Jakarta Bus Electrification: Health & Air Quality Impact Assessment

2021 Analysis – C40 Benefits of Urban Climate Action
Measuring air quality and health impact

Context
- Jakarta data

Climate action
- E-buses data

Output
- Change in air pollution transport emissions

Outcome
- Change in the city air pollution concentration

CRF/Multipliers
- PM$_{2.5}$ and NO$_x$ concentration-response functions to quantify the health impacts of air pollution reduction

Impact
- Health and health economic impact
Measuring air quality and health impact

Context

Jakarta data
- Air quality
- Population
- Number of deaths per year
- Hospital admissions (respiratory & cardiovascular)

E-buses data
- Type and number of buses
- Km travelled

Climate action

Output

Change in air pollution transport emissions

Outcome

Change in the city air pollution concentration

CRF/Multipliers

PM$_{2.5}$ and NO$_x$ concentration-response functions to quantify the health impacts of air pollution reduction

Impact

Health and health economic impact
- Reduction in premature deaths
- Increase in life expectancy
- Increase in life years
- Reduction in hospital admissions
- Value of statistical life (premature deaths)
- Healthcare costs
Understanding the benefits: Medellin electric buses

The city assessed the impact of electrifying all buses within the city (6,980), which are responsible for 21% of transport PM$_{2.5}$ emissions.

11,960 premature deaths each year in Colombia are due to PM$_{2.5}$ levels

BUSES represent 21% of road transport sector PM$_{2.5}$ concentration

-8.3% of PM$_{2.5}$ non-background concentration

37 deaths avoided per year

+6 days in life expectancy per person

24 hospital admissions avoided

COP $24$ MIL avoided healthcare costs

-8.3% of PM$_{2.5}$ non-background concentration

37 deaths avoided per year

+6 days in life expectancy per person

24 hospital admissions avoided

COP $24$ MIL avoided healthcare costs
Understanding the benefits: Bangalore electric buses

The city assessed the impact of electrifying all the private and public buses, which currently represent 25% of the transport PM$_{2.5}$ emissions.

PM$_{2.5}$ emissions coming from transport may double by 2030

-4.8% of PM$_{2.5}$ non-background concentration

1,325 deaths avoided per year

+32 days in life expectancy per person

1,815 hospital admissions avoided

INR 67M avoided healthcare costs
Understanding the benefits: Jakarta electric buses

In Jakarta, the annual average concentration of fine particulate matter is more than four times greater than the World Health Organization recommended safe level.
Understanding the benefits: Jakarta electric buses

Transport is a major source of both PM$_{2.5}$ and Greenhouse Gas (GHG) emissions in the city, with more than 17 million vehicles registered in the city.

- Half of Jakarta’s air pollution (PM$_{2.5}$ concentration) comes from the transport sector.

**PM$_{2.5}$ CONCENTRATION 4 TIMES HIGHER THAN THE WHO RECOMMENDED VALUE**

**123,700 PREMATURE DEATHS EACH YEAR IN INDONESIA ARE DUE TO AIR POLLUTION**
TransJakarta: 83% electrification scenario

12,172 buses expected to operate in the TransJakarta fleet in 2030. This analysis will quantify the air quality and health benefits of electrifying 83% of these, compared to rolling out 100% diesel Euro 2.

<table>
<thead>
<tr>
<th></th>
<th>83% electric</th>
<th>100% diesel (euro 2)</th>
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<tbody>
<tr>
<td></td>
<td>Large</td>
<td>Medium/small</td>
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<tr>
<td>Diesel buses (euro 2)</td>
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<tr>
<td>Electric buses</td>
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<tr>
<td>Total emissions</td>
<td>78</td>
<td>239</td>
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<td>(t PM$_{2.5}$/ year)</td>
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<tr>
<td>Total emissions</td>
<td>1,800</td>
<td>10,700</td>
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<td>(t NOx/ year)</td>
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</tbody>
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Results: 83% electrification by 2030

**PM$_{2.5}$**

-0.2% of PM$_{2.5}$
Non-background concentration

20 deaths avoided per year

+1 day in life expectancy per person

+340 Life years gained

INR 200M
Healthcare costs saved per year

INR 140B
Value of life saved per year

**NO$_x$**

-2.5% of NO$_x$
Non-background concentration

40 to 100 deaths avoided per year

+2 to 5 days in life expectancy per person

+650 to 1,700 Life years gained

INR 800M
Healthcare costs saved per year

INR 260 to 700B
Value of life saved per year
Assumptions and data inputs

**Population and health**

- Population and death data is from the Health Department of DKI Jakarta Province for the latest date available (2018 for population, 2016 for death rates). An increase of 21% (Oxford Economics) to the 2018 population was used to account for the population in 2030.

- No hospital admission rates are available – the current ones are proxy from the UK in 2018. This means it may be a conservative estimate as the air pollution in the UK (London for this data) is lower than the air pollution from Jakarta. Another aspect to consider is that behaviours to go to hospital related to diseases may be different across countries. More nationally/regionally specific data would improve the robustness of the study.

- The cost of hospital admission is based on influenza hospital admissions (2019), and used as a proxy for the cost of respiratory and cardiovascular hospital admissions. In its current form, it likely underestimates the savings.

- The Value of a Statistical life used to calculate the economic value of life saved uses a proxy value from Thailand, taken from the OECD database. This refers to the amount a sample of the population is willing to pay (in monetary terms) to reduce their risk of mortality.

- PM$_{2.5}$ and NOx concentrations are based on the average across all air pollution monitoring stations in 2019 in the city.

- The background concentration is based on the national average concentration of PM$_{2.5}$ in 2016 as no other local data or source apportionment was available to account for air pollution outside the city boundaries.

- The emission factors are generic from the European Environment Agency (euro), and do not reflect the traffic congestion nor the state of the roads.

Emissions coming from the increase in electricity-use for the new buses are not counted in the analysis: the increase in energy demand compared to energy demand from buildings and industry will not be significant enough to reflect on the city concentration. However, shifting to renewable energy is essential to ensure a clean air for all citizens.
Assumptions and data inputs

Source apportionment

• The share of PM$_{2.5}$ and NOx emissions attributed to Transjakarta’s buses was calculated based on the number of vehicles in the city, their average distance travelled per year and an average emission factor from Euro 2. Information on the vehicle fleet is based on Statistik Transportasi DKI Jakarta 2017 (data from 2016), as being the latest public data available.

• The share of PM2.5 attributable to transport in the city concentration is from the Breathe Easy study. NOx source apportionment is from the WHO database (2013).

2030 Electric vs Diesel scenario

• The daily average kilometres travelled per bus is assumed to be the same in 2030 as in 2020.

• The average kilometres travelled by large buses is 239 kilometres per day, as currently covered by the BRT system (Rencana Implementasi document from Transjakarta, 2021). For medium buses, they average 159 to 181 kilometers per day, and an average value of 170 has been used for this study. Medium and small buses have the same average kilometres travelled per day.

• For the electric scenario, 83% of the planned large and medium/small buses are presumed to be electric in 2030. The remaining buses in the fleet are assumed to be Euro 2 standard, to compare to the current level of the bus fleet. The number of buses has been provided in the Rencana Implementasi document from Transjakarta, 2021.

For NOX, the reduction in NOX due to bus electrification is 100%. Electric buses have no exhaust emissions from PM2.5 and NOX, as there is no engine combustion. However, all buses still have remaining PM2.5 emissions from non-exhaust sources such as tyres, road dust and brakes. This means that 100% of NOX emissions from buses can be reduced with electrification, and up to 75% of PM2.5 emissions (for electric buses against euro 2 diesel buses).
Thank you

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