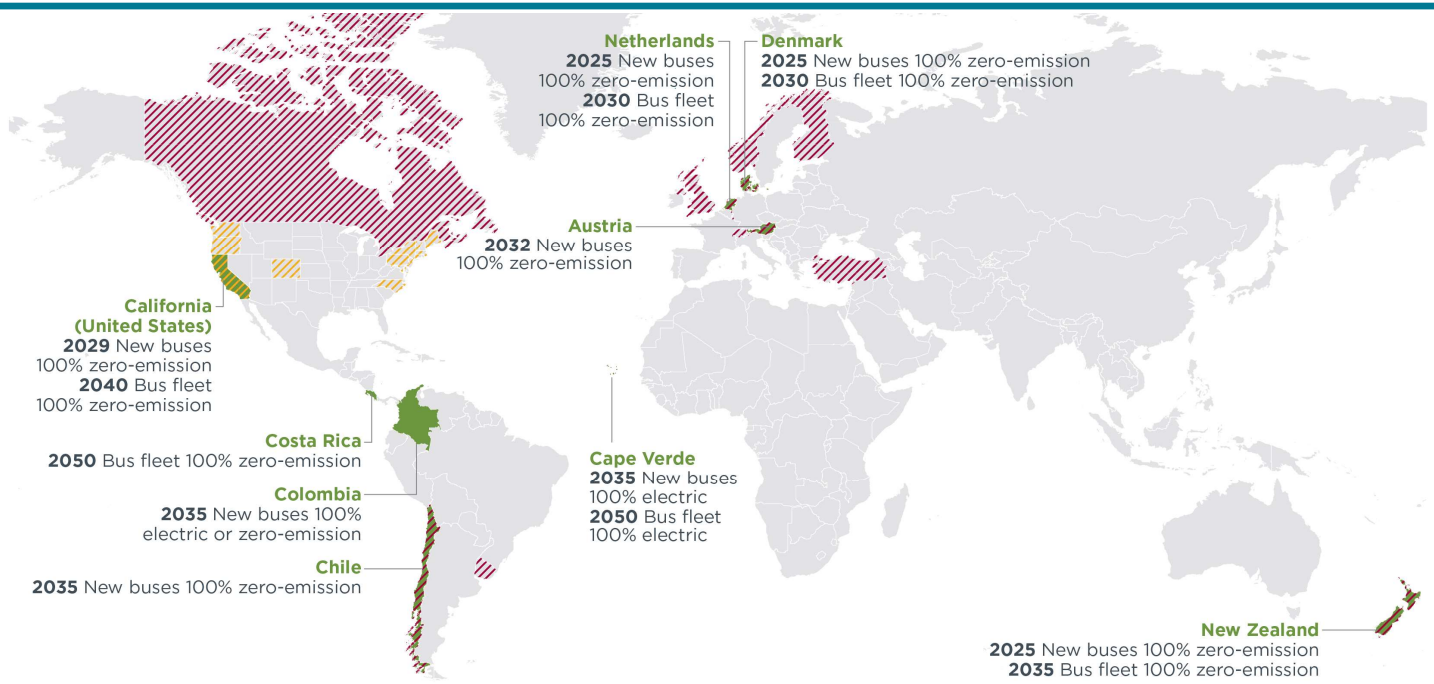
Governments that adopted targets for phasing out combustion engines from buses



U.S. states Memorandum of Understanding (MoU)
California, Colorado, Connecticut, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont and Washington and the District of Columbia
2030 New medium- and heavy-duty vehicles 30% zero-emission
2050 New medium- and heavy-duty vehicles 100% zero-emission

Global Memorandum of Understanding (MoU)
Austria, Canada, Chile, Denmark, Finland, Luxembourg, Netherlands, New Zealand, Norway, Scotland, Switzerland, Turkey, United Kingdom, Uruguay, Wales
2030 New medium- and heavy-duty vehicles 30% zero-emission
2040 New medium- and heavy-duty vehicles 100% zero-emission

https://theicct.org/decarbonizing-bus-fleets-global-overview-of-targets-for-phasing-out-combustion-engine-vehicles/

Detailed technical analysis is needed to support E-bus procurement decisions

- Battery electric bus technology presents complex technical and financial questions to operators.
- E-buses present higher capital costs compared to traditional buses, but offer much lower operating costs
- Operating range questions must be addressed before scaling up
- **Total Cost of Ownership (TCO)** is a better tool to compare costs across very different technologies.
  - TCO is defined as the sum of the costs to acquire, operate, and maintain the vehicle and fueling infrastructure over a period of time.
- Policy and procurement barriers must be identified and addressed

Phases of TCO Analysis

Fleet

Fleet level TCO analysis

- Evaluates average cost per km for the average bus (diesel, electric, CNG)
- Explores impact of contract duration, taxation policies, electricity and fuel pricing
- Help identify barriers that can be addressed by authorities and procurement

Route

Route level TCO analysis

- Evaluates cost per km at the route level – focuses on energy consumption challenges
- Identify best route to electrify, cost effective,
- Identifies detailed technical issues before investing in E-buses
- Help bus operators make technical and economic decisions

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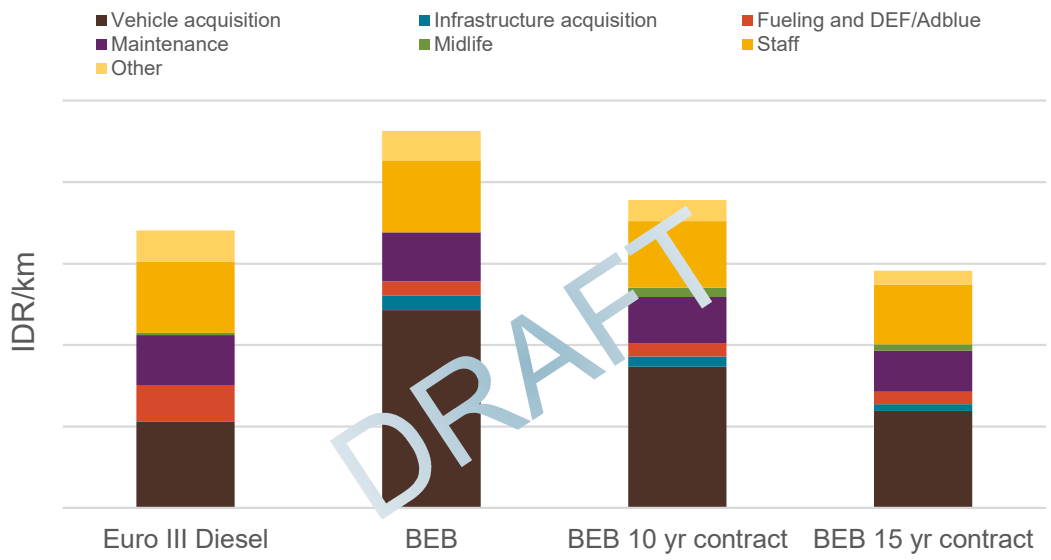
Fleet level TCO analysis

Example for Transjakarta

Impact of Contract Duration on TCO (IDR/km)



- **Preliminary recommendations from this study**:
  - Increasing contract duration from 7 to 15 years offers the lowest TCO per km for BEBs. This follows practices for BEB contracts in Latin-American countries.
  - Ensure high daily utilization for BEB, the higher the value the lower the TCO
  - Eliminating diesel subsidies improve the BEB's TCO differential with respect to diesel bus TCO
  - Reducing taxes and fees for BEB improve their TCO with respect to diesel

Why Route Level TCO Analysis?

Route level TCO analysis goes further to a more detailed level of TCO analysis by focusing on TCO of each route identified, answering these important questions when operator plans to procure an e-bus:

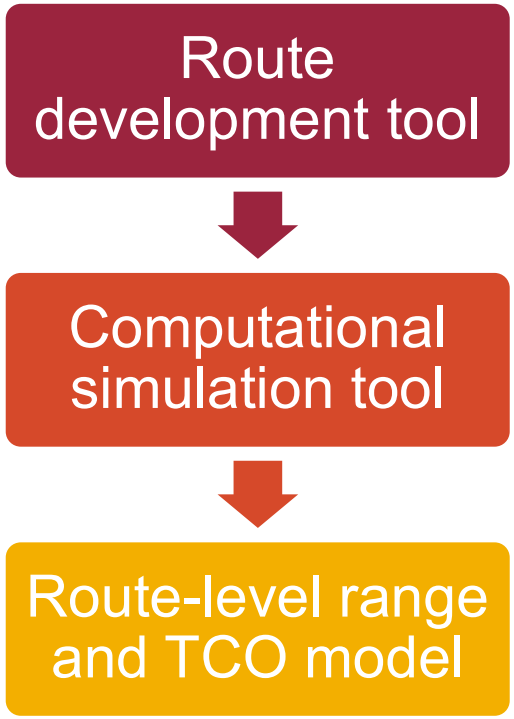
- How does the estimated range of battery-electric buses compare to the daily utilization of diesel buses currently in service?
- How do route and operational characteristics affect bus energy consumption and the range of electric buses?
- **From a cost and operational perspective, which routes make the most sense to electrify first?**
- **Where and when should electric buses charge?**

ICCT's route level TCO modeling components

GPS data for buses servicing individual routes used to develop **representative drive cycles**

Vehicle simulation modeling applied to estimate **energy consumption** of different technology options

Energy consumption outputs from simulations used in estimation of driving range and **total cost of ownership**



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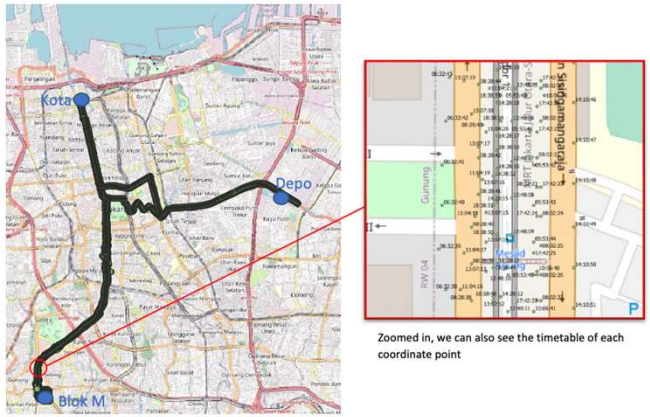
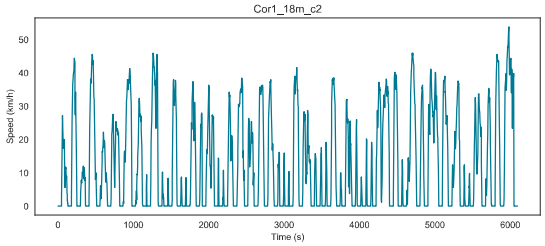
Drive cycle development uses real-world bus operational data to construct a representative duty cycle for a given route

Example Drive Cycle Result: Transjakarta

(1) GPS Installation



(2) Data Verification and Cleaning

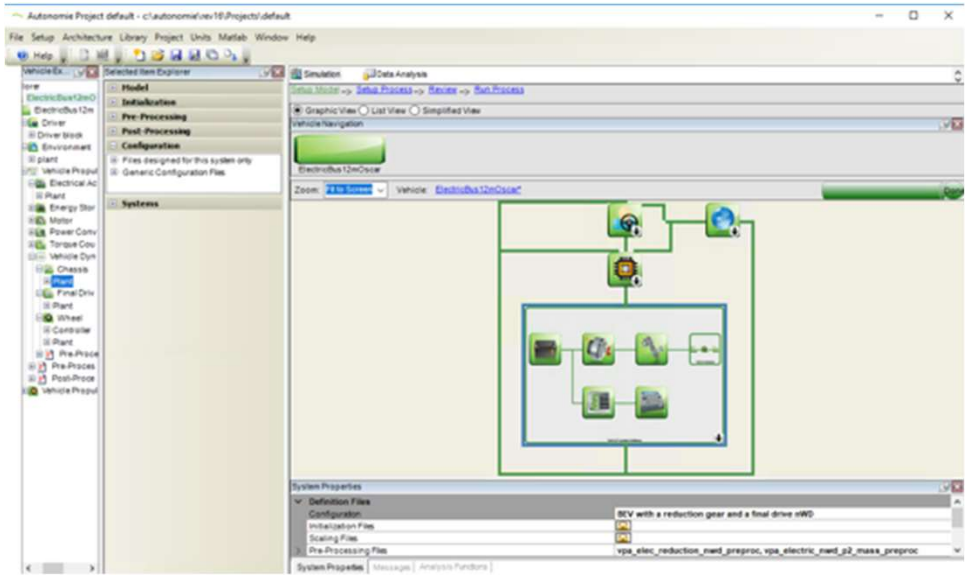


(3) Drive Cycle Development

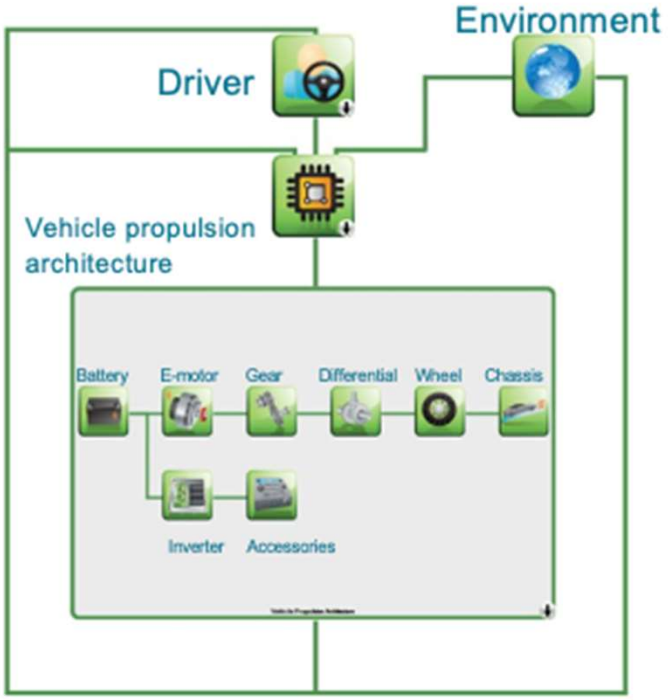
GPS and drive cycle development for 8 routes has been completed

Computational vehicle simulation software applied to estimate route-specific energy consumption for diesel and e-bus options

Autonomie simulation GUI



Example of electric bus system simulation



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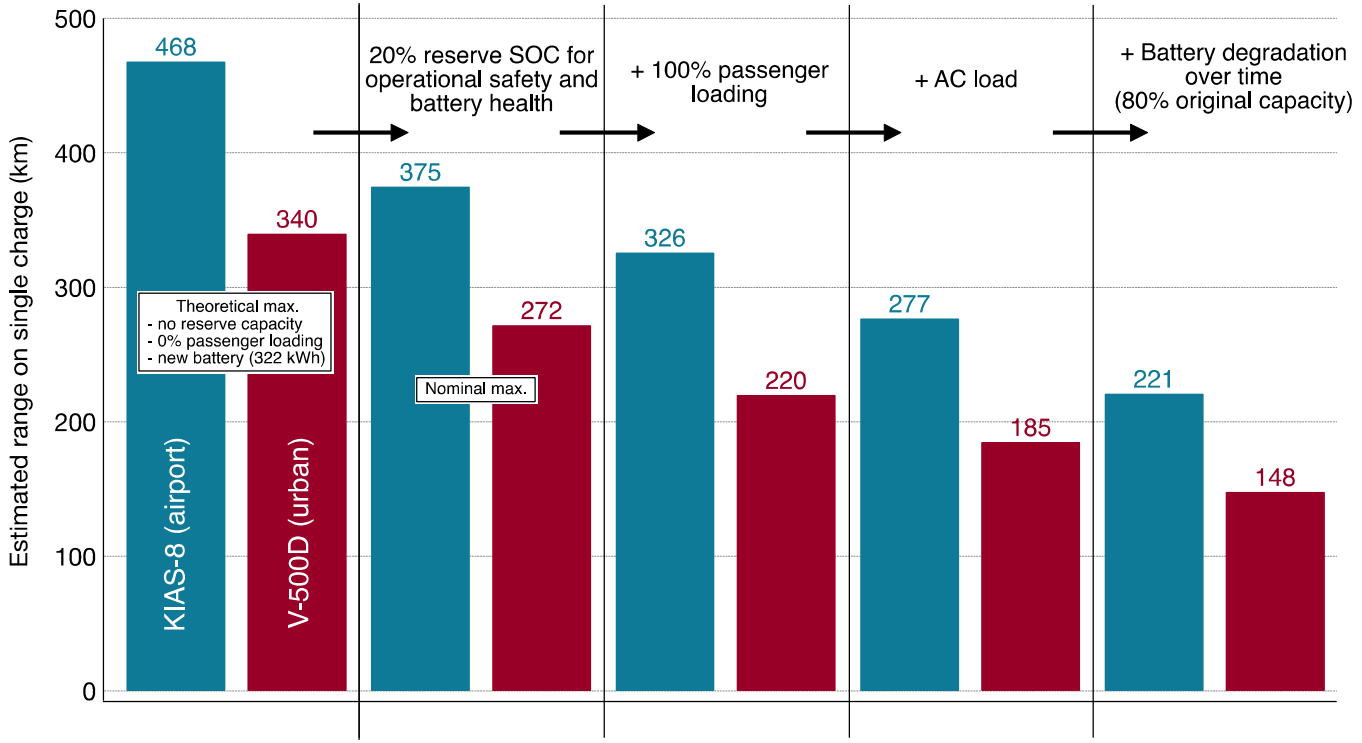
The same E-bus offers different operating ranges depending on route conditions and other factors

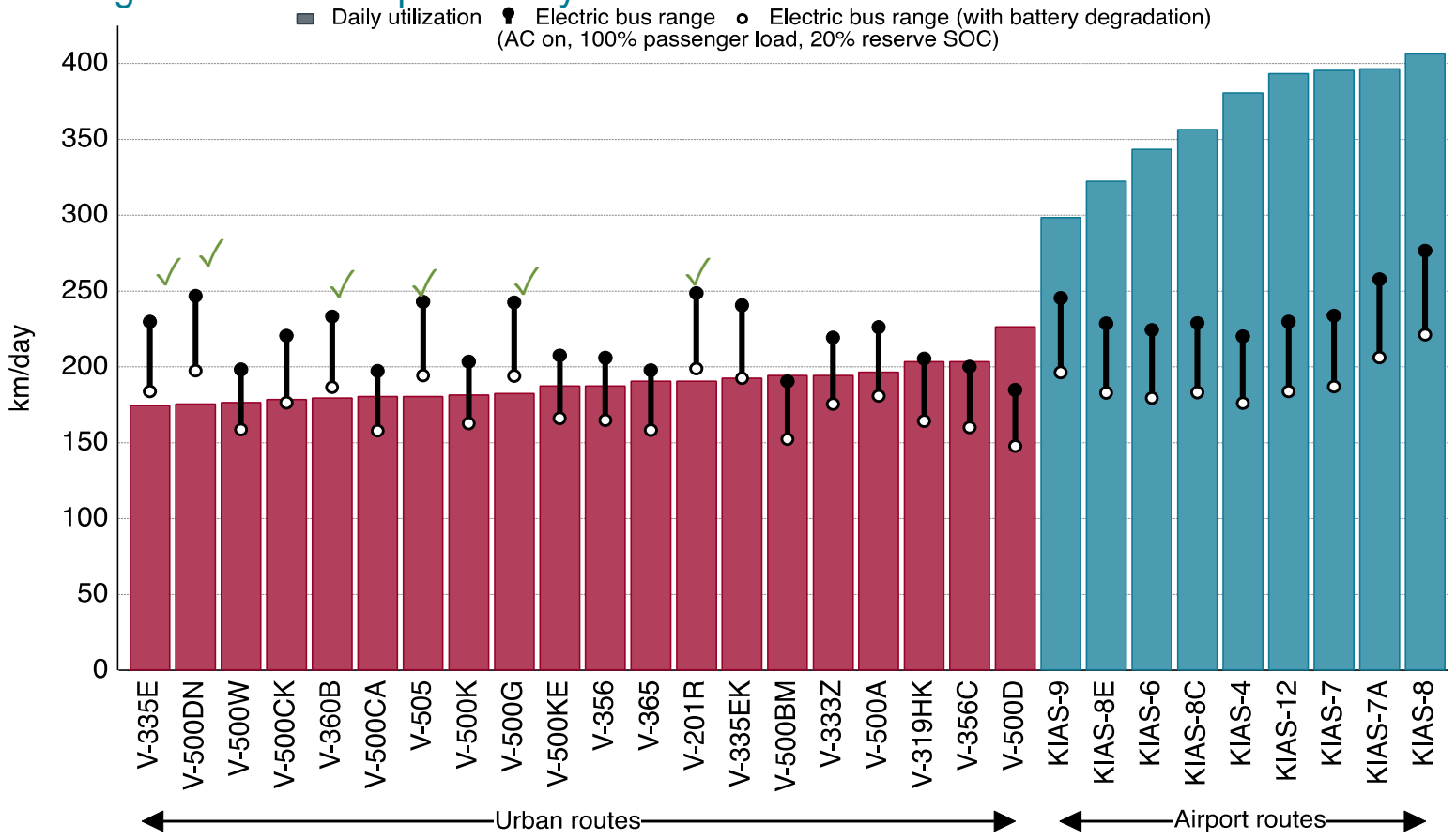
Daily range per full charge on a 12 m bus with a 322 kWh nominal battery capacity on 2 different routes



Example from ICCT's Bangalore E-bus adoption study

Comparison of estimated range and daily utilization indicates which routes are most suitable for 1:1 replacement

Example from Bangalore E-bus adoption study



12 m bus, 322 kWh battery capacity

Key messages

- TCO analysis is a powerful tool to identify and address policy and procurement barriers for E-bus deployments
- High level TCO analysis helped identify contractual practices that required tunning, as well as broader national policies that need changes
- Route level TCO offers other insights: the same e-bus with the same battery capacity shows different Energy Consumption (kWh/km) under different routes due to differences in driving patterns, passenger loading and road grade
- Drive cycle development and vehicle simulation can inform assessments of electric bus energy consumption and range on specific routes.
- **Route-level modeling and schedule analysis can inform electric bus transition strategies and technology selection**.

Thank you!

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