URBAN ARTICLE 6 ACTIVITY: ELECTRIC BUSES POWERED BY RENEWABLE ENERGY IN YOGYAKARTA, INDONESIA

Perspectives Climate Research

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The following activity concept has been developed under the project 'Urban climate action: Pilot projects under Article 6 of the Paris Agreement in Indonesia and Thailand,' funded by the International Climate Initiative (IKI) of the German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU). This concept is designed to assist the Yogyakarta provincial and city government in leveraging international climate finance through Article 6 to implement sustainable urban action that will be self-sustaining and scalable, financed through the sale of emission reductions. It was developed in close collaboration with local stakeholders, coordinated by ICLEI Indonesia.

Background and context

Nationally, the energy sector is the second most emissions-intensive sector in Indonesia. In Yogyakarta City, the energy sector is the primary source of emissions, accounting for 90% of the total emissions. Within the energy sector, Yogyakarta City's emissions come mainly from electricity consumption (55%), transportation (25%), and stationary energy (20%) (Environment Agency of Yogyakarta City, 2017). Traffic in the city is dominated by private cars, scooters, motorized and traditional pedicabs, and regional bus transit. Bus transit is organized by Trans Jogja, which operates 128 buses serving 17 routes throughout Yogyakarta province, all running on diesel engines.

Given the high emissions of transit in Yogyakarta and Indonesia as a whole, electric mobility (e-mobility) is a priority area for potential Article 6 activities. Currently, the Provincial Transport Agency of Yogyakarta is planning to pilot three electric feeder buses in partnership with Trans Jogja in 2024 through the Malioboro district, a popular tourist and shopping area of central Yogyakarta. However, the buses would not be powered with a dedicated renewable energy installation, limiting the mitigation benefits of the feeder activity, given Indonesia's high percentage of fossil fuels in the energy mix. The transport agency also lacks the funding to implement the project as planned, partially due to impacts of the coronavirus pandemic on city and provincial budgets.

In addition, at a national level, the Indonesian government has not yet identified the electrification of public transport as part of its NDC. Notably, the only mitigation activities targeting public transport include switching to compressed natural gas consumption and energy efficiency measures.

These factors make electric transit a promising candidate for Article 6, which could leverage additional funding for e-mobility.

Activity design

Given Yogyakarta's barriers to introducing clean mobility, the envisioned Article 6 activity proposes converting all 128 diesel buses of the Trans Jogja fleet to electric buses, powered by renewable energy. The electric buses will be introduced gradually as the existing buses reach end-of-life, with charging stations introduced over time, as well. The activity will span 15 years, with 26 buses and 6-7 charging stations introduced each year for the first five years (a total of 128 buses and 32 charging stations).

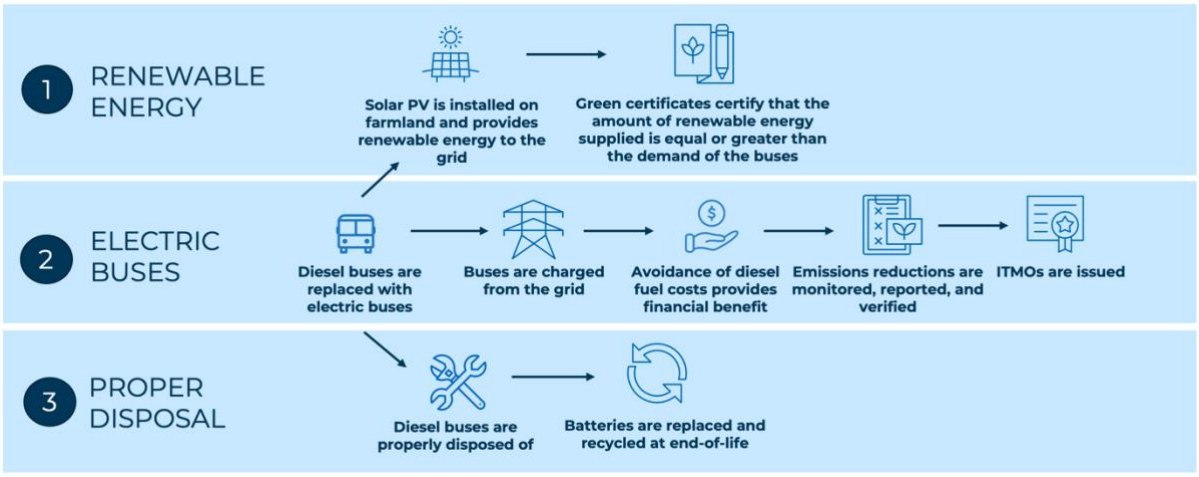
In local consultations, stakeholders identified the Ngabean parking area as a potential site for a bus depot with charging stations within the heart of the city.

To achieve significant emission reductions, the buses must be charged with renewable energy. As there is not sufficient space within the dense urban area to install sufficient solar PV capacity, renewable energy will be procured for the buses through green certificates, accounting for additional PV installed offsite that generates as much or more energy than the buses consume.

To ensure no negative environmental impacts, the retired diesel buses and e-bus batteries will be disposed of properly.

An overview of the activity design can be seen in Figure 1.

Figure 1: Overview of the activity concept



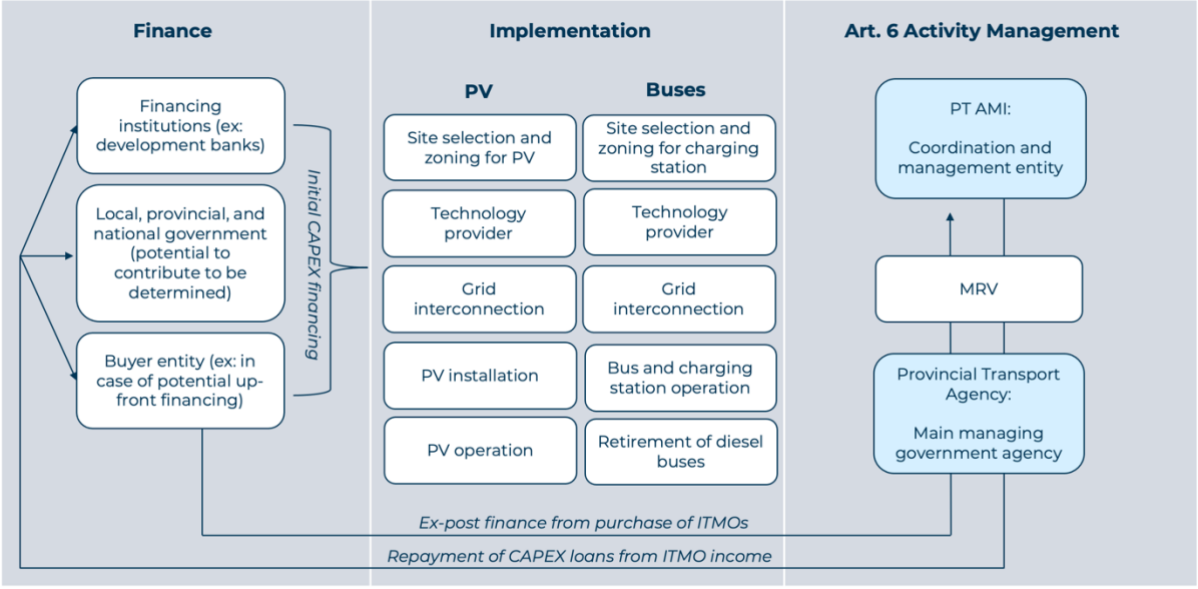
Source: Perspectives Climate Research

Institutional setup

Recent stakeholder consultations in Yogyakarta have already defined crucial roles within the activity design. The Yogyakarta Provincial Transport Agency has agreed to serve as the main managing government agency. PT AMI, the government-owned enterprise operating Trans Jogja, will serve as the coordination and management entity. Further roles and responsibilities of various stakeholders will be defined at a later stage.

An overview of the roles of various stakeholders in each component can be seen in Figure 2.

Figure 2: Overview of planned institutional setup



**Blue bubbles indicate roles which have been agreed upon with stakeholders.*
White bubbles indicate roles which must be clarified at a more advanced stage.

Source: Perspectives Climate Research

Mitigation potential and projected cost

The mitigation potential of this activity totals about 154,000 tCO_2e over 15 years. The total cost of the activity is estimated at approximately 63 million euros. At an ITMO price of 40-50 euros, the activity would result in cost savings of 75,000 euros over 15 years, taking into account savings on fuel, ITMO revenues, and the retirement of diesel buses. An overview of the activity cost and mitigation potential can be seen in Table 1.

The implementation of e-mobility in Yogyakarta's public transport has significant potential for replicability and upscaling across Indonesia's major cities. By leveraging the lessons learned from Yogyakarta's e-mobility initiative, other cities can tailor similar strategies to their unique contexts, paving the way for a cleaner and more sustainable transportation network nationwide.

Table 1: Emissions reduction potential of the activity

Emission reduction potential of the electric bus activity																
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**TOTAL**
Number of e-buses (total)	26	51	77	102	128	128	128	128	128	128	128	128	128	128	128	128
Number of charging stations required (total)	6	13	19	26	32	32	32	32	32	32	32	32	32	32	32	32
Total cost of e-buses + chargers (per year) (CAPEX + OPEX)	6,575,140 €	6,857,740 €	7,094,140 €	7,370,300 €	7,635,260 €	2,336,060 €	2,336,060 €	2,336,060 €	3,211,196 €	3,211,196 €	3,211,196 €	3,211,196 €	3,211,196 €	2,336,060 €	2,336,060 €	63,268,863 €
Total cost of diesel buses (per year)	3,875,760 €	4,513,367 €	5,163,358 €	5,826,102 €	6,501,980 €	3,284,338 €	3,317,523 €	3,351,372 €	3,385,897 €	3,421,114 €	3,457,034 €	3,493,673 €	3,531,045 €	3,569,164 €	3,608,045 €	60,299,772 €
Emissions reductions (tCO2e/yr)	2,367	4,734	7,100	9,467	11,834	11,834	11,834	11,834	11,834	11,834	11,834	11,834	11,834	11,834	11,834	153,841
Income from sale of ITMOs (EUR)	106,506 €	213,011 €	319,517 €	426,022 €	532,528 €	532,528 €	532,528 €	532,528 €	532,528 €	532,528 €	532,528 €	532,528 €	532,528 €	532,528 €	532,528 €	6,922,863 €
Annual Savings	-2,592,874 €	-2,131,362 €	-1,611,266 €	-1,118,176 €	-600,753 €	1,480,806 €	1,513,991 €	1,547,839 €	707,229 €	742,445 €	778,366 €	815,005 €	852,376 €	1,765,632 €	1,804,513 €	- 33,423,252 €
Discount rate	5%															
Costs-Savings (15 years)	**75,890 €**															

Source: Perspectives Climate Research

The promotion of e-mobility has the potential to be a truly transformational activity, supporting Indonesia's transition to net-zero emissions by reducing dependence on fossil fuels and promoting sustainable means of transportation.

If you would be interested in purchasing ITMOs from this activity, please contact butzengeiger@perspectives.cc.