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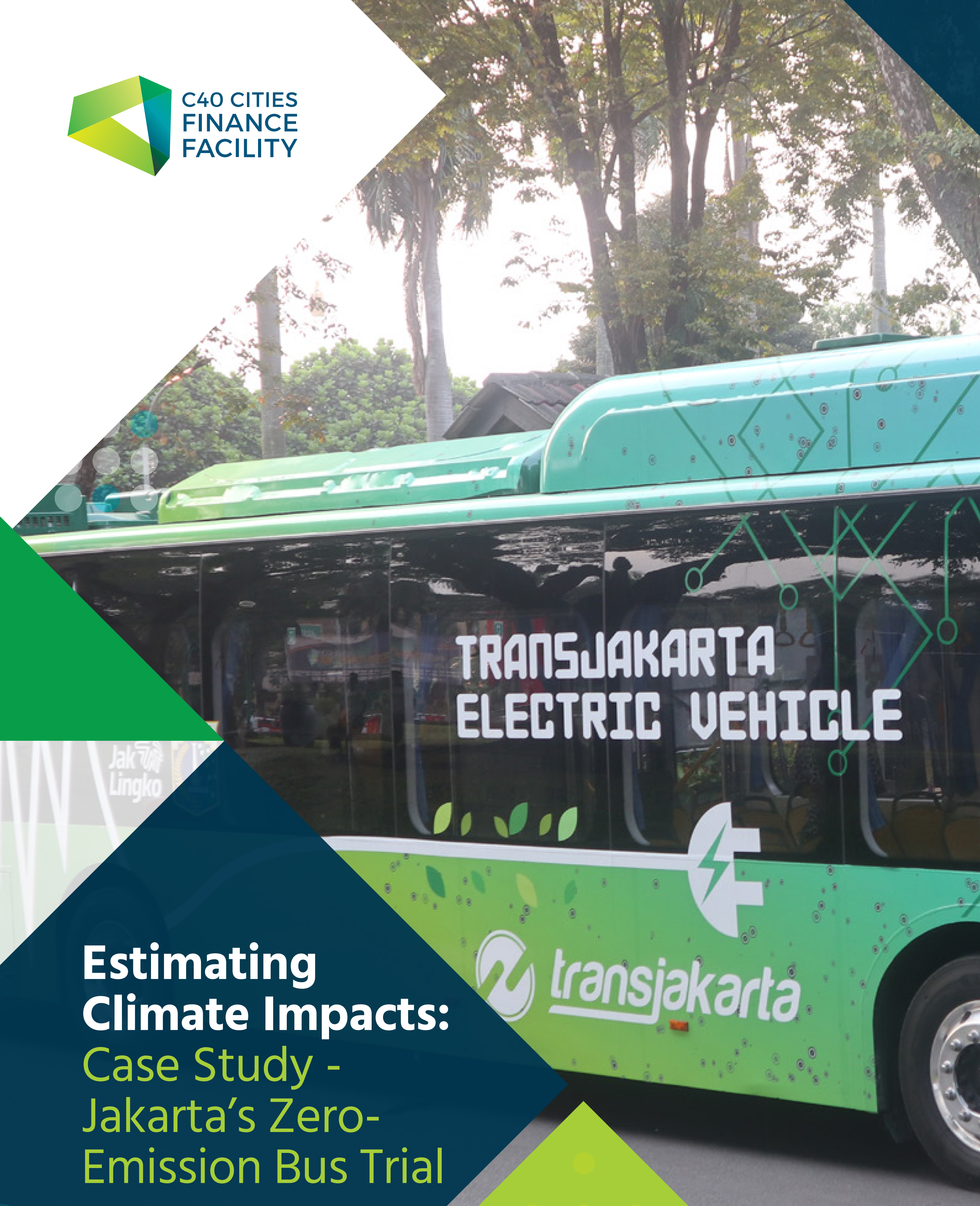

Estimating Climate Impacts: Case Study - Jakarta's Zero-Emission Bus Trial

Project Description

As part of its air quality measures and climate protection commitments, the City of Jakarta will start to electrify the community's public transportation system. Transjakarta, the city-owned bus operator, is planning to replace all fossil buses with zero-emission buses (ZEBs) by 2030. TransJakarta currently runs 2,500 buses on 13 BRT corridors, spanning 250 km, and more than 130 routes. This replacement programme will start with a pilot project that will switch 100 diesel buses in the fleet to e-buses.

The C40 Cities Finance Facility (CFF) is assisting the City in structuring this pilot through the development of a comprehensive procurement package and provision of transaction advisory services. The project aims to create a workable and replicable framework for achieving transformative actions, which reduce greenhouse gas emissions, improve air quality and build climate resilience.

Objectives of the project

The use of diesel vehicles in the Transjakarta fleet contributes to Jakarta's GHG emissions and poor air quality. More than 70% of Transjakarta buses are Euro II and Euro III diesel technologies, this poor efficiency is compounded by the use of a very high sulphur fuel (2,500 ppm) which creates high levels of toxic particle matter soot.

Implementation of this project will create many benefits for the city, including:

- Starting the transition to lower emissions public transport, with significant GHG emission reductions and health benefits for its residents;
- Cost savings through reduced expenditures on fuel and maintenance;
- Increased understanding of e-bus technology, operations, and business models in the Indonesian context.

Data & Methods

General methodological considerations

The mitigation potential for a project is determined by comparing the difference in GHG emissions generated in the baseline scenario against the project scenario. The baseline scenario is calculated using parameters that describe the context conditions assuming the planned intervention (switching to zero emission buses in this case) is not implemented. The project scenario reflects the changes in conditions that the planned intervention will create.

For an zero-emission bus project, the baseline scenario reflects the activity of the fossil fuel buses that would be used if they were not replaced by zero-emission buses. Emissions for a given year are calculated based on energy consumption. The total energy consumption depends on the number of kilometres travelled per bus, the bus fleet composition as well as the fuel efficiency of those buses.

The project emissions are calculated in the same way: the total yearly distance travelled is multiplied by the efficiency of the zero-emission buses and the emission factor for grid electricity (specific to the year).

More detailed documentation and discussion of the methods used in the calculation (including equations definition of terms) can be found in the accompanying document 'Estimating Climate Impacts - A Methodology for Estimating GHG Emission Mitigation Potentials of Infrastructure Projects'.

Baseline scenario data

For the Jakarta zero-emission bus project, the baseline scenario assumes that the diesel buses currently used would continue to run instead of zero-emission buses. The number of diesel buses in the baseline is the same as the number of zero-emission buses in the project as there is a one-to-one switch to electric.

According to Transjakarta, the fleet's targeted buses are all standard 12 m diesel buses and have Euro II standards and have an average fuel efficiency of 2.03 km/litre. The details of the routes and relative kilometres travelled of the buses aimed at being replaced are listed in Table 1.

The emission factor for diesel oil is taken from international standard IPCC values and corresponds to 0.270874 kg CO_2e/kWh.

Project scenario data

For the Jakarta EV bus project, the project scenario reflects the activity of the 100 zero-emission buses which will replace the existing standard 12 m diesel buses running on the three routes identified.

A key assumption for the project scenario is the efficiency of the EV buses used in the project, which would ideally reflect real-life operations. In the case of Jakarta, a major factor impacting energy efficiency is the high AC usage due to the hot climate. Pilots have been undertaken in the city (though with lower ridership and lighter traffic due to the Covid-19 pandemic) and have found the 12m BYD buses had an energy efficiency of 1.0 kWh/km.

Route 6	Route 6D	Route 9D
66 buses	18 buses	16 buses
242 km/day/bus	154 km/day/bus	178 km/day/bus

Table 1 - Details of the 'baseline' buses

Until normal conditions resumed, the energy consumption of EV buses was estimated using data from EV bus operations in Fuzhou. Using data from a fleet of 300 EV buses, the consultants assessed the relation between temperatures, AC usage and electricity. Taking into account Jakarta's climate, the efficiency was estimated to be around 1.2 kWh/km.

While this is an acceptable assumption for an ex ante analysis, obtaining real-life data of energy usage from the Transjakarta trial's buses in typical conditions will be important to improving the accuracy of the GHG emission reduction estimates during the project monitoring phase.

Another important project assumption is the electricity grid emission factor. This was calculated over the Transjakarta project lifespan using the national government's electricity generation mix target for 2020-2028 for the Java-Bali-East Nusa Tenggara grid. The 2020 emission factor reported by Indonesian ministry of energy is 0.82924 kgCO_2e/kWh and the future target states an increase in the low-carbon energy share from 7.9% in 2020 to 17.6% in 2028, decreasing the grid emission to 0.67301 kgCO_2e/kWh.

Results and emission reductions

This sub-section provides an overview of the GHG emissions impacts of the project. The calculations are completed for each year of operation from 2021 (the assumed initiation year) to 2050 (the final horizon year for the analysis). Table 2 describes the estimated emission mitigation values for the Jakarta zero-emission bus project and in Figure 1 the evolution of baseline and project emissions is presented.

The project's cumulative GHG emission reduction impact from 2021 to 2050 is 100,461 t CO_2e. Annual reductions vary from approximately 2,000 tonnes CO2e in 2021 to approximately 3,500 in 2050 tonnes CO_2e. It should be noted that the mitigation impact could be higher if the grid electricity was lower in carbon emissions. The current grid emission factor is high (0.817 kg CO_2e/kWh in 2021) because of the use of coal to generate electricity. The decrease in electricity emission by 2030 (0.673 kg CO_2e/kWh), calculated from governmental targets, is a limited improvement.

Reducing the grid emission factor further would help the Transjakarta zero-emission project achieve lower emissions. If the grid electricity was generated from 100% renewable energy, then the project emissions would be zero.

Overall, the expected impact will be relatively modest as only 100 buses will be replaced and because of the high grid emission factor.

tCO_2e/year	2021	2050	Average
Jakarta E-bus Trial	2,062 tCO_2e	3,518 tCO_2e	3,349 tCO_2e

Table 2 - GHG mitigation impacts

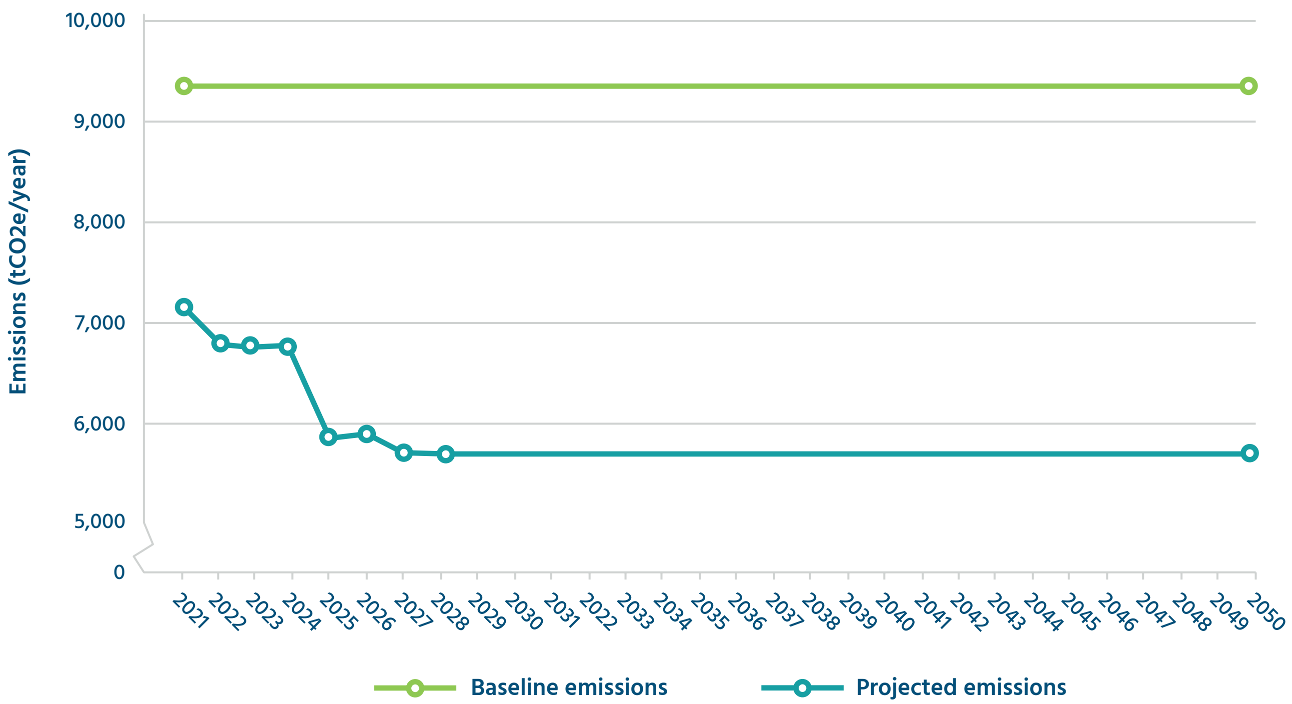

Figure 1 – Evolution of Baseline and Project emissions

Challenges and lessons learned

This section presents a summary of the GHG assessment process highlighting the challenges encountered and the solutions adopted by the impact assessment team.

Data collection process

The data collection process of the Jakarta E-bus Trial ran smoothly throughout the entire period. Data for an EV bus project are often easy to obtain due to the small number of parameters required, especially for smaller scale projects that do not have a wide variety of baseline or new bus types.

All the technical parameters such as type of diesel and zero-emission buses, fuel efficiencies, bus kilometres travelled and the number of buses were obtained from the study "E-Buses for BRT Corridors 1 and 6 of Transjakarta" commissioned by Grütter Consulting.

Uncertainties for all the e-bus related parameters of this project are considered low, highlighting how performing a GHG assessment after design parameters are defined greatly improves estimate accuracy and creates an efficient process.

Focus on electricity emission factor for e-bus projects

In countries with an major proportion of coal powered electricity generation such as is the case in Indonesia, the predicted GHG impact of the project can be heavily affected by the electricity grid emission factor is expected to evolve over time. The grid emission factor represents the emission intensity of the electricity being used in the project and is determined by the mix of electricity generation at national or regional level. While some cities do have the ability to influence their local grid mix or purchase electricity from specific electricity providers through PPAs, this option is not available in most cases. For Jakarta's pilot EV bus project, the regional grid mix for Java, Bali and East Nusa Tenggara was used.

A three step method was followed to calculate the electricity emission factor throughout the project's lifespan:

1. The current emission factor (for 2019) for the Java, Bali and East Nusa Tenggara grid was obtained from the Ministry of Energy and Mineral Resources yearly electricity statistics document.
2. Governmental targets for the grid mix were collected from National Government plans, detailing the evolution of the energy sources used to generate power for Jakarta's regional grid from 2019 to 2028[1]. The targets were used along with global average emission intensity per fuel and generation technology to calculate the emission intensity variation year-on-year.
3. This year-on-year variation was applied to the current emission factor to extrapolate the electricity emission factor from 2021 to 2028.

The absence of reliable emission reduction targets for the electricity sector beyond 2028 meant that the electricity emission factor was kept constant in subsequent years. Following the conservative principle used in project-level accounting, further emission factor reductions could not be projected beyond 2028 due to the lack of evidence.

The relatively low emission reductions created by the project also illustrate the vulnerability of some urban climate action projects to national governmental actions. While the current conditions allow the project to reduce emissions compared to the baseline, about 40% of total emission savings currently estimated will depend on the achievement of national policies. Those emission reductions can be viewed as conditional on national-level action.

When considering national emission reduction targets in the electricity sector, it is thus recommended to conservatively assess the feasibility of the policies described in order to decrease the risks of overestimating the emission reductions from the project. Such policies can often be found in a country's NDCs or in government plans for new renewable or fossil fuel power generation capacity. If substantial uncertainties exist around the national grid decarbonization actions, it may be appropriate to revise the calculations to use the current base year emission factor. This would dampen the project emission reductions.

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1. – The Java, Bali and East Nusa Tenggara regional grid's energy mix:
2020 - Coal 72.0%, natural gas 18.9%, geothermal 4.1%, hydropower 3.75%, fuel oil 1.2% & renewables 0.1%.
2028 target - Coal 57.4%, natural gas 24.7%, geothermal 8.3%, hydropower 6.5%, fuel oil 0.3% & renewables 2.8%.

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