URBAN ARTICLE 6 ACTIVITIES

URBAN ARTICLE 6 PILOT CANDIDATES IN ADDIS ABABA AND KAMPALA

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ABOUT THE PROJECT

Abstract

This publication presents potential urban Article 6 activities in Addis Ababa, Ethiopia and Kampala, Uganda. These case studies were developed as part of the project 'Urban market approaches under Article 6 of the Paris Agreement – Recommendations for practical implementation', focused on developing concrete structures for the use of urban carbon market approaches in Ethiopia and Uganda. Four case studies are presented in priority sectors: 1) Transition to electric cooking in Kampala, 2) Bus rapid transit in Kampala, 3) E-mobility in Addis and 4) Green cooling in Addis health facilities. Emission reduction potential and investment costs have been estimated for each project, along with suspected practical challenges that may arise during the implementation process. Based on stakeholder consultation and positive cost-benefit analysis, several case studies can be identified that hold significant potential for adoption in Uganda and Ethiopia, with the potential for replication across Africa and similar contexts. The most promising case studies – electric cooking in Kampala and e-mobility in Addis – should be developed further towards implementation due to their high environmental and benefits and low costs.

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Disclaimer

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TRANSITION TO ELECTRIC COOKING IN KAMPALA

In the Greater Kampala Metropolitan Area (GKMA), under the business-as-usual scenario, GHG emissions are projected to increase from 6.9 million tCO_2e in 2014 to 14.6 million tCO_2e in 2030. The household sector is currently the greatest contributor to GHG emissions in Kampala, and is estimated to be the second-greatest in 2030, after the transport sector.[1] This is predominantly a result of the fuel types used for cooking, with 76% of households using charcoal in 2019/2020 as opposed to other energy sources.[2] Addressing household cooking is therefore a priority with regards to climate change mitigation in Kampala.

Transitioning households (particularly those in urban areas) to electric cooking has been highlighted by Uganda's Ministry of Energy and Mineral Development (MEMD) as a priority, as around 90% of Kampala's electricity is renewable, sourced from hydropower. The majority of households in Kampala (57%) are connected to the national grid, yet choose to cook with charcoal and other fuel types because of the relatively high cost of electricity. In response to this, Uganda's Electricity Regulator Authority (ERA) introduced a 'Cooking Tariff' in January 2022 to incentivise electric cooking, where a reduced tariff (0.11 USD/kWh) is applicable for units consumed between 81-150 kWh. However, some barriers to uptake still remain: i.e., the perception that electricity is one of the most expensive forms of energy and the upfront cost of efficient electric cooking technology. These should be the entry points for the Art. 6 programme.

The objectives of the Art. 6 programme would be as follows: i) increase uptake of electricity for cooking – with ~90% of Uganda's electricity supply being renewable, a transition to electric cooking will significantly reduce GHG emissions when compared to traditional biomass; ii) capitalise on and support the introduced 'Cooking Tariff' to maximise uptake of electric cooking; iii) overcome the initial investment barrier for households; and iv) raise awareness on the benefits of clean cooking.

To achieve these objectives, a number of potential policy measures could be put in place. Discounts/subsidies could be introduced for households – for example, grants or loans for purchasing efficient electric cooking technology. If necessary, subsidies/grants/loans could be provided to private sector producers of electric cooking technology for large-scale production and distribution under the programme. For example, electric pressure cookers with integrated meters to monitor use could be distributed to 50,000 households to enable easy monitoring of progress. This corresponds to control-group approaches commonly used for similar project types under the CDM. There could also be a role here for national minimum efficiency performance standards, which appliances would need to meet to be eligible. Finally, an awareness-raising programme could be implemented for households in Kampala to counter the public perception of electricity being the most expensive option and to increase knowledge of the health benefits of switching from charcoal to electricity.

[1] Kampala Capital City Authority (KCCA) (2016): Kampala Climate Change Action Strategy, Kampala

[2] Uganda Bureau of Statistics (UBOS) (2021): Uganda National Household Survey 2019/2020, Kampala

The estimated emission reduction potential is summarised in Table 1 (conservative scenario) and Table 2 (optimistic scenario). The estimates show that the emission reduction potential is substantial: over a 10-year period, emission reductions accumulate to 4.1 million tCO_2e (conservative scenario), and 8.4 million tCO_2e (optimistic scenario).

Table 1: Emission reduction potential – conservative scenario (0.15 t charcoal/yr)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
# households Kampala total	564,050	593,380	624,236	656,696	690,845	726,769	726,796	804,318	846,142	890,142
% transformation to electric cooking	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40
# electric devices	22,562	47,470	74,908	105,071	138,169	174,424	214,077	257,382	304,611	356,057
ER (t CO_2/ yr)	**55,457**	**116,681**	**184,123**	**258,263**	**339,615**	**428,730**	**526,195**	**632,637**	**748,726**	**875,177**
Cumulative ER (t CO_2)	**55,457**	**172,138**	**356,260**	**614,523**	**954,138**	**1,382,869**	**1,909,064**	**2,541,701**	**3,290,427**	**4,165,604**

Table 2: Emission reduction potential – optimistic scenario (0.3 t charcoal/yr)

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
# households Kampala total	564,050	593,380	624,236	656,696	690,845	726,769	726,796	804,318	846,142	890,142
% transformation to electric cooking	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40
# electric devices	22,562	47,470	74,908	105,071	138,169	174,424	214,077	257,382	304,611	356,057
ER (t CO_2/ yr)	**112,734**	**237,192**	**374,288**	**525,002**	**690,378**	**871,533**	**1,069,661**	**1,286,038**	**1,522,026**	**1,779,080**
Cumulative ER (t CO^2)	**112,734**	**349,952**	**724,214**	**1,249,216**	**1,939,593**	**2,811,126**	**3,880,787**	**5,166,825**	**6,688,852**	**8,467,931**

For the initial cost estimates, the conservative scenario was used. We assume the introduced 'Cooking Tariff' to be continued. Hence, key components of the suggested Art. 6 programme would be: i) a subsidy of investment costs (buying electric cooking devices); and ii) an awareness-raising programme to motivate households to switch. Table 3 summarises expected annual costs. Total cost over the 10 year-period amounts to USD 1.4 million.

Table 3: Estimated cost of the suggested urban Art. 6 programme

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
# households Kampala total	564,050	593,380	624,236	656,696	690,845	726,769	726,796	804,318	846,142	890,142
% transformation to electric cooking	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40
# electric devices	22,562	47,470	74,908	105,071	138,169	174,424	214,077	257,382	304,611	356,057
# electric pressure cookers	11,281	23,735	37,454	52,536	69,084	87,212	107,038	128,691	152,306	178,028
# electric cookplates (USD)	11,28	23,735	37,454	52,536	69,084	87,212	107,038	128,691	152,306	178,028
Additional cost electric pressure cookers (USD)	321,213	354,619	390,631	429,429	471,206	516,166	564,529	616,525	672,402	732,424
Additional cost cook plates (USD)	176,667	195,040	214,847	236,186	259,163	283,891	310,491	339,089	369,821	402,833
Awareness raising campaign	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
Total cost	**747,880**	**799,659**	**855,478**	**915,615**	**980,369**	**1,050,058**	**1,125,019**	**1,205,614**	**1,292,233**	**1,385,257**

Based on the emission reduction and cost estimates provided above, an ITMO price of USD 5 appears to be more than sufficient to finance the programme.[3] Considering the current Art. 6 market outlook, it might be possible to reach significantly higher ITMO prices. Surplus revenues could then be used to cross-fund: i) investments in better renewable electricity and grid infrastructure; or ii) other Art. 6 activities with higher abatement costs, such as a Bus Rapid Transport (BRT) programme, or any other urban Art. 6 programme in Kampala or Uganda.

The proposed Art. 6 activity 'Transition to electric cooking in Kampala' can result in significant benefits for climate (reduces emissions from using charcoal produced from non-renewable biomass), health (reduced indoor pollution causing respiratory diseases), and landscapes (reduced pressure on forests). With 4-8 million tCO_2e over a 10 year-period, the suggested Art. 6 activity has a high emission reduction potential, even at moderate conversion rates (4%/yr). In addition, investment costs are comparatively low, so that low ITMO prices would be sufficient for re-financing the activity. Potential higher ITMO-prices may allow for broadening of the activity or cross-funding other mitigation activities in Kampala/Uganda characterised by higher abatement costs.

[3] All assumptions would need to be verified in a more detailed feasibility study, which is beyond the scope of this work. Overhead and administrative costs would also need to be added in line with the actual structures of the programme.

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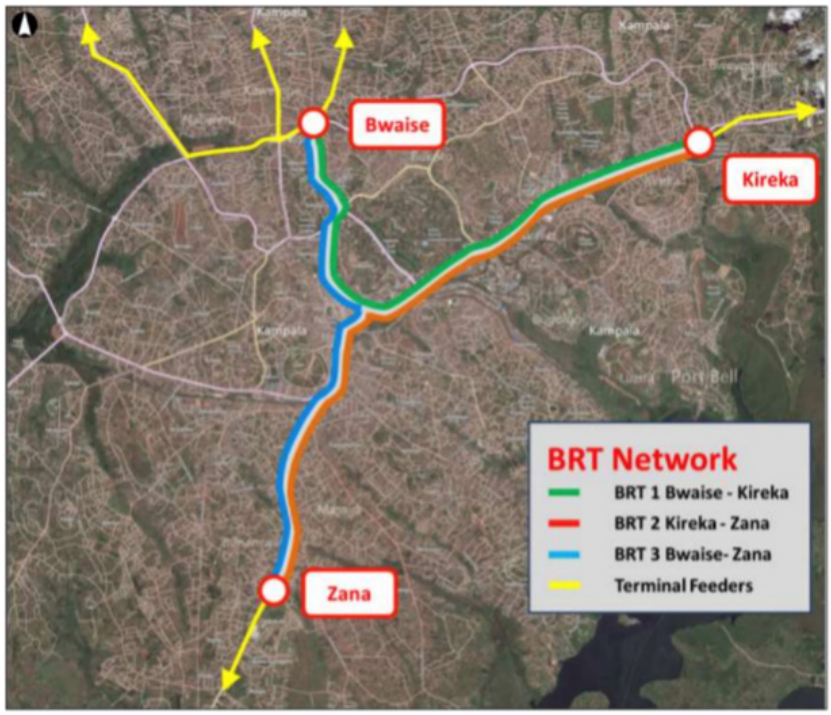
BUS RAPID TRANSIT IN KAMPALA

To address climate change in Kampala, transportation is a key sector. Under a business-as-usual scenario, transportation is estimated to be the largest contributor of emissions, totalling 31% of total emissions by 2030, primarily due to use of old vehicles, small omnibuses (called 'matatus'), congestion and heavy reliance on imported fossil fuels. Transit in Kampala, Uganda is currently dominated by minibuses and motorbike taxis ('boda bodas'), resulting in highly congested streets and significant air pollution. A number of transit options have been proposed to reduce congestion and promote sustainable transportation, including bus rapid transit.

A bus rapid transit system is promising as a project with clearly quantifiable mitigation benefits that will reduce emissions and provide safe transit to citizens of Kampala. A bus rapid transit system (BRT) consists of dedicated road lanes that cannot be used by vehicles other than buses, ensuring buses do not sit in traffic and providing quick and efficient transit. This concept considers a 25km pilot project of three main lines along Bombo Road, Entebbe Road and Jinja Road that pass through the city centre. The pilot would be operated by 165 buses, 18m long, with a capacity of 150 passengers each. Five additional feeder lines would link the main lines to outlying districts.



Source: Spooner et al. (2020)

The cost of this three-line pilot is estimated at USD 429 million, including USD 400 million for construction of BRT infrastructure (including lanes, stations, terminals, signalling, ticketing etc.) and USD 29 million for land acquisition and resettlement. Direct operating costs are approximated at USD 11.8 million per year for the pilot lines. Total operating costs (direct operating costs, systems management, vehicle fleet leasing and infrastructure maintenance) are estimated at approximately USD 21.4 million per year. Annual revenue is projected to total USD 37.4 million, including leakage from fare evasion.

The still-prevailing barrier for implementation is a lack of funding. Though the project was proposed over 11 years ago and has the full support of the Kampala Capital City Authority, no further steps towards implementation have been taken due to lack of financing. Art. 6 could help overcome this barrier. The additional revenue from Article 6 emissions reductions could help in making the project bankable and economically viable. The main policy instruments involved within this project are as follows:

- Subsidised construction of BRT lanes
- Subsidised tickets for low-income groups
- Marketing campaign/environmental awareness-raising (to make citizens aware of the benefits of the new bus system and promote ridership)
- Potential boda boda integration policies (such as subsidising purchase of electric (or other low-carbon) boda bodas with additional Art. 6 funds)

With a view to make the overall project feasible and achieve implementation, Article 6 funding should first be used to cover construction costs. Potential excess revenues may then be used to subsidise ticket prices for selected groups. Fare reductions could begin at 15-30% and increase depending on the revenue of the BRT system. For a 15% fare reduction (from an average ticket price of UGX 1225 to UGX 1041), the total cost of providing this reduction would be UGX 36.3 billion (USD 10.2 million). For a 30% fare reduction (from an average ticket price of UGX 1225 to UGX 858), the total cost would be UGX 72.7 billion (USD 20.3 million).

Under the initial assumptions, the Uganda Development Bank would provide (most of) the initial funding for the project through a loan, which will be repaid with revenue from ticket sales and ITMO-sales once the BRT-system is operational. The Uganda Development Bank could distribute the CAPEX funds to the KCCA, who will act as project coordinator and forward funds to the Ministry of Works and Transport for its implementation tasks. The KCCA will monitor ridership and report emissions reductions data to the Ministry of Water and Environment, who—as the national focal point—will communicate this data to the UNFCCC, securing Art. 6 revenue.

Total baseline emissions for taxis, boda bodas and minibuses are approximately 494,000 tCO_2e/year. Based on approximations from available data, a diesel BRT system would emit approximately 12,600 tCO_2e/year, while an electric BRT system would emit only 700 tCO_2e/year.

Current emissions and potential emission reductions						
	Number of vehicles (vehicles/day)	Average emissions (g/km)	Average distance (km/day)	Annual emissions (tCO_2/year)	Annual emission reductions (assuming 5% decrease in alternate vehicles) (tCO_2/year)	Annual emission reductions (assuming 20% decrease in alternate vehicles) (tCO_2/year)
Taxis	25,000	190	60	104,025	5,201	20,805
Boda bodas	250,000	70	50	319,375	15,969	63,875
Minibuses	8,000	220	110	70,664	3,533	14,133
Projected diesel BRT emissions	165	860	243	12,568	12,568	28,278
Projected electric BRT emissions	165	49	243	717	717	717
	Total annual emission reductions (tCO_2/year) (electric buses)				**23,986**	**98,096**
	Total annual emission reductions (tCO_2/year) (diesel buses)				**12,135**	**70,535**

Source: Authors' calculation based on data from Government of Kenya (2019), ICCT (2012), Spooner et al. (2020), and World Bank et al (2010).

Potential emission reductions range between 12,135 tCO_2e/year (for diesel buses reducing use of alternate vehicles by 5%) and 98,096 tCO_2e/year (for electric buses reducing alternate vehicles by 20%).

ITMO income from 2024 (project start) to 2040 can also be estimated. Assuming a price of USD 25/tCO_2e, for the average diesel scenario, ITMO income would increase from USD 1 million in 2024 to USD 2.1 million in 2040. For the average electric fleet scenario, ITMO income starts at USD 1.5 million and increases to USD 3.1 million.

Net present value (NPV) can also be calculated. NPV totals USD -274 million for the average diesel scenario, while it stands at USD -210 million for the average electric bus scenario, due to the increased income from ITMOs. This compares to an NPV of USD -303 million (diesel buses) and USD -246 million without any ITMO-revenues. From these calculations, it is clear that sale of ITMOs can contribute to project finance, but at a price of USD 25 will not completely cover capital and operating expenses. Following the same assumptions, an ITMO-price of USD 110 would be required to achieve a positive NPV for the case with highest emission reductions (electric buses, 20% replacement of conventional vehicles) until 2040.

Overall, a bus rapid transit system could provide significant emission reductions and contribute to safer transit and reduced congestion in Kampala, though the high capital expenditure necessary means that ITMO revenue will only result in a positive NPV at a price of USD 110/tCO_2e. If stakeholders are interested in pursuing this idea further, a more detailed feasibility-study needs to be conducted and potential barriers, such as land acquisition and resistance from boda boda drivers, must be addressed.

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E-MOBILITY IN ADDIS ABABA

Around 70% of registered vehicles in Ethiopia are found in Addis Ababa. The transport sector in Addis accounts for approximately 11.26 million tCO_2, or about 78% of the city's total emissions. Road transport makes up around 51% of the total emissions of the city.[1] Despite the heavy tax on imported cars, the number of cars in Ethiopia has been rapidly increasing. Around 110,000 cars were imported in 2016, i.e., a 50% increase compared to the preceding two years. This trend is expected to continue in the future. Around 85% of imported cars in Ethiopia have an average age of 20 years and most of these cars are highly polluting. The Ministry of Transport aims to reduce GHG emissions from the transport sector by introducing different measures ranging from expanding public transportation to promoting e-mobility. The Ministry plans to introduce 4,850 electric buses and 148,000 small electric vehicles by 2030, but concrete measures and financing are still lacking.[2] Marathon Motor Engineering, a joint venture between Hyundai Motor Company and Olympic Champion Haile Gebrselassie, started producing the electric Hyundai Ioniq in Ethiopia in 2020.[3] However, as of today e-mobility in Addis is marginal and currently out of sight both for businesses and private users due to significant investment barriers: the price of (new) electric vehicles is 5-10 times that of (used) conventional cars. Also, charging infrastructure is lacking. It is important to note that the operation of electric vehicles is much cheaper than that of conventional cars due to continuous savings on diesel/gasoline and maintenance. Hence, one 'only' needs to overcome the initial investment barrier.

The objective of the proposed *Addis Article 6 e-mobility programme* is to initiate and expand use of e-mobility in Addis. With a 90% share of renewables in the electricity mix, shifting to e-mobility holds significant potential of emission reductions compared to diesel-/gasoline-driven vehicles.

In the initial phase, the Art. 6 programme could start with the taxi services market segment (small taxis and mini-buses), as they have a high utilisation rate and thus high fuel savings. Applying a programmatic approach, it would be possible to add other market segments (e.g. two-/three-wheelers; private cars) in subsequent steps.

The proposed *Addis Article 6 e-mobility programme* should apply a combination of the following measures and policies to promote the switch to electric taxis:

- Price premiums to reduce the cost difference between electric vehicles and conventional cars, thus making a switch more attractive for taxi owners;
- Zero- or low-interest loans for electric taxis/mini-buses to incentivise an early switch;
- Tax benefits for electric taxis/mini-buses;
- Public investments in level 3 charging stations (quick-chargers) to allow for transformation towards e-mobility; and
- Further economic incentives can be provided by offering free-of-charge or low-cost charging stations.

[1] Capital (2022): Marathon Motor launches first electric vehicle charging station, January 3, 2022, here (accessed January 01, 2022)

[2] Ministry of Transport (2020): Transport sector ten years perspectives plan, Addis Ababa

[3] Kuhudzai Remeredzai (2020): 1st Ethiopian-assembled all electric Hyundai ioniq rolls out of Haile Gebrselassie's Marathon Motor Engineering Plant, CleanTechnica, July 27, 2021, here (accessed January 15, 2021)

Considering the constant growth of the transport sector in Addis since the early 2000s, we assume a total of 15,000 mini-buses and 5,000 small taxis and an average travel distance of 200km per vehicle to derive an initial estimate of the emission reduction potential of the proposed programme.[4]

Total emission reduction will depend on the share of conventional cars replaced. Table 1 summarises the emission reduction potential over a period of 15 years for a moderately ambitious roll-out plan. The cumulative emission reductions over the 15-year period amount to about 4,500,000 tCO_2.

Table 1: Emission reduction potential – electrification of taxi services in Addis (initial estimate)

	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Replacement by EVs	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1	1	1	1	1	1
ER (t CO_2)	79,523	119,285	159,049	198,808	238,570	278,331	318,093	357,855	357,616	397,616	357,616	357,616	357,616	357,616	357,616
Total until 2030	1,073,564														
Total until over 15 years (2033)	**4,532,827**														

Our analysis shows that operating an EV is more economically attractive than a conventional taxi. If the additional capital expenditure (CAPEX) for electric vehicles is low (here: USD 10,000), the higher purchase price is levelled out by saved fuel costs after only two years. Over a 15-year period, a positive NPV of USD 63,000 can result. If the additional CAPEX is high (here: USD 35,000), the higher purchase price is levelled out by saved fuel costs after seven years. Over a 15-year period, a positive NPV of USD 39,000 results, as shown in Table 2.

Table 2: Cost and revenue analysis for small taxis (high CAPEX scenario)

Small taxis (USD)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Additional CAPEX new EV compared to new ICE (per vehicle)	35,000	-	-	-	-	-	-	-	-	-
Saved fuel cost per EV (USD/yr)		4,765	4,765	4,765	4,765	4,765	4,765	4,765	4,765	4,765
Saved maintenance cost per EV (USD/yr)		150	150	150	150	150	150	150	150	150
Annual balance	- 35,000	4,915	4,915	4,915	4,915	4,915	4,915	4,915	4,915	4,915
Total balance	- 35,000	- 30,085	- 25,169	- 20,254	- 15,338	- 10,423	- 5,507	- 592	- 4,324	- 9,239
NPV	**$38,731.60**									

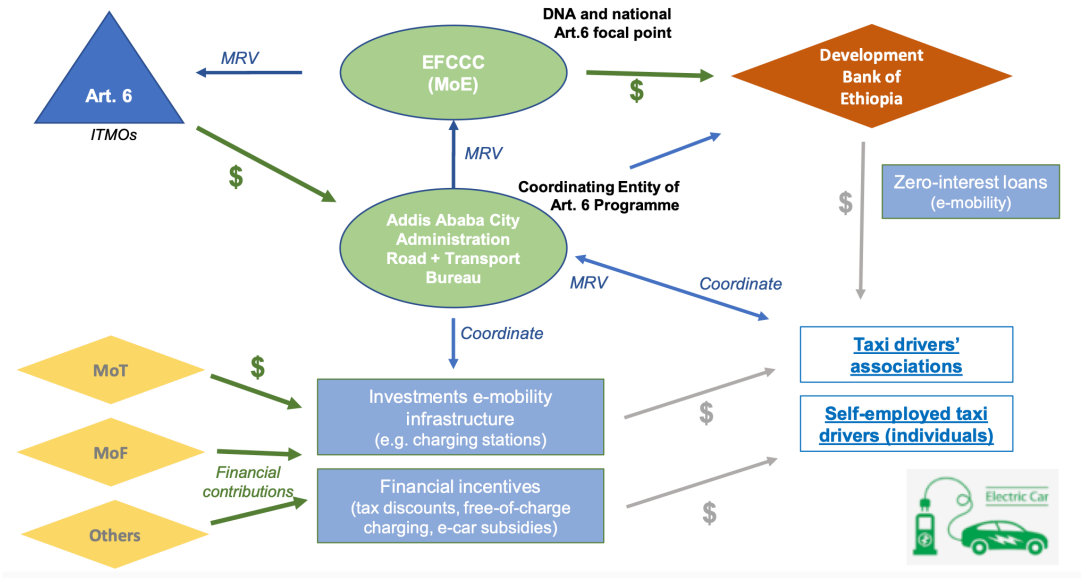
[4] These numbers need to be verified and updated as part of a more detailed analysis.

The city authority of Addis and/or the Government of Ethiopia would need to invest in reliable quick-charging stations as a system enabler. Assuming CAPEX for a level-3 charger of USD 27,500 and annual operation costs (OPEX) of 20% of CAPEX, a total investment of USD 24 million would be required.

Our analysis shows that such costs can be financed by an annual 'flat-rate' fee of 500 USD, payable by taxi owners. This would be sufficient to cover CAPEX and OPEX of the charging stations. From the taxi owner's point of view, the NPV of their switch to e-mobility would be lower, but still clearly positive (USD 55,000 for the low-CAPEX scenario, and USD 31,000 for the high-CAPEX scenario). For more details, please see the full report.

The following figure visualises how different policies can be structured under an Art. 6 programme, as well as potential roles of key stakeholders. The proposed structure is to be discussed with the relevant stakeholders in Addis and Ethiopia.

Figure 1: Possible structure and involved stakeholders for small taxis and mini-buses



Source: Authors

The research undertaken for this case study indicates that the proposed Art. 6 activity could result in significant benefits for:

1. the climate, due to a large-scale reduction in emissions (4.5 million tons CO_2e over a 15-year-period);
2. the economic well-being of taxi owners/operators, as they will be enabled to increase their net-earnings; and
3. the health of Addis Ababa's population by reducing local pollution from the transport sector.

As the initial economic assessment shows, savings from avoided fuel costs are so substantial that a shift to electric vehicles is economically attractive for taxi owners and can be designed to be cost-neutral for governmental institutions building the required charging infrastructure.

The key challenge is to overcome the investment barriers that come with the high upfront costs of electric vehicles and charging infrastructure. This can be achieved by financing mechanisms where the funding agency or bank provides a loan to taxi owners. ITMO revenues could be used either as securities or for investing in renewable energy and/or grid infrastructure that may be needed to provide and expand reliable, zero-carbon charging services.

Such approaches would need to be explored in more detail, in close collaboration between local actors and national and international funding agencies/ITMO buyers.

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GREEN COOLING IN ADDIS ABABA HEALTH FACILITIES

Background

Nearly all households in Addis Ababa have access to electricity, mainly through grid connection.[1] However, there are frequent and long hours of power outages.[2] Unreliable power supply poses critical challenges in particular to health facilities. Addis Ababa hosts the largest number of health facilities in Ethiopia: 101 public health centres and 13 hospitals, which are managed by the city administration office and the federal government.[3] The city envisages becoming a medical tourism hotspot. With the outbreak of Covid 19, reliable energy access in health service centers is more critical than ever for a city like Addis with more than 5 million people.

Diesel generators are the main backup energy source during power outages. While the country's Cold Chain Rehabilitation Plan (2014-2018) aims to strengthen the health sector's cold chain capacity by replacing kerosene cooling machines with solar-powered cooling machines, a lack of available funding has so far prevented its implementation.[4]

Replacing existing diesel generators in public health facilities with 'green cooling' devices, i.e. solar-powered refrigerators and freezers using modern cooling agents with low climate impacts, could be turned into an Article 6 pilot.

Proposed 'Article 6 Green Cooling in Health Facilities' programme

The Article 6 Green Cooling in Health Facilities programme aims to strengthen sustainable energy access in Addis Ababa. The programme has the following key objectives:

- Deployment of green cooling technologies in public health facilities;
- Replacing existing diesel generators; and
- Broadening the energy supply basis; i.e., reducing dependency on grid electricity.

These objectives can be achieved through various policy instruments, such as direct subsidies for purchasing new green cooling devices, low-interest loan schemes, or tax reduction. If applied on a broader scale – i.e. going beyond use in hospitals – an awareness raising programme could be helpful.

[1] GoE (2019): National electrification program 2.0 integrated planning for universal access, Government of Ethiopia, Addis Ababa

[2] Meles, Tensay (2020): Impact of power outages on households in developing countries: evidence from Ethiopia, in: Energy Economics, 91, p. 1-11

[3] Addis Ababa Health Bureau (2022): Covid-19 prevention and regulation measures, here (accessed January 14, 2022)

[4] GoE (2015): Ethiopian national expanded programme on immunization, comprehensive multi-year plan 2016- 2020, Federal Ministry of Health, Addis Ababa

Initial quantitative assessment

Estimation of the emission reduction potential

To assess the emission reduction potential of the potential Art. 6 programme, the typical energy consumption for cooling in hospitals has been investigated. Unfortunately, data availability for Addis/Ethiopia is poor, so the estimation below relies on a high number of assumptions.

Assuming that diesel generator sets run approximately one hour per day in hospitals, and are replaced by solar-powered green cooling devices, about 800 tCO_2/yr can be avoided in total for all hospitals and health stations in Addis. Besides, green cooling devices have the advantage of utilising fewer harmful cooling agents. The global warming potential (GWP) of old cooling agents often is extraordinarily high – e.g., the GWP of R124a is 1530, compared to a GWP of 3 of the new cooling agent iso-butane. Avoiding leakage of harmful cooling agents and replacing them with less harmful substances in green cooling devices could further reduce emissions by 300 tCO_2e per year, as seen in Table 1. This, however, requires a proper recycling system for replaced devices.

Table 1: Emission reduction estimate for Addis's green cooling programme

In total, the annual emission reduction potential can be estimated as 1,000 tCO_2e/year, or 20,000 tCO_2e over 20 years.

Emission reduction potential	
Co_2 emissions gen-sets	791 t CO_2/yr
Avoided leakage of cooling agents (required proper recycling system!)	291 t CO_2/yr
Total	**1,082 t CO_2/yr**

Estimation of costs and required ITMO-prices

Assuming 8 mid-size refrigerators and 2 freezers per hospital, and half this amount for health wards, we estimate a total of 508 refrigerators and 127 freezers in Addis's health sector that could be replaced. With the assumed investment-and recycling costs per device summarised in Table 3, the replacement and recycling would accumulate to about USD 390,000.

Table 3: Cost estimate for Addis's green cooling programme

Costs	Number of units	USD/device	USD total
PC refrigerators	508	500	254,000
PC freezers	127	600	76,200
Recycling costs cooling agents		100	63,500
Saved fuel costs			- 5,519
Total			**388,181**
ITMO revenues @24 USD/ITMO (15yr)			**389,458**

Based on these numbers, an ITMO price of USD 24 would be necessary to break even.

Conclusions

Introducing green cooling devices, combined with proper recycling of old coolers,can result in significant environmental benefits. If applied in the health sector, improved cooling chains also result in significant health benefits by improving quality and reliability of medical services.

However, as the emission reduction benefits per cooling device are small, a high number of cooling devices need to be included to achieve significant total impact. This would call for a programmatic approach covering a high number of consumers. Working with hospitals and potentially other public buildings (e.g. schools, administration buildings) etc. can be a good starting point and allows for learning and introduction of processes and infrastructure (e.g. recycling, local manufacturing green cooling).

In order to make the activity more interesting for potential donors, investors and ITMO purchase entities, the scope of the Art. 6 activity should be expanded to reach sufficient scale. Potential options for up-scaling are:

- Business centres;
- Agricultural value chains (food security, horticulture);
- Public markets; and
- Private households.

In the health sector itself, options to increase the emission reduction potential would be to expand the activity to the introduction of energy efficient lighting (if not yet implemented), and the installation of solar PV rooftops, potentially combined with battery storage as back-up.

CONCLUSIONS AND NEXT STEPS

This publication presented case studies for potential implementation under Article 6 of the Paris Agreement in Addis Ababa, Ethiopia and Kampala, Uganda as part of the project 'Urban market approaches under Article 6 of the Paris Agreement – Recommendations for practical implementation'. The project focused on developing concrete structures for the use of urban carbon market approaches in Ethiopia and Uganda, developing four case studies in priority sectors: 1) Transition to electric cooking in Kampala, 2) Bus rapid transit in Kampala, 3) E-mobility in Addis and 4) Green cooling in Addis' health facilities.

Overall, the **electric cooking activity in Kampala was found to be the most promising, offering high emission reduction potential at comparatively low ITMO prices,** facilitated by the high penetration of renewables in Uganda's grid. For the same reason, **the proposed e-mobility programme in Addis also offered high potential.** Here, the main barrier currently is the initial purchase of EVs, but fuel savings result in a short payback period. Purchase of EVs could therefore be incentivised with tax reductions, subsidies, etc. Again, comparatively low ITMO prices would be sufficient to unlock significant emission reduction potential.

The bus rapid transit project—while a local priority—requires high ITMO prices to cover the substantial construction costs to implement such a system, reducing the financial viability. However, increased public transit options in Kampala could bring significant social and environmental benefits.

Green cooling in health facilities will only bring limited emission reductions, unless uptake is widespread also beyond the health sector. There are several options for moving beyond the health sector, i.e., targeting agricultural value chains (food security, horticulture), public markets, business centres and even private households. Those options could be explored in more detail.

There is also high potential for replication across Africa and similar contexts.

The most promising case studies – electric cooking in Kampala and e-mobility in Addis – should be developed further towards implementation due to their high social and environmental benefits and low costs. With a view towards implementation, an in-depth feasibility study for each case study should be completed to obtain more precise cost and revenue estimates. Then, next steps would include identifying possible donor agencies and reaching out to potential ITMO buyers. These activities have the potential to unlock significant emission reductions as well as social- and health-related co-benefits at comparatively low cost to local and national government, assisted by Article 6.

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