Final report

Scoping carbon market instruments to unlock carbon finance for sustainable mobility in Sub-Saharan Africa

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Shell Foundation | AMPERSAND | IGC International Growth Centre | south pole

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Acronyms and abbreviations

ACR	American Carbon Registry
CCBS	Carbon, Community and Biodiversity Standard
CCF	Climate Cent Foundation
CDM	Clean Development Mechanism
EV	electric vehicle
EPA	Environmental Protection Agency
GHG	greenhouse gas
GPS	global positioning system
GS	Gold Standard
IGC	International Growth Center
IPCC	Intergovernmental Panel on Climate Change
ITMO	Internationally Transferred Mitigation Outcomes
kWh	kilowatt hours
LoI	Letter of Intent
MPG	miles per gallon
MRV	monitoring, reporting and verification
MWh	megawatt hours
NDC	Nationally Determined Contribution
REMA	Rwandan Environmental Management Authority
SCF	Standard Crediting Framework
SDG	Sustainable Development Goal
tCO_2e	tonnes of carbon dioxide equivalent
TPI	Transition Pathway Initiative
TSVCM	Task Force on Scaling Voluntary Carbon Markets
UN	United Nations

Executive summary

Context

Today, transport is responsible for 25% of global emissions, equal to around 12 billion tCO_2e/year. 70% of these emissions come from road transport. With companies and countries setting zero-emission targets for 2030-2050, there is an ever-increasing demand for climate mitigation in the energy and transport sectors. While carbon credits from renewable energy generation are abundant on carbon markets, credits from transport are the most underrepresented climate action mechanism in the carbon finance sector. Electric mobility (e-mobility) represents the convergence of the energy and transport sector, as it not only replaces fossil fuels with electricity as a transport fuel but also provides storage capacity that enables a greater share of renewable energy to be used efficiently. E-mobility provides a key opportunity to decarbonise both the transport and power sectors and deserves greater attention from carbon markets.

The electric vehicle (EV) company Ampersand is committed to reducing emissions from conventional transport in East Africa. Ampersand is currently active in Rwanda, where it offers rent-to-own contracts to EV owners and operates a fleet of about 35 two-wheeled motorcyle-taxi vehicles with swappable batteries and the associated charging infrastructure. Supported by Shell Foundation and in collaboration with the Internal Growth Center (IGC), Ampersand serves as a case study to explore the potential for using carbon market instruments to scale e-mobility ventures in East Africa and emerging economies. In the case of Ampersand, South Pole set out to assess potential emission savings and related revenue streams from carbon market instruments to serve as an example for early-stage e-mobility enterprises in East Africa. In parallel, South Pole explored the potential size of the buyers' market for carbon credits from these types of e-mobility enterprises.

Objective

Together with Ampersand, Shell Foundation and IGC, South Pole 1) defined the system boundaries of the potential e-mobility carbon project; 2) identified applicable standards/methods and corresponding data requirements; 3) modelled the potential for carbon credits originating from EV motorcycle taxis in Rwanda; 4) analysed the buyers' market for carbon credits originating from transport projects; and 5) identified potential buyers.

Learnings and recommendations

Learnings

- The supply of transport-related carbon credits is the lowest category of all sectors (<2% of the total market), while related sectors (petrochemical, aviation, transport) have the highest demand for carbon offsets.
- While the list of clients buying transport-related carbon credits is quite diverse, it does show that clients desire credits related to their industry.
- Looking at the ever-increasing number of companies and organisations with net-zero targets, there are compelling reasons to believe that forward-thinking companies will seek to further decarbonise their operations and supply chains, and offset unabatable emissions using e-mobility carbon credits.
- Ampersand's planned operations could potentially create emission reductions of around 450,000 tonnes of CO_2e over the next 10 years in Rwanda alone.
- The estimated price point for e-mobility credits on the voluntary market is between $4 and $8.5 per tonne CO_2e. This could ultimately be higher given the demand forecasts for the voluntary carbon markets.
- The Government of Rwanda has expressed interest in such pilot activities and is actively developing a framework to prepare for Article 6 transactions.

Key takeaways

- Considering that transport is responsible for over a fifth of global CO2 emissions, decarbonising the transport sector is crucial to keep temperature rise below 2ºC relative to pre-industrial levels. If companies in the transport and energy sector are committed to their environmental targets/net-zero targets, investments in their own sector are unavoidable.
- Carbon market mechanisms can pave the way for transforming the transport and energy sectors, through investments in sector-related offsets from for example electric mobility. This type of carbon investment can accelerate the transformation of both sectors towards a lasting, low-carbon pathway.
- The convergence of energy and mobility through battery electric vehicles unlocks new opportunities for emission reduction. It replaces fossil fuel for transport use by electricity and at the same time creates the potential to add storage capacity to the electricity grid. This storage capacity allows a more flexible and resilient electricity grid that is able to buffer electricity from renewable energy sources, allowing an increased share of renewable energy to be generated and used.
- To scale e-mobility carbon projects, the monitoring, reporting and verification (MRV) system of carbon standards must be simplified, while reducing costs. The use of digital processes and the development of corresponding process requirements to improve baseline estimations are recommended to be further explored.
- Bilateral cooperation on carbon markets under an Article 6 pilot initiative could significantly increase the value of e-mobility offsets and create opportunities to scale access to finance for e-mobility. This is worth exploring.

1 Introduction

About South Pole

"Our mission is to realise climate action for all and to accelerate the transition to a climate-smart society."

South Pole helps clients address climate change impacts while mitigating risk and creating value on their sustainability journeys. With an award-winning, 15-year history of providing sustainability solutions, our team of 350+ sustainability advisors, scientists and engineers now stretches across 19 countries. The team consists of leading experts in their field. South Pole is the largest developer of climate action projects globally with over 700 carbon projects[1], spanning various technologies from afforestation to waste gas recovery, on nearly all continents. To date, we have sold over 180 million carbon credits to clients all around the world, mostly in the voluntary carbon market but also in compliance markets. Our corporate clients operate in the financial, energy, transport, fashion and food sectors, to name a few.

Understanding the objective

Transport is currently responsible for 25% of global emissions, equal to around 12 billion tCO_2e/yr.[2] 70% of these emissions come from road transport. With companies and countries setting zero-emission targets for 2030-2050, there is an ever-increasing demand for climate mitigation in the transport sector. The electric vehicle (EV) company Ampersand is committed to reducing emissions from conventional transport in East Africa. Ampersand is currently active in Rwanda, where it offers rent-to-own contracts to EV owners and operates a fleet of about 35 two-wheeled motorcycle-taxi vehicles with swappable batteries and the associated charging infrastructure. The demand for electric motorcycles (e-motorcycles) is high, with over 7,000 drivers currently on the waiting list.[3]

The Shell Foundation has expressed interest in an independent carbon emission reduction assessment, together with a feasibility assessment of carbon revenue as an additional cash flow for early-stage electric mobility (e-mobility) companies in East Africa. Ampersand's e-motorcycle activities have been selected to serve as a case study. To this end, South Pole received a grant from Shell Foundation to explore the potential benefits of carbon market instruments in scaling e-mobility ventures in East Africa and emerging economies. This leads to the research questions shown in Box 1. Results of this evaluation can be used in communication with government institutions, multilateral institutions and funding organisations.

Box 1: Research questions

Research question 1:

To what extent can carbon financing for e-mobility in Sub-Saharan Africa provide potential revenue streams for early-stage enterprises (like Ampersand) and at what volume of vehicles does it become economical to complete the full standards verification?

Research question 2:

What is the potential size of the market in relation to buyers of carbon credit for these types of mobility enterprises (and potentially other (non-EV) that realise environmental impact through efficiency gains)?

[1] In this report, 'carbon projects' refers to projects that issue carbon credits traded on the voluntary carbon market.
[2] The environmental impact of today's transport types – TNMT
[3] Rwandan electric motorcycle startup Ampersand raises $3.5m funding

2 About carbon credit mechanisms

What are carbon credits?

Carbon finance is a results-based finance framework whereby a monetary reward is given for every tonne of CO_2 reduced (avoided/captured). A carbon credit serves as proof of this emission reduction and is an asset that can be traded and sold. Such credits are issued through carbon standards, which are institutions that describe the procedure of how a tonne of CO_2 reduction as result of an activity can be proven. The rules for verifying emissions are documented in quantification methods, which vary according to the type, size and context of the activity.

In general, to calculate the emission reductions of an activity, a method compares the emissions of the programme activity (intervention through with emissions are reduced), with the emissions of the activity under the baseline system (business-as-usual, no interventions), within a predefined system boundary. Additionally, most carbon standards also try to quantitatively or qualitatively measure the impact of co-benefits, relating to the United Nations Sustainable Development Goals (UN SDGs).

Box 2: Defining 'issued' and 'retired' carbon credits

Issued carbon credits: carbon credits that have been certified under a specific greenhouse gas (GHG) accounting project development methodology and verified by a third-party auditor. These carbon credits are ex-post (meaning the emission reductions, avoidance or removals have already taken place) and are ready to be sold. They are listed on their respective carbon registries.

Retired carbon credits: carbon credits that have been sold and retired can no longer be bought or traded by any entity. Note that some traders and companies buy carbon credits to retire them at a later date.

How carbon mechanisms work

Table 1 illustrates how carbon credits are developed, issued and traded, leading to real-world emission reductions and financial rewards for those who realise them.

Table 1: Carbon finance mechanism – schematic

	Phase 1: Initial assessment	Phase 2: Carbon project development	Phase 3: MRV	Phase 4: Sale of credits
Project proponent	A project proponent (or intermediary like South Pole) will perform an assessment to evaluate the technical and financial feasibility of the carbon project concept. This will, among other tasks, include checking methodology requirements before the carbon offset development begins. Based on a positive outcome of the initial project assessment and using the results of that assessment, the carbon project development can begin the project registration phase.	In a Project Design Document, the project proponent demonstrates that the project meets all the requirements of the carbon standard and methodology (e.g. additionality), models projected pipeline volumes, describes the procedures in place to monitor/collect the required data (i.e. monitoring plan) and invites local stakeholders to provide input on the project activity. Project proponents must submit a request to open an account in a carbon registry, register their project and issue carbon credits into their registry account.	To quantify and issue the climate mitigation impacts, project proponents must follow the monitoring plan to track the GHG emissions savings and report them in a monitoring report.	These carbon credits can be sold on the open market to individuals and companies that can 'retire' them as a means to offset their emissions. One carbon credit represents 1 tonne of GHG emissions reduced from the atmosphere.
Third party		An independent third party validates whether the project complies with the standard's rules and requirements.	An independent auditor needs to be contracted to verify the reductions claimed in the monitoring report.	Generated carbon credits are efficiently sold by a third party that acts as a broker or promoter of the credits. For example, South Pole can sell to its network of clients to obtain the highest value. Buyers can be actors that purchase credits to offset their emissions.

	Phase 1: Initial assessment	Phase 2: Carbon project development	Phase 3: MRV	Phase 4: Sale of credits
Carbon Standard		When a project has been registered under the carbon standard, project developers can be issued tradable GHG credits.		Standard generates a unique credit (certificate) that all conditions of the standard have been met. Each credit is assigned a unique serial number so it can be tracked across its lifecycle.[4]

(Source: South Pole, 2021)

4 https://verra.org/wp-content/uploads/2016/05/Project-Cycle-Factsheet.pdf

3 Carbon credit landscape for transport

"We believe that electrifying two and three-wheeled vehicles in developing countries represents one of the low hanging fruits for climate change mitigation globally, and can have a profound positive impact on urban air quality."

***James Everett**, Managing partner of Ecosystem Integrity Fund*[5]

Today, transport is responsible for 25% of global emissions. In Rwanda, the transport sector accounts (in 2015) for 13% of the country's total GHG emissions, of which more than 25% were estimated to come from 110,000 domestic motorcycles.[6] Despite the high impact transport has on global warming, it is the most underrepresented sector in climate action and the carbon finance sector. Transport and other land-use projects combined have so far issued less than 2% of the global total of carbon credits (see Figure 1), and global carbon markets have very limited experience with carbon credits originating from the transport sector.[7] Several bottlenecks and challenges are hampering the uptake of climate mitigation in the transport sector, including technology and efficiency updates in the sector that have caused rapid changes in the baseline, complex additionality justifications, and complex and expensive conventional MRV processes under current standards. In addition, few carbon standards have a methodology for transport in place.

South Pole believes that innovations in the transport sector, particularly in the EV space, offer opportunities for both significant carbon emission reductions and cost monitoring (through, for example, fleet management software, smart battery technology, cloud-connected devices and smart metering) that was not possible before. Thus, battery EV technologies will be able to accelerate the origination of carbon credits from the transport sector, creating awareness of and demand for such credits.

[5] EIF is the Ecosystem Integrity Fund and a co-investor in Ampersand. (2021) Online: https://disrupt-africa.com/2021/04/12/rwandan-electric-motorcycle-startup-ampersand-raises-3-5m-funding/
[6] https://www.nama-facility.org/projects/rwanda-accelerating-the-deployment-of-e-mobility-through-the-deployment-of-electric-motorcycle-tax/
[7] http://docplayer.net/186526387-State-and-trends-of-carbon-pricing-2020-washington-dc-may-2020.html

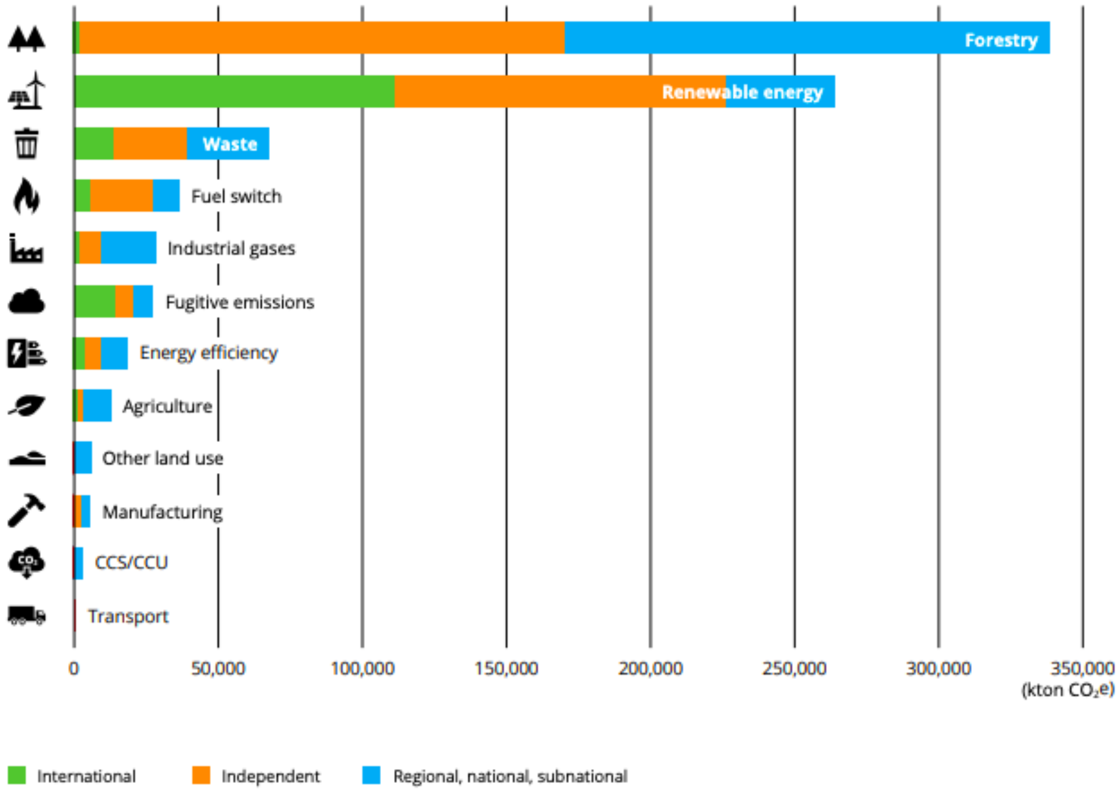

Figure 1: Issuance volumes in kilotonnes of CO_2e by sector and type of mechanism for 2015-2019

(Source: World Bank Group (2020) State and Trends of Carbon Pricing 2020, Retrieved online, Jan. 2021)

This can be particularly significant for emerging economies that may be exposed to the risk of internal combustion engine (ICE) vehicles 'dumping'. The African continent, for example, imports 40% of used vehicles worldwide. A flood of old ICE cars to the African continent could hinder its electrification, paradoxically making the case for e-mobility carbon projects even stronger, as they would be very additional (see the definition provided below). However, Energy Monitor predicts that older EVs from Europe, North America and Japan may also "trickle" into the country.[8]

While electrification and EVs are gaining traction in many parts of the world, with countries such as the UK banning the sale of new conventional petrol and diesel cars and vans by 2030 (and hybrids by 2035), their uptake in other countries remains limited. For example, South Africa is considered the largest EV market on the African continent but only 1,000 EVs were purchased in 2019.[9] From a carbon project perspective, this means that as e-mobility quickly gains traction in specific geographies, it will become both appealing and impactful to target clean transportation development in places with low electrification rates. However, frequent brownouts in some African countries pose challenges that could limit e-mobility development. Also, countries with low electrification rates where many rural households do not have access to regular electricity exacerbate the challenge of reducing emissions in both the public and private transport sectors.[10]

[8] Jonathan Gaventa, "Africa's bumpy road to an EV future", *Energy Monitor*, last updated 2 February 2021, https://energymonitor.ai/sector/transport/africas-bumpy-road-to-an-electric-vehicle-future#:~:text=Electric%20cars%20remain%20rare%20in,in%20most%20other%20African%20countries.

[9] Ibid.

[10] Ibid.

While Rwanda, where Ampersand currently operates, has the ambition to electrify and decarbonise transport, consumers worldwide have several technological and financial concerns about switching their ICE vehicle for an EV: significantly higher vehicle costs, limited driving range, long charging times, lack of EV charging infrastructure, lack of stable energy supply and perhaps safety concerns.[11] In parallel, other ecosystem players like governments, utilities and vehicle dealerships have concerns about the transformation.

Carbon finance mechanisms can potentially help project proponents overcome some key financial barriers, like high vehicle costs and a lack of charging infrastructure, by providing a financial reward for avoided emissions. Those who implement EV charging infrastructure and those who use this infrastructure for EV charging, replace fossil fuels with electricity and, therefore, avoid tailpipe emissions. Ensuring an attractive carbon market for low-carbon transport is crucial to attract investment (particularly foreign investment) into e-mobility.

Box 3: Example case: Thailand SHIFT Asia programme (a bilateral climate corporation under Article 6 of the Paris Agreement)

Switzerland has made approximately CHF 20 million (USD 20.7 million) available through its Pilot Activities of the Climate Cent Foundation (CCF) to implement pilot activities to discover and address specific issues with the implementation of Article 6.[12] Increasing the ownership of EVs in Thailand under the SHIFT Asia programme is one of them. Under this programme, the Swiss government purchases carbon offsets resulting from the shift to EVs, which is not included in Thailand's National Determined Contribution (NDC). Carbon finance is used to lower vehicle prices and support investments in EV charging infrastructure. Under a bilateral agreement, the carbon offsets are then adjusted correspondingly in the carbon accounts of both countries. The project is currently in the preparation phase. South Pole has been leading the development of this pilot programme.

[11] https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/electric-vehicle-trends-2030.html
[12] http://docplayer.net/186526387-State-and-trends-of-carbon-pricing-2020-washington-dc-may-2020.html

4 Ampersand case study

This section will explore the potential benefits of a carbon finance programme, particularly for Ampersand. Ampersand, based in Rwanda, is a manufacturer of e-motorcycles and an operator of EV battery swapping and charging infrastructure. The section starts with a methodological assessment, followed by an emission reduction forecast and a market study for potential offtakers of the resulting emission reductions.

Carbon standards and methodologies on transportation

There exist several methodologies regarding transport carbon credits under the main carbon certification bodies: the Gold Standard (GS), the Clean Development Mechanism (CDM) and the Verified Carbon Standard (VCS).[13] Table 2 shows a comparative analysis of different carbon standards and methodologies that relate to the electrification of the transport sector. Taking into account the uncertainty around the continuation of the CDM under the Paris Agreement, a voluntary carbon standard like the VCS is likely the most appropriate option for Ampersand in the context of this project.

[13] VCS and GS Programmes recognise the CDM programmes as acceptable to be listed within their registries and have their project credits converted to their own units (e.g. Verified Carbon Units and Verified Emission Reductions).

Table 2: Comparative analyses of different carbon standards and methodologies

Methodology	Applicable to	Approving carbon standard	Suitable for the Ampersand project
Vehicle electrification			
CDM AMS-III.C	Emission reductions through the adoption of **electric and hybrid vehicles.**	CDM/GS/VCS	**Yes.** However, due to uncertainty on the continuation of the CDM in light of Article 6 negotiations of the Paris Agreement, this methodology is not recommended. Also, CDM calculations are generally more conservative than VCS calculations.
VM0038	The **charging of EVs through EV charging systems**, including their associated infrastructure, whose GHG emission reductions are achieved through the displacement of emissions from conventional fossil fuel vehicles used for passenger and freight transportation as a result of the electricity delivered by the project chargers.	VCS	**Yes.** Applicable globally for regions with less than 5% EV market penetration. E-motorcycles are an eligible vehicle segment. *Note: Definition of vehicle segment must be consistent with definitions provided by the governing national regulatory system(s) of the project locations (i.e. an EV motorcycle, must be seen as a 'motorcycle' vehicle by the local authorities).*
CDM AMS-III.S	Introduction of low-emission vehicles/technologies to **commercial vehicle fleets.** It is used for vehicles generating less greenhouse gas (e.g. CNG, LPG, electric or hybrid) for **commercial passengers and freight transport, operating on a number of routes with comparable conditions.** The retrofitting of existing vehicles is also applicable.	CDM/GS/VCS	Methodology applies to vehicles with regular routes. The project activity needs to take place on comparable routes before the project activity and should not change the level of service (e.g. distance/number of passengers). Project participants must demonstrate this. It is unlikely that on-demand taxi services operate fixed routes. *Note: Emission reductions associated with a difference in carbon content between non-renewable fuel and less carbon-intensive non-renewable fuel used for substitution are NOT eligible.*[14]

[14] Ibid.

Methodology	Applicable to	Approving carbon standard	Suitable for the Ampersand project
CDM AMS-III.BM	**Lightweight two and three-wheeled personal transportation.** It is used for project activities that shift the mode of transport of urban passengers to mechanical bicycles, tricycles, e-bikes or e-tricycles, by **implementing related infrastructure in an urban area** such as bicycle lanes, bicycle-sharing programmes (through dockless bicycles or sharing stations) and bicycle parking areas.	CDM/GS/VCS	**No.** Methodology only supports e-bikes in the case where an "electric motor assists propulsion by pedalling". Motorised electric two-wheelers are not eligible under AMS-III.BM at the time of writing.
Methodology for GHG emission reductions through truck stop electrification	**Truck stop electrification.** The emission reductions emanate from the diesel engine idling of long-haul trucks through the installation and use of single-system truck stop electrification technologies.[15]	American Carbon Registry (ACR)	**No.** No trucks involved in the project.

(Source: South Pole, 2021)

[15] "Truck Stop Electrification", American Carbon Registry, n.d., https://americancarbonregistry.org/carbon-accounting/standards-methodologies/emission-reductions-through-truck-stop-electrification

Based on our assessment (Table 2), the preferred methodology of choice would be VM0038 Version 1.0 of the VCS, titled 'Methodology for Electric Vehicle Charging System'. This methodology applies to "the charging of electric vehicles (EVs) through EV charging systems, including their associated infrastructure, whose GHG emission reductions are achieved through the displacement of emissions from conventional fossil fuel vehicles used for passenger and freight transportation as a result of the electricity delivered by the project chargers."[16] The methodology is based upon the CDM approach AMS-III.C 'Small-scale methodology for Emission reductions by electric and hybrid vehicles'.[17] The methodology applies to charging systems for battery EVs, including motorcycles, for a list of countries (the so-called 'positive list'). The successful issuance of carbon credits under this standard will generate Verified Carbon Units. Since 2019, the VCS has issued more credits than the CDM.[18] This shows that the activity in the voluntary market is growing as companies purchase voluntary credits through independent crediting mechanisms.

Boundary setting

Table 3: Overview of project boundaries in which the ex-ante emission accounting takes place

Dimension	Boundary setting
Geographical	For this assessment, the geographical scope is limited to the national boundaries of Rwanda.
Temporal	The timeline for the assessment is 10 years, which corresponds to the average carbon crediting lifetime of a project.
Upstream/downstream	Downstream: only avoided tailpipe emissions may be included in the emission accounting under VM0038.
Transport subsector	Passenger transport (two-wheeled motorcycle taxis)
Emission gases	Carbon dioxide (CO_2) (Optional: methane (CH_4) and nitrous oxide, no other gases)

(Source: South Pole, 2021)

Providing additionality

Carbon finance should be a key instrument to overcome barriers. Therefore, every activity is subject to an additionality check. The additionality check needs to verify whether the activity would have occurred, all else being constant, without the offset project. If the answer is no, the project meets the additionality requirement.

Box 4: Definition – additionality

> Additionality is a core requirement for carbon project development. It means that the development of a carbon project is additional in comparison with a baseline of business-as-usual, prior to the project's implementation. Concretely, this means that the carbon project is not common practice where it is planned and/or may not be financially viable without the revenue from the sale of carbon credits. No carbon project is developed without proving it is additional.

[16] https://verra.org/wp-content/uploads/2018/09/VM0038-Methodology-for-Electric-Vehicle-Charging-Systems-v1.0-18-SEP-2018.pdf
[17] https://cdm.unfccc.int/methodologies/DB/AWVYMI7E3FP9BDRQ646203OVPKFPQB
[18] World Bank (2020) State and Trends of Carbon Pricing 2020.

Methodology VM0038 uses module VMD0049 'Activity Method for Determining Additionality of Electric Vehicle Charging Systems' to determine additionality, which in turn applies CDM tools to demonstrate additionality. The additionally of the project is confirmed in cases where the regulatory surplus, market share test and/or barrier analysis are proven.

Step 1: Prove regulatory surplus

Additionality is proven when emission reductions do not result from regulatory steps taken by the project's host country. Rwanda has made the electrification of transport part of its conditional NDC (conditional upon external support). As such, the activity can be regarded as additional.

Step 2: Market share test

Additionality is proven when the project region has less than 5% market penetration of electric vehicles in the vehicle segment of the project. This can be verified through either the **EV market share proxy test**; an annual sales-based penetration rate (for which data is typically more readily available) or – if the region was not qualified using the proxy metric – the **EV market share test**, which is the final determinative test in order to qualify for the positive list. Our assessment under the EV market share test concluded that the proposed activity meets the additionality criteria of the VERRA methodology VM0038, based on the following data:

1) 112,000 fossil fuel-powered motorcycles registered in Rwanda. The latest data available is from 2018, as published under the Rwanda Statistical Yearbook 2019[19];

2) 20-30 electric two-wheelers in Rwanda according to the following two sources:
    a) article under the Ministry of Infrastructure website that celebrates the completion of 250,000 km by 20 e-motorcycles; and
    b) planned number of e-motorcycles is denoted by a publication under the Urban Electric Mobility Initiative by the Wuppertal Institute. It denotes 30 e-motorcyles and 100 e-bikes in the scoping on page 6.[20] No follow up publication regarding the implementation could be found.

These numbers indicate a market share penetration between 0.02% and 0.08%, which is well below the threshold of 5%. Based on this metric, Rwanda can be added to the positive list.

Step 3: Barrier analysis

Where step 2 is not applicable, the case study proponent must demonstrate that the project activity would otherwise not be implemented due to the existence of one or more barrier(s) listed in the latest version of the CDM methodological tool 'Demonstration of additionality of small-scale project activities'. These refer to barriers that would lead to the implementation of a technology with higher emissions, such as 1) investment barriers, 2) technological barriers, 3) barriers due to prevailing practice or regulatory policy requirements, 4) institutional barriers, 5) or limited information, managerial sources or organisational capacity. Since the project passed step 2, additionality is deemed sufficiently proven. However, these barriers have been previously identified in Rwanda and summarised by NAMA Support Projects: "barriers such as lacking asset financing for e-motorcycle drivers, lacking inventory financing for e-motorcyle manufacturers, regulatory uncertainties and gaps in technical standards, limited availability of charging/swapping

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[19] https://www.statistics.gov.rw/publication/statistical-yearbook-2019#:~:text=The%20Annual%20Statistical%20Yearbook%2C%202019,and%20Communication%3B%20Travel%20and%20Tourism%3B

[20] Shrestha, S. Teko, E. (2019) E-mobility for last-mile connectivity in Kigali, UEMI (Online) http://www.uemi.net/uploads/4/8/9/5/48950199/uemi_kigali_project_scoping.pdf Online, 2021 - Reference to motorcycles in table 8.2.2 on page 103.

stations, and limited awareness of low-carbon mobility solutions across different groups of stakeholders still hinder the electrification of motorcycles at scale."[21]

[21] https://www.nama-facility.org/projects/rwanda-accelerating-the-deployment-of-e-mobility-through-the-deployment-of-electric-motorcycle-tax/

5 Accounted emissions

The quantification of emissions and emission reductions is done ex-ante based on the VCS VM0038 Methodology for Electric Vehicle Charging Systems Version 1.0[22] and available data. Net emission reductions will be assessed ex-post and can differ from the calculation below. Two main factors influencing net emission reductions are the distance driven by the project vehicles and the energy source of the electricity that goes into the project vehicle batteries.

Baseline emissions

The following is a formula and parameter description for the baseline emission assessment of ICE vehicles:

$$BE_y = \sum_{i,f} ED_{iy} * EF_{ify} * 100 * IR_i^{y-1} / (AFEC_{iy} * MPG_{iy})$$

Where:

BEy	=	Baseline emissions in year *y* (tCO_2e)
EDi,y	=	Electricity delivered by project charging system serving applicable fleet *i* in project year *y* (kWh)
EFj,f,y	=	Emission factor for the fossil fuel *f* used by comparable fleet vehicles *j* in year *y* (tCO_2e/gallon)
IRi	=	Technology improvement rate factor for applicable fleet *i*
AFECi,y	=	Weighted average electricity consumption per 100 miles rating for EVs in applicable fleet *i* in project year *y* (kWh/100 miles)
MPGi,y	=	Weighted average miles per gallon rating for the fossil fuel vehicles comparable to each EV in applicable fleet *i*, in project year *y* (miles per gallon)

Where the weighted average electricity consumption is calculated as follows:

$$AFEC_{iy} = \sum_a (EV_{aiy} * EVR_{aiy}) / \sum_a EVR_{aiy}$$

Where:

AFECi,y	=	Weighted average electricity consumption per 100 miles rating for EVs in applicable fleet *i* in project year *y* (kWh/100 miles)
EVa,j,y	=	Electricity consumption per 100 miles rating for model *a* EV in applicable fleet *i* in project year *y* (kWh/100 miles)
EVRa,j,y	=	Total number of model *a* EVs in applicable fleet *i* on the road by project year *y* (cumulative number of EVs)

An where the weighted average miles per gallon rating is calculated as follows:

$$MPG_{iy} = \sum_a (MGP_{aiy} * EVR_{aiy}) / \sum_a EVR_{aiy}$$

[22] https://verra.org/methodology/vm0038-methodology-for-electric-vehicle-charging-systems-v1-0/

Where:

MPGi,y	=	Weighted average miles per gallon rating for fossil fuel vehicles comparable to each EV in applicable fleet *i* in project year *y* (miles per gallon)
MPGa,i,y	=	Mile per gallon rating for the fossil fuel vehicle model deemed comparable to each EV model *a* from applicable fleet *i* in project year *y* (miles/gallon)
EVRa,i,y	=	Total number of model *a* EVs in applicable fleet *i* on the road by project year *y* (cumulative number of EVs)

Project emissions

Formula and parameter description for EV project emissions as assessed ex-ante.

$$PE_y = \sum_{ij} EC_{ijy} * EFkw_{ijy}$$

PEy	=	Project emissions in year *y* (tCO_2e)
ECi,j,y	=	Electricity consumed by project chargers sourced from region *j* serving applicable fleet *i* in project year *y* (kWh/year)
EFkw i,j,y	=	Emission factor (average) for the electricity sourced from region *j* consumed by project charging systems serving applicable fleet *i* in year *y* (tCO_2e/kWh)

Note: Where time-of-day estimates are available, additional calculations may be included.

Net emission reductions

The net GHG emission reduction for a particular year corresponds to emission reduction through activity in that year, considering what emissions could have been in the baseline scenario. The formula and parameter description for net GHG emission reduction is:

$$\mathrm{ER_y} = (\mathrm{BE_y} - \mathrm{PE_y} - \mathrm{LE_y}) * \mathrm{D_y}$$

Where:

ERy	=	Net GHG emission reductions and removals in year *y* (tCO_2e)
BEy	=	Baseline emissions in year *y* (tCO_2e)
PEy	=	Projects emissions in year *y* (tCO_2e)
LEy	=	Leakage in year *y* (tCO_2e)
Dy	=	Discount factor to be applied in year *y* (%)

Note 1: Leakage is not considered an issue under this methodology and is therefore set at zero. This is consistent with CDM methodology AMS-III.C, which sets leakage at zero.

Note 2: No discount is applied in regions where: a) no GHG credits have been issued before for projects that introduce EV fleets in the EV charging system project's region, or b) when the case study proponent can demonstrate that the EV charging systems included in the project are comprised of a private or closed charging network (e.g. private terrain or reserved exclusively for its fleet).[23] According to South Pole's database research, no credits have been issued for projects that introduce EVs in the project area of Rwanda. Therefore, the applied discount factor is 1.

[23] This is allowed, as private and closed charging networks, even if publicly owned, are not subject to the risk that EV fleets with issued certified GHG credits would have access to its charging network, and the EV fleets that do use the network have not issued separate GHG credits of their own. Public charging systems operating as open networks would not normally be able to demonstrate such a lack of access and, therefore, must determine whether a discount factor should be applied.

6 Parameter study

Fixed ex-ante parameters

The section below gives an overview of the parameters used in the emission calculations, their values and the sources.

Table 4: Overview of fixed ex-ante parameters and their source/availability

Parameter abbreviatio n	Description/unit	Source	Value applied (preliminary)
MPGa,i,y	Miles per gallon rating for the ICE vehicles comparable to each EV in applicable fleet *i*, in project year *y* (miles per gallon)	Use values from credible national government sources. For initial assessment, a survey value delivered by the case study proponent is used. *Note: RURA is responsible for monitoring fuel quality in Rwanda. A 2019 report by REMA measured an average fuel consumption of 25.08 km/l in a small scale survey. These figures are compared in the scenario analyses (section 7).*	43 kilometers/litre = 101.15 miles/gallon (When using factors 3.785 litres = 1 gallon and 1 km = 0.6215 miles)
EFj,f,y	Emission factor for the fossil fuel *f* used by comparable fleet vehicles *j* in year *y* (tCO_2e/gallon)	Use values from credible international or national government sources. For this case, the Intergovernmental Panel on Climate Change (IPCC) default value is used: https://www.epa.gov/sites/production/files/2015-11/documents/emission-factors_nov_2015.pdf (Table 2)	0.0088 tCO_2/gallon (54 gr/km) 0.0090 tCO_2e/gallon (including CH_4 in CO_2e)
IRi	Technology improvement rate factor for applicable fleet *i*	Default value from CDM AMS.III-C	0.99
EFkw i,j,y	Emission factor (average) for the electricity sourced from region *j* consumed by project charging systems serving applicable fleet *i* in year *y* (tCO_2e/kWh)	Use credible government data sources. Values are taken from Sweco (2019) Electric Mobility in Rwanda; Background and feasibility report, based on government data.	0.000504 tCO_2e/kWh for the Rwandan grid
EVa,j,y	Electricity consumption per 100 miles rating for model *a* EVs in applicable fleet *i* in project year *y*. (kWh/100 miles)	Values from credible national governmental sources. *Note: EV motorcycles are relatively new in Rwanda (< 50 on the road). For the initial assessment, values from the case study subject have been used.*	4.58 kWh/100km, equal to **7.37 kWh per 100 miles**

(Source: South Pole, based on VCS VM0038 methodology)

Parameters to be monitored – project vehicles

Table 5 provides an overview of the parameters that need to be monitored during the case study's lifetime. For the purpose of ex-ante emission reduction calculations, the table contains ex-ante values supplied by case study proponent Ampersand.

Table 5: Overview of to-be-monitored parameters and their source/availability

<table>
<tr><th>Parameter abbreviation</th><th>Description/unit</th><th>Frequency and monitoring method</th><th>Ex-ante value (source: case study proponent, based on records)</th></tr>
<tr><td>EVRa,j,y</td><td>Total number of model a EVs in applicable fleet i on the road by project year y (cumulative number of EVs)</td><td>Annually – own vehicle registration (closed charging network) or national government data (open charging network)

<u>Note:</u> Closed networks may use the number of EVs on the road from the fleet they serve. Open networks need credible national governmental sources.</td><td><table>
<tr><th>Year</th><th>EV Rwanda</th><th>EV East Africa (total)</th></tr>
<tr><td>2020</td><td>20</td><td>20</td></tr>
<tr><td>2021</td><td>1,100</td><td>1,100</td></tr>
<tr><td>2022</td><td>5,000</td><td>5,200</td></tr>
<tr><td>2023</td><td>14,000</td><td>15,800</td></tr>
<tr><td>2024</td><td>29,200</td><td>35,900</td></tr>
<tr><td>2025</td><td>54,200</td><td>73,700</td></tr>
<tr><td>2026</td><td>54,000</td><td>106,000</td></tr>
<tr><td>2027</td><td>52,200</td><td>177,800</td></tr>
<tr><td>2028</td><td>51,000</td><td>276,200</td></tr>
<tr><td>2029</td><td>52,400</td><td>399,400</td></tr>
</table>
<u>Note:</u> Case study estimates, so to some extent 'false accuracy' in 2022 and beyond.</td></tr>
<tr><td>ECi,j,y</td><td>Electricity consumed by project chargers sourced from region j serving applicable fleet i in project year y (kWh/year)</td><td>Annually (minimum) – measured value based on kWh delivered by charging systems in year y, using on-site electricity meters</td><td><u>Note:</u> This value is normally collected on a per-charger basis. For the ex-ante calculations, a per-vehicle energy consumption (conservative case study value of 150 km/day) is multiplied by the forecasted number of vehicles on the road (EVRa,j,y).

Per vehicle electricity consumption is 2,205 kWh/year[24]</td></tr>
<tr><td>EDi,y</td><td>Electricity delivered by project charging system serving applicable fleet i in</td><td>Annually (minimum) – measured value based on kWh delivered by charging systems in year y,</td><td>For chargers with a maximum power level of 19.2 kW (240 V @ 80 amps), the electricity delivered (EDi,y), will be considered the same as electricity consumed by the chargers (ECI,j,y) since L2s are highly efficient chargers</td></tr>
</table>

[24] Based on 150 km per working day: 72 km per full charge requires 6.875 kWh per motorcycle per working day. At 6.17 working days per week, it is 42.42 kWh per week. At 52 weeks per year, it is 2,205 kWh per e-motorcyle per year.

Parameter abbreviation	Description/unit	Frequency and monitoring method	Ex-ante value (source: case study proponent, based on records)
	project year *y* (kWh/year)	using on-site electricity meters	with de minimis losses due to their own power consumption (i.e. ED = EC). For this assessment, the ED = EC assumption is used.

(Source: South Pole, based on VCS VM0038 methodology)

7 Net emission reductions

Following the net emission reduction calculation mentioned above, and considering the parameters described in the previous section, the following ex-ante results have been calculated.

Table 6: Baseline emissions for case study fleet over the crediting period

Crediting Period	Total number of project vehicles on the road	Electricity delivered by project chargers	Emission factor fossil fuel	Baseline emissions
Year	Number	kWh/year	tCO_2e/gallon	tCO_2e/year
1	20	44,100	0.0088	54
2	1,100	2,425,500	0.0088	2,897
3	5,000	11,025,000	0.0088	13,158
4	14,000	30,870,000	0.0088	36,689
5	29,200	64,386,000	0.0088	76,093
6	54,200	119,511,000	0.0088	139,623
7	54,000	119,070,000	0.0088	137,755
8	52,200	115,101,000	0.0088	131,842
9	51,000	112,455,000	0.0088	127,430
10	52,400	115,542,000	0.0088	129,730

(Source: South Pole calculations, using methodology VM0038)

Table 7: Project emissions for case study fleet over the crediting period

Crediting period	Electricity consumed by EV batteries	Emission factor for the electricity sourced	Project emissions
Year	kWh/year	tCO_2e/kWh	tCO_2e/year
1	44,100	0.00050	23
2	2,425,500	0.00050	1,223
3	11,025,000	0.00050	5,557
4	30,870,000	0.00050	15,559
5	64,386,000	0.00050	32,451
6	119,511,000	0.00050	60,234
7	119,070,000	0.00050	60,012
8	115,101,000	0.00050	58,011
9	112,455,000	0.00050	56,678
10	115,542,000	0.00050	58,234

(Source: South Pole calculations, using methodology VM0038)

Table 8: Net emission reductions for the case study fleet in Rwanda over the crediting period

Crediting period	Baseline emissions	Project emissions	Emission reduction (electric grid emission factor)
Year	tCO_2e/year	tCO_2e/year	tCO_2e/year
1	54	23	31
2	2,897	1,223	1,674
3	13,158	5,557	7,601
4	36,689	15,559	21,130
5	76,093	32,451	43,642
6	139,623	60,234	79,389
7	137,755	60,012	77,743
8	131,842	58,011	73,831
9	127,430	56,678	70,752
10	129,730	58,234	71,496
Total over the crediting period			**447,289**

(Source: South Pole calculations, using methodology VM0038)

Scenario assessment

A 2018 report by the World Bank mentions that Rwanda's electricity generation mix generation has decarbonised significantly between 2013 and 2018 due to a shift away from oil and towards hydro and lake methane power. The World Bank estimates that the grid emission factor was reduced from 328 kg/MWh to 137 kg/MWh over these five years. These factors are not officially acknowledged by the Rwandan government.[25] The government-approved number of 504 kg/MWh that South Pole applied is significantly higher. In the scenario analyses below, South Pole compared the effect of the three different grid emission factors and a 100% renewable energy scenario on the project emissions and the net emission reductions.

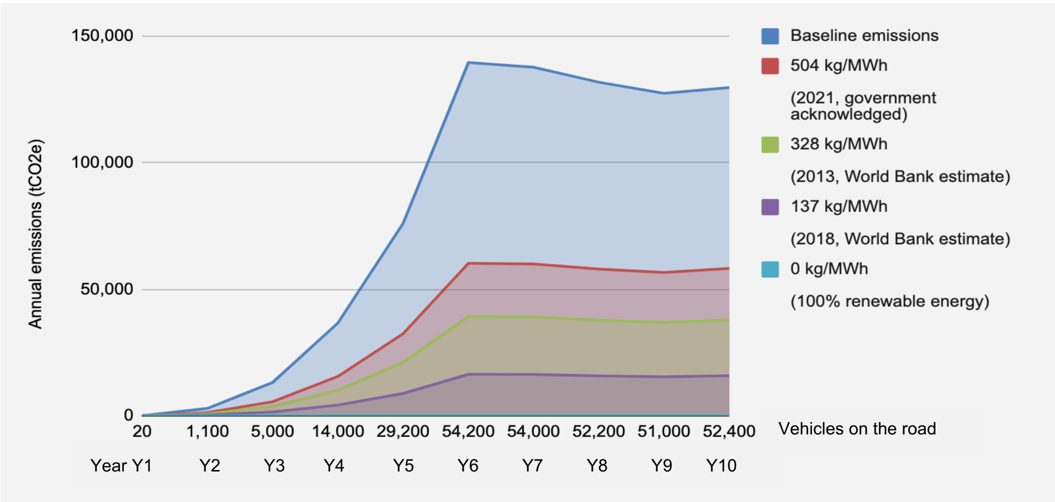

Figure 2: Annual emissions of the project vehicles in different grid emission factor scenarios, following the vehicle implementation plan of the case study proponent

(Source: South Pole, 2021)

[25] https://documents1.worldbank.org/curated/en/139261567389640856/pdf/Rwanda-Third-Rwanda-Energy-Sector-Development-Policy-Financing-Project.pdf (page 48)

Table 9, below, shows that both on a macro (accumulated fleet over 10 years) and micro (per vehicle unit per year) level, the emission factor of the electricity source has a strong impact on the net emission reductions. For carbon finance, this means it also heavily impacts the revenues from the mitigation activity and could be an argument for an increased share of clean electricity to be used in charging EV batteries.

Table 9: Net emission reduction under different grid emission factors

Grid emission factor	**504 kg/MWh** (2021, government acknowledged)	**328 kg/MWh** (2013, World Bank estimate)	**137 kg/MWh** (2018, World Bank estimate)	**0 kg/MWh** (100% renewable energy)
Accumulated emission reductions	447,289	568,805	700,676	795,271
Average annual per vehicle	1.43	1.82	2.24	2.54

For the initial emission reduction analysis, a fuel consumption factor of 43 km/l was applied. This was the result of a small-scale practical test led by the case study proponent in Kigali with drivers of a motorcycle comparable to the EV proposed in the case study. A 2019 report by the Rwanda Environment Management Authority (REMA) that included a small-scale energy survey for motorcycles in Rwanda, found an average fuel consumption factor of 25.08 km/l. The survey was based on questionnaires among 70 motorcycle drivers and showed great diversity in fuel consumption factors (*ranging from 12 km/l to 52.5 km/l*). The survey did not specify details of the motorcycles' engine capacity or size. It must also be noted that the results are from questionnaires and the report states that a similar questionnaire among car users found that *"most of the respondents were not sure of how much fuel they consume per day/week and of the distance travelled per day."*[26] From a carbon project development perspective, a government source is considered reliable. However, due to the high variability of the values, unclear vehicle specifications and limited number of respondents, the verification entity might question the integrity of the data and raise a query on the fuel efficiency value. For conservative purposes, the analyses in this report apply the practical test results and the related fuel efficiency factor of the case study proponent. An analysis on the effect of different fuel consumption factors on the net emission reductions indicates that more detailed testing will likely benefit the carbon revenues. More information on this can be found in section 9.

[26] REMA (2019) *Energy surveys for national GHG emissions inventory under Rwanda initial biennal update report.* p. 34.

8 Carbon markets and carbon pricing

Demand for carbon offsetting (transport sector)

Net-zero emission targets fall short of what is required to meet the Paris Agreement to keep global heating well under 2ºC. Therefore, companies need to strengthen their climate roadmap and can rely on short-term carbon offsets for this. Voluntary carbon markets can accelerate emission reduction efforts toward net zero and gain increasing interest from the private sector. The Task Force on Scaling Voluntary Carbon Markets (TSVCM) "estimates that demand for carbon credits could increase by a factor of 15 or more by 2030 and by a factor of up to 100 by 2050. Overall, the market for carbon credits could be worth upward of $50 billion in 2030".[27]

The automobile industry's participation in achieving net-zero emissions at the global level by 2050 is crucial. Up to 80% of automobile emissions are from exhaust pipes, that is, the use of vehicles.[28] Despite this, few automobile companies decarbonise and then offset their inevitable emissions from Scopes 1, 2 and 3 (refer to definitions below). Recent research by the Transition Pathway Initiative (TPI) found that net-zero emission targets in the automobile industry do not cover the most significant emissions: those from the use of sold vehicles (Scope 3).[29] In April 2021, the TPI found that out of the 23 automobile companies it assessed, just one company had carbon performance[30] aligned with the Paris Agreement benchmarks in 2030, to keep global heating to under 2ºC, and two companies had 2ºC-aligned carbon performance. Ten companies were not aligned with the Paris Agreement. Regarding 2050 carbon performance alignments, the figures shifted to three, five and 10 companies respectively.[31]

Box 5: Definitions – scope of emissions[32]

- **Scope 1** emissions are "direct emissions from owned or controlled sources".
- **Scope 2** emissions are "indirect emissions from the generation of purchased energy".
- **Scope 3** emissions are "all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions".

South Pole worked with several large automobile giants in the past several years that have offset part of their emissions by purchasing our carbon credits. They have bought carbon credits certified under different carbon certification bodies, including the GS and VCS, as well as the additional Carbon, Community and Biodiversity Standard (CCBS). Table 10, below, highlights the latest data on the carbon credits automobile companies have bought from South Pole over the past three years. Note that prices have steadily increased as the voluntary carbon market has gained traction in recent years.

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[27] Blaufelder et al., "A blueprint for scaling voluntary carbon markets to meet the climate challenge", *McKinsey*, 29 January 2021, https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge

[28] Hannon et al., "The zero-carbon car: Abating material emissions is next on the agenda", *McKinsey*, 18 September 2020, https://www.mckinsey.com/business-functions/sustainability/our-insights/the-zero-carbon-car-abating-material-emissions-is-next-on-the-agenda

[29] Dietz et al., "TPI State of Transition Report 2021, *Transition Pathway Initiative*, April 2021, https://www.transitionpathwayinitiative.org/publications/82.pdf?type=Publication

[30] Carbon performance is defined by the TPI as *"how current and future emissions align with the goals of the Paris Agreement".* Emission reduction targets are central to carbon performance.

[31] Dietz et al, "TPI State of Transition Report 2021, *Transition Pathway Initiative*, April 2021, https://www.transitionpathwayinitiative.org/publications/82.pdf?type=Publication

[32] Greenhouse Gas Protocol, https://ghgprotocol.org/sites/default/files/standards_supporting/FAQ.pdf

Table 10: Transaction volumes towards buyers from the automotive sector (2018-2020)

Project location	Project type	Carbon standard	Average sales price bracket in EUR	Volume bought (range)
Asia	Renewable energy, waste handling	GS CER, GS VER, VCS	2.15–5.00	10,000–3,000,000
North America	Renewable energy, forestry	VCS, VCS-CCBS	3.25–10.00	4,000–14,000
South America	Forestry	VCS	5.00–10.00	900–10,000
Africa	Clean cookstoves, water filters, forestry	VCS, VCS-CCBS	4.50–5.50	16,000–70,000
Australia	Forestry	VCS	10.00–15.00	200–10,000
Europe	Renewable energy	GS VER	6.00–12.00	0–5,000

(Source: South Pole internal data, May 2021)

In recent years, South Pole has interacted with many automobile companies, as well as broader transport companies working in logistics, shipping, delivery, mail, aviation, mobility etc. Several of these companies have expressed interest in buying carbon credits from projects related to transport, electrification and improved logistics. However, as shown in Table 10, almost all offsets purchased by transport sector clients are from sectors other than transport. Many factors influence which carbon offsets automobile clients decide to purchase.

1) First, **price** is often the main criteria clients consider when choosing offsets. This does not mean they only buy the cheapest carbon credits, but it is a factor that significantly impacts their decision-making.
2) Second, **proximity to business, both geographically and in terms of carbon credit type**, is a strong determinant of which carbon credits are purchased. For example, clients from North America may want a proportion of their offsetting portfolio to come from North American projects. That way, they can better communicate this with their clients as part of a sustainability drive, if applicable. Regarding the type of carbon credit, clients often seek to align their business practices with a project's technology. As such, several automobile clients have requested transport or energy-efficient carbon projects in their portfolio (further details on the supply of transport carbon credits in the next section).
3) Third, when clients disclose the breakdown of the emission they want to offset, they sometimes want to **link projects with the emissions source**. If a client wants to offset emissions from their supply chain or logistics, they may wish to invest in corresponding carbon projects.
4) Finally, as clients from all sectors face increased scrutiny on their climate strategies and as governments tighten their climate commitments, we can expect an increasing number of automobile and broader transportation clients to **offset their emissions from all three scopes**.

The high project development costs and lower emission reduction potential per unit (which leads to fewer credits generated and relatively high MRV costs) are reasons why carbon credit buyers hesitate to purchase transport-related carbon credits. Furthermore, only very few transport-related carbon projects currently exist, which means that volumes demanded by automotive sector players cannot be met by the limited supply of such credits.

Supply of transport offsets (transport sector)

Out of all major international, national and regional crediting mechanisms, both independent and governmental, for both compliance and voluntary markets, only seven include the transport sector. Under almost every crediting mechanism, the transport sector accounts for the lowest contribution to the total credits issued (see Figure 3). An assessment of carbon registries in December 2020 by the TSVCM found that transport carbon projects make up less than 1% of all available carbon credits.[33] South Pole's analysis of the GS, ACR and VCS registries found that, to date, 1,271,737 carbon credits from 41 transport-related projects have been issued. Only 975,708 carbon credits have been retired from 40 projects at the time of writing (see Box 2 for the definitions of 'issued' and 'retired'), as shown in Figure 3. These projects range from truck stop electrification in the US, vehicle efficiency, fuel optimisation and anti-idling, among others.

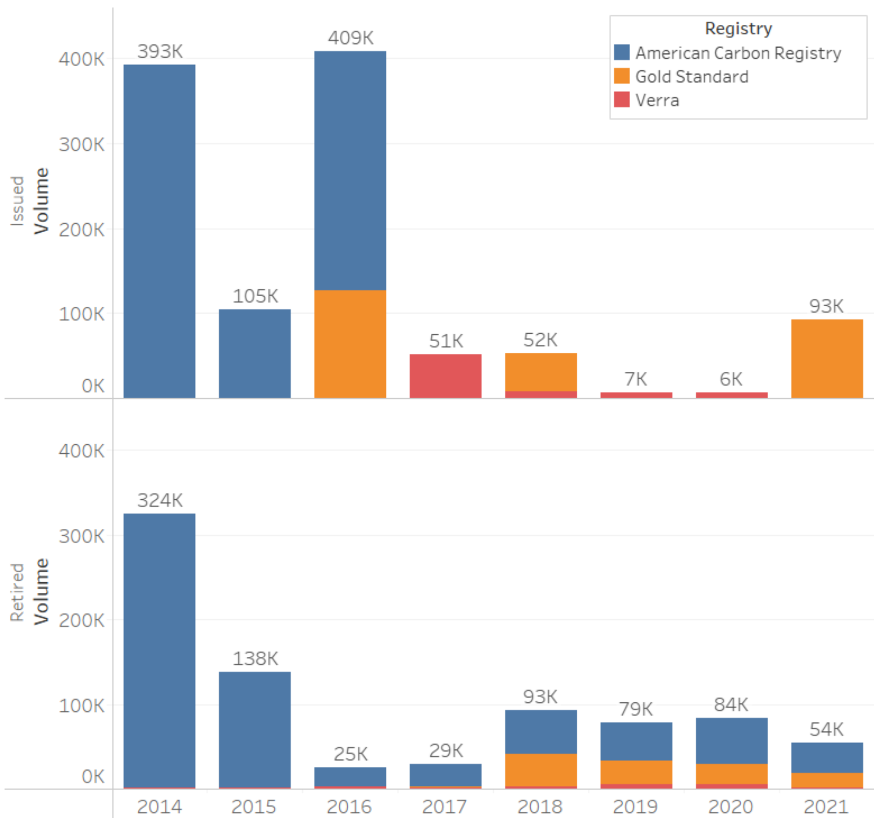

Figure 3: Transport credits issued or retired by each registry, based on their issuance or retirement date[34]

(Source: South Pole, based on carbon registry data, May 2021)

[33] Definitions: CCP stands for Carbon Capture Projects, REDD+ stands for countries' efforts to reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks, ARR stands for Afforestation, Reforestation and Revegetation. Source: TSVCM (2021) https://www.iif.com/Portals/1/Files/TSVCM_Report.pdf

[34] Note that the years in Figure 3 do not correspond to the credit's vintage, i.e. credits that were retired could have been issued in earlier years.

With new, low-cost technologies for vehicle monitoring, some of the cost barriers for carbon credits from e-mobility might be overcome, thereby increasing the automotive sector's interest in purchasing offsets from mobility projects. Considering the scarcity of transport-related carbon projects and the need for automobile companies to address their Scope 3 emissions (by offsetting unavoidable emissions in the short term), e-mobility carbon credits are set to gain momentum in the voluntary carbon market.

Perceived value of transport carbon credits

Corporate clients approach South Pole to offset some of their emissions from various Scopes (1, 2 and/or partially 3) for the following reasons.

- To achieve **carbon neutrality**, that is, to compensate for (usually unavoidable) emissions by purchasing carbon credits. Often, Scopes 1 and 2 are the emissions that are offset. They can still claim carbon neutrality even without offsetting all unavoidable emissions.
- For added **brand value**. By demonstrating a commitment to the environment and taking responsibility for GHG emissions they (directly or indirectly) produce, automobile producers gain a brand advantage that could lead to increased market share and client retention.
- For **reputational benefits**. Investing in carbon credits and communicating this to clients can improve automobile clients' reputation, which has not always been pristine.
    - *(e.g. In 2017, German manufacturer BMW listed adverts on Facebook for its electric i3 car. The video claimed that the car produced "zero emissions [...] and [that it] help[ed] to give back to the environment". This claim was challenged and the UK's Advertising Standards Authority ruled that these claims were misleading and the ad was pulled.*[35])

As mentioned above, there is a scarcity of e-mobility and even transport-related carbon credits. Therefore, to model potential price points of such credits, we have used renewable energy projects as they are the closest match in terms of project category. Many renewable energy carbon credits have been traded since the beginning of the voluntary carbon market, meaning that the historical pricing data on these credits is robust. Here, renewable energy is defined as solar, wind, biomass and hydropower.

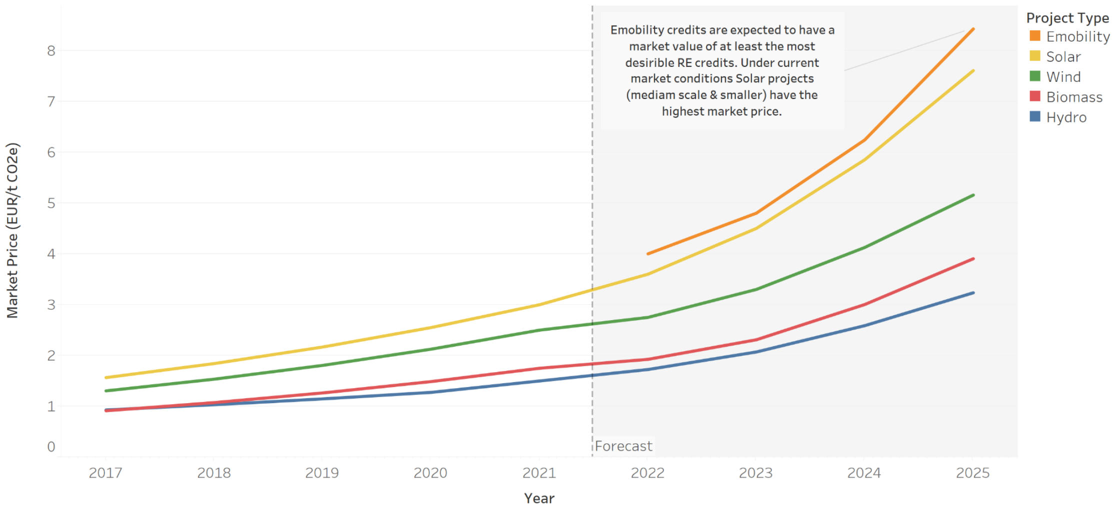

Figure 4: Historical and forecasted renewable energy credit prices, including a forecast for e-mobility

[35] ASA (2017) "*ASA Ruling on BMW (UK) Ltd*", https://www.asa.org.uk/rulings/bmw--uk--ltd-a17-389311.html

(Source: South Pole, using registry and South Pole data, June 2021)[36]

The graph shows that e-mobility carbon credits are expected to have a market value at least equal to renewable energy and likely higher, as indicated by the orange line. Based on historical pricing and taking into consideration supply and demand, it is expected that e-mobility carbon credits could be sold at an average price of EUR 4–8.50 between 2022 and 2025 respectively.

However, pricing considerations also depend on the volume available, volume traded, project location and the standard under which it is certified. There is a high level of uncertainty around this predicted pricing. Further, grouping renewable energy projects by category masks data heterogeneity. For example, an off-grid solar project in Sub-Saharan Africa is likely to be significantly more expensive than a large solar power plant elsewhere.

Also, as renewable energy is considerably cheaper than it was even 10 years ago, and despite carbon standards becoming more stringent on which RE projects can become carbon projects (as prices decrease, additionality becomes harder to demonstrate), it is expected that e-mobility carbon projects will issue far fewer credits than renewable energy projects. Indeed, considering the deployment of renewable energy in recent years and the development of economies of scale, e-mobility arguably remains more niche and, therefore, is pricier in the short to medium term.

The current global carbon market is fragmented. The lowest prices are paid for carbon credits from projects and jurisdictions that are:

a) excluded from use within the most relevant/high volume carbon markets;
b) seen of questionable integrity and are at risk of creating negative reputational impacts for their buyers (non-additional, large scale renewable energy projects in China, hydrofluorocarbons avoidance) for use within the voluntary carbon market; or
c) at a high risk of being double counted or double claimed because of unclear accounting governance.

The highest prices are paid for carbon credits from projects and jurisdictions that are:

a) permitted as compliance instruments in key carbon markets; and
b) seen as having high integrity, quantifiable co-benefits related to other (non-climate) SDG, contribute to future cost reductions of technologies that aim to reduce hard to avoid emissions (technology removals) for use within the voluntary carbon market, or are originated and accounted for without any double counting/claiming risks.

Cost-benefit estimates – Ampersand case study

Based on the price forecast and the VCS cost structure of project registration and credit origination, South Pole has created the chart shown in Figure 5. It gives an overview of the costs versus the revenue of a carbon project, expressed in vehicle years on the road (see Box 6). Revenues are projected in 3 different scenarios: 1) the low price forecast on the voluntary market, 2) the high price forecast on the voluntary market and 3) an estimated price forecast under a bilateral trade agreement under Article 6.2 of the Paris Agreement.

Box 6: Definition – vehicle years

> Vehicle years are used as a unit for calculating the emission reductions and represent one vehicle driving for one year (i.e. 10,000 vehicle years equals 10,000 vehicles on the road for one year, or 5,000 vehicles on the road for two years or 2,000 vehicles on the road for five years, etc).

[36] The trend of carbon credit market prices in EUR/tCO_2e. Current and historical market prices are based on wholesale credit volume trades for a composite of GS and VCS projects. The forecast is based on the average annual growth of volume weighted market prices for composite projects.

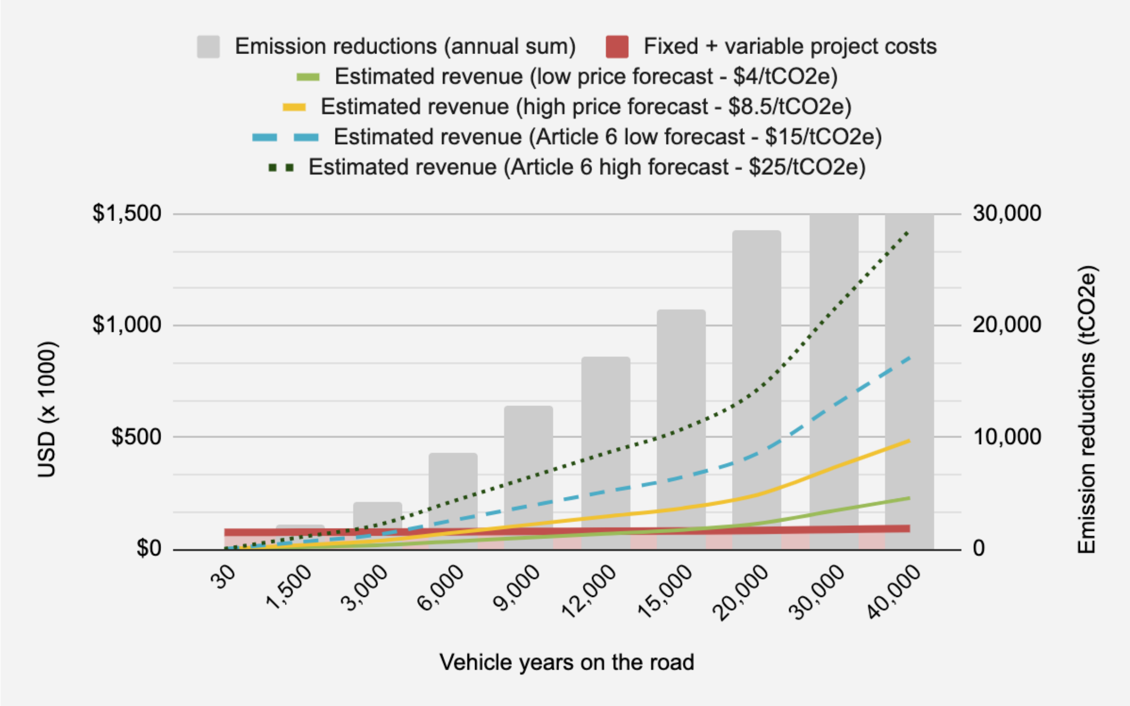

Figure 5: Rough cost-benefit analysis of a carbon project for the Ampersand case study

(Source: South Pole, 2021)

What can be seen from the figure is that for the estimated costs to break even with the estimated revenue in a low-price voluntary market scenario, the case study proponent would need at least the carbon credits of 14,000 vehicle years (e.g. 1,400 vehicles on the road for 10 years). For a more positive price scenario, of around USD 8.5/tonne, that number would be reduced to about 6,700 vehicle years. Under an Article 6 pilot program (i.e. a dedicated offtake buyer, access to key carbon markets and reduced double claiming risk) this break-even point could be as low as 3,000 vehicle years or less. However, voluntary carbon market prices depend largely on supply and demand and prices paid in Article 6 pilots depend on price negotiations and the marginal abatement costs to overcome barriers to implementing the activity at scale.

Table 11: Vehicle year break-even point at different carbon price levels

Carbon price	Vehicle year break-even point
Low price forecast – USD 4/tCO_2e	14,100
High price forecast – USD 8.5/tCO_2e	6,700
Article 6 low forecast – USD 15/tCO_2e	3,800
Article 6 high forecast – USD 25/tCO_2e	2,300

(Source: South Pole, model based on case study emissions)

9 Recommendations

Practical testing

Different levels of data granularity come at different costs. Default values extracted from existing sources, such as IPCC/Environmental Protection Agency (EPA) reports, often can be found at no additional cost, whereas a more precise measurement comes at a high cost.

Table 12: Costs of data granularity

	Availability	Project accuracy	Costs
International standardised datasets (e.g. IPCC, scientific research institutes)	High (e.g. IPCC/EPA database)	Low (global default factors, averaged numbers.)	Low (e.g. free access)
National or regional datasets	Medium (data type might not be available/government approved)	Medium/high (data might not have the necessary level of detail)	Low/medium (e.g. restricted database access)
Survey or data collection	Low (project-based, specific data)	High (level of detail can be managed)	High (e.g. on-the-ground surveys)

(Source: South Pole, 2021)

Based on the 2019 REMA energy survey, there is reason to believe that baseline emissions of vehicles are potentially higher than the default values used in this report. A quick cost estimation for the fuel economy test by the case study proponent, comes down at around USD 18,000, depending on the level of skill and amount of time required for the data collection and processing. At the moment, this has not been assessed in further detail. In the REMA survey, the highest motorcycle fuel efficiency found was 52.5 km/l, and the average fuel efficiency was 25.1 km/l. The fuel efficiency factor applied in this report is 43 km/l. Table 13 shows the potential net emission reductions per vehicle per year, with different fuel efficiency factors.

Table 13: Net emission reductions under different fuel consumption factors

Fuel consumption	55 km/l	45 km/l	35 km/l	25 km/l
Accumulate emission reductions (10 years)	273,774	411,945	629,067	1,019,889
Average annual emission reduction per vehicle	0.87	1.32	2.01	3.26

9.1.1 Recommendation for practical testing

Speaking to different experts in the field, the fuel consumption and emissions could significantly differ from the default values found in the literature. Current standard methodological requirements require detailed practical testing of 200+ vehicles and come at a significant cost. Additional investments for testing might not be cost-effective in a scenario whereby a) the emission factor after testing is higher than the default factor, or b) the deployed volume of vehicles on the road is not in line with the ex-ante projection, or c) the distance driven by the driver is not in line with the ex-ante projection, or d) the grid emission factor changes due to increased share of fossil fuel in power plants – and thus the project emissions increase. Therefore, it is generally uncommon for transport projects to diverge from default factors and apply practical testing.

Nonetheless, the REMA study gives strong indication that the baseline values can potentially be significantly lower than default factors. Additionally, MRV systems are becoming increasingly digitised, which will offer opportunities for improved baseline emission monitoring at lower costs. South Pole recommends exploring opportunities for practical testing and in particular digital monitoring practices, as they are expected to create cost reductions for monitoring while also yielding carbon emission savings.

Automated MRV

Conventional rules for MRV and the issuance of certified emission reductions (like the VCS) require on-site inspections and manual checks. In the case of e-mobility, this would lead to prohibitively high transaction costs. Developments in mobility services have created new digital technologies for monitoring fleets and operating charging stations. South Pole suggests implementing these available digital technologies increase cost efficiency and minimise the need for on-site inspections and manual checks of individual vehicles. Parties have expressed interest in exploring digital verification methods for e-mobility carbon credit issuance to speed up the issuance process and reduce monitoring costs.

Digital MRV can ensure consistent and transparent data reporting from charging stations and EVs, capturing all metrics required to quantify and issue carbon credits. However, such systems are not yet the standard and a revision of the data collaboration process may be required once a feasibility study is conducted. The digital MRV system will likely be based on digital data capture and reporting using the battery management systems inside of charging stations. Automated measurement enables the tracking of the parameter values at certain time intervals, which helps better monitor each parameter. Measurements of the relevant parameters are performed using a calibrated device: a meter conforming to certain accuracy class and technical standards installed at the asset where the raw data is monitored.

To ensure the data reflects the normal operation of the project (to rule out any manipulation), metering data shall be assessed for correlation with associated records. The monitored data will be uploaded through a decentralised, automated process to a digital platform run by the carbon managing entity. The raw data received from the data logger/smart meter is stored in a centralised database on a server or the cloud. After automated checks, the data will be processed with a calculation engine that determines the overall emission reduction based on the raw data and associated emission factors. Accessibility to raw data is restricted by customisable access rights and functions for different users (e.g. project owner, carbon managing entity, standards bodies). A reporting function would enable the automatic generation and export of reports in file formats aligned with the monitoring report formats of the UNFCCC or other relevant bodies. All monitoring parameters will be recorded in line with the proposed monitoring plan, compliant with VM0038.

South Pole intends to pre-verify all inputs and processes through the use of Internet of Things devices, thus replacing the need for ex-post verification procedures and allowing the case study proponent to submit issuance requests on a digital basis. The verification process in a digital MRV is envisaged as a single upfront audit of the digital MRV platform and associated calculation engine, followed by periodic verifications for the respective crediting period. After the digital MRV is audited, validated and certified, automated issuance of carbon standards would be allowed during a period of at least five years (VCS update cycle). Digital MRV could significantly reduce costs while allowing for faster carbon payments cycles, thereby increasing and accelerating the flow of carbon finance to the project operator.

9.1.2 Recommendation on automated MRV

Data necessary to verify project emissions is already collected digitally to a large extent (e.g. digital energy meters on charging infrastructure). Also, more and more EVs have onboard sensors that are capable of receiving and sending data/information, and there is still scope to significantly improve the precision of these measurements. However, technology is only one important aspect in the shift to digital making carbon credits digital, as many other processes for verification and issuance have yet to be digitised or automated. The benefits of digitised carbon credits will come through scale and require the involvement of other players in the origination and trading process. Thus, it makes sense to involve other stakeholders from the outset. South Pole, together with partner organisations, is in the initial stages of developing a digital MRV system for decentralised assets such as vehicles. While digital MRV is not simple to implement in practice (i.e. due to challenges related to integration with existing carbon standard procedures), its potential to realise cost savings and scaling emission savings in the transport sector means merits further exploration.

Bilateral Article 6 programme vs. voluntary market

In 2020, Rwanda announced a USD 11-billion climate action agenda (with funding coming from both domestic and international sources) featuring a 38% reduction of GHG emissions by 2030 with a plan to mitigate an equivalent of up to 4.6 million tonnes CO_2e.[37] Switching from ICE motorbikes and cars to electric ones is part of the country's transport agenda. In Rwanda's NDC, the switch to EVs is considered a conditional measure, meaning that it would be implemented if funding from external sources is secured. Additional funding into e-mobility through an Article 6 carbon finance programme represents an opportunity to implement such conditional measures and support Rwanda's climate action agenda.

Article 6 of the Paris Agreement establishes a dedicated crediting mechanism managed by the UNFCCC (Article 6.4) to be fully operationalised only once rules are agreed upon by Parties to the Paris Agreement. This mechanism corresponds to a carbon standard, as explained in the section 'About carbon credit mechanisms' above.

Article 6 also allows for countries to develop their own carbon finance programmes, or use existing ones, to generate carbon assets and outlines rules and guidance to oversee transfers between countries of mitigation outcomes (known as Internationally Transferred Mitigation Outcomes (ITMOs)). Such transfers are starting to be negotiated and several countries are cooperating on Article 6 pilots seeking to test the operationalisation of ITMO transfers. Preserving the environmental integrity of such international transfers is at the heart of Article 6, notably through the avoidance of double counting. The latter is preserved by requiring each country cooperating under Article 6 to correspondingly adjust their GHG accounts by adding the number of mitigation outcomes transferred abroad to the account of the selling country and by subtracting them for the buying country.[38] The implication for the selling country is that an emission reduction sold abroad cannot be counted towards the achievement of its own NDC mitigation target.

The value of carbon-linked performance payments for Article 6 pilot activities are generally higher than prices on the voluntary carbon market. Implementing e-mobility activities under this piloting framework could accelerate low-carbon investments in low-income countries. The incentive for private sector investment could help some countries leapfrog their technological development. But all of this can only occur if the carbon finance programme and the transfers abroad are credible, reliable and have integrity.[39]

Setting up an Article 6 mitigation activity, or even a pilot to test approaches with a potential buyer country, supports capacity building activities and prepares countries to participate in future Article 6 arrangements. Peru, Ghana and Senegal – acting as host countries – have already entered into bilateral agreements with Switzerland as a potential buyer and are currently structuring Article 6 mitigation activities to generate mitigation outcomes to be transferred to the country. This has made them early movers and more attractive to investors.

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[37] https://www.environment.gov.rw/news-detail/rwanda-announces-ambitious-climate-action-plan
[38] https://www.climatefocus.com/sites/default/files/Climate-Finance-Innovators_Article-6-piloting_State-of-play-and-stakeholder-experiences_December-2020.pdf
[39] https://www.wri.org/insights/what-you-need-know-about-article-6-paris-agreement

The REMA government authority has already developed a programme to pilot a standardised crediting framework for emission reductions from energy access that could eventually exist under Article 6.[40] An evaluation of that programme expressed interest in expanding it to other sectors and mentioned that "Rwanda may want to focus on sectors and technologies with high development impacts, and not simply those with the greatest mitigation potential."[41] E-mobility would be perfectly suited for this.

The attractive design of carbon finance regulations and the related governance structures needed in a developing country can be a powerful tool for attracting more green finance/products/practices to accelerate a country's transition towards a green economy and improve the well-being of its people. Governments can have significant influence over the value of carbon credits originated within their jurisdiction by providing clear guidance and regulation.

Box 7: Key regulatory designs for international carbon cooperation

1) Clarify eligibility criteria

Provide explicit guidance to investors/project owners on the project types and sectors that are permitted to generate carbon credits. This guidance is best when aligned with national development policy and the country's NDC. This guidance will provide greater certainty that direct green investment could be de-risked through carbon revenues from the sale of carbon credits.

2) Provide assurance re carbon credit ownership

Set out specific rules and procedures to clarify the legal ownership of carbon credits from eligible project types. These procedures can include rules for the sharing of carbon credits[42] among different stakeholders and avoid the double claiming problem, i.e. competing claims for a carbon credit from the same emission reduction.

3) Establish accounting framework and procedures to avoid double counting

The Government can either establish a national GHG registry or participate in an existing one to facilitate the digital accounting of GHG emissions and emission reductions to help them fulfil their UNFCCC reporting obligations and conduct the required corresponding adjustments under Article 6 (and required under some VCM programmes and for CORSIA). This helps clarify the regulations and procedures associated with international transfers and corresponding adjustments.

4) Clarify regulatory treatment for carbon credits

The Government should also clarify the treatment of carbon credits for tax purposes (e.g. VAT, export).

The consequences of a proactive and positive carbon credit regulation are expected to be:

a) a significantly larger inflow of green capital that generates a return in carbon credits and delivers associated co-benefits. Independent studies show that the economic value per 1 tonne of carbon credit amounts to more than 100 USD/tonne of carbon credit[43]; and

b) a 5 to 10-fold increase in the value per unit of carbon credits: from 2-3 USD/tonne to 10-30 USD/tonne of carbon credit.

[40] http://climatechange.rema.gov.rw/sites/default/files/SCF%20Roadmap%20for%20Rwanda%20Pilot.pdf;
[41] http://climateportal.rema.gov.rw/sites/default/files/SCF%20Rwanda%20lessons%20learned.pdf
[42] Sharing could mean that a mandated amount/share must be sold to (or transferred to (free of cost) to a national NDC fund.
[43] https://www.icroa.org/Offsets

9.1.3 Recommendation on Article 6

The Rwandan NDC encourages the use of market instruments to reach its climate targets and has experimented with a new regulatory framework (the Standardized Crediting Framework (SCF)) for international cooperation under Article 6.[44] When considering the vehicle years required for the project to break-even (between 7,000 and 15,000 vehicle years on the road), Article 6 cooperation could significantly improve the business case for an e-mobility carbon project. At higher prices, the project breaks even with fewer vehicles on the road. The SCF uses a positive list approach to additionality for various energy access technologies. It is worth exploring the eligibility criteria to get a technology on this positive list and to make an argument for e-mobility to be included. Such a request could be supported with the argument that the additional revenue from the sales of the credits is necessary to cover early investment risks. Rwanda takes a host-country led approach regarding these Article 6 explorations. A letter from REMA (the government entity responsible for the NDC target) stating that they will not claim carbon credits originated under the e-mobility carbon programme activities will create clarity in both present and future situations and will be beneficial to the value of the voluntary carbon credits – opening up opportunities for international cooperation. Half of countries' initial NDCs (constituting 31% of global emissions) include the use of international cooperation through carbon markets.[45] This shows great potential for scaling lessons learned.

Renewable energy charging

Renewable energy carbon projects connected to the electricity grid are in many instances no longer additional. As rules around renewable energy carbon projects tighten, due to the affordability and widespread adoption of renewable technologies, there is scope for e-mobility carbon projects to replace renewable energy projects.[46] In addition, it is expected that off-grid renewable energy projects will increase, especially in Least Developed Countries and low-income countries. This can be effectively combined with the electrification of transport and energy storage in vehicle batteries.

South Pole regards EVs as an essential link in the energy system of the future as a buffer between the electric grid and fluctuating renewable energy. It replaces fossil fuels as a transport fuel, enables greater grid flexibility, allows for the efficient use of excess renewable energy that is otherwise lost and thereby also replaces grey electricity. This is especially true for decentralised renewable energy generation (such as solar mini-grids), which helps replace both fossil fuel use from transport and diesel-powered electricity generators by using EV batteries as an energy buffer. Because of this double emission savings potential and transformative nature, e-mobility is ideally positioned for high-quality carbon projects (see Figure 6). It is the intention of the SHIFT programme to drive this at scale, globally.

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[44] http://climateportal.rema.gov.rw/sites/default/files/SCF%20Rwanda%20lessons%20learned.pdf

[45] IETA, "The Economic Potential of Article 6 of the Paris Agreement and Implementation Challenges", September 2019 (online) https://www.ieta.org/resources/International_WG/Article6/CLPC_A6%20report_no%20crops.pdf

[46] Max Roser, "Why did renewables become so cheap so fast? And what can we do to use this global opportunity for green growth?", *Our World in Data*, 1 December 2020, https://ourworldindata.org/cheap-renewables-growth

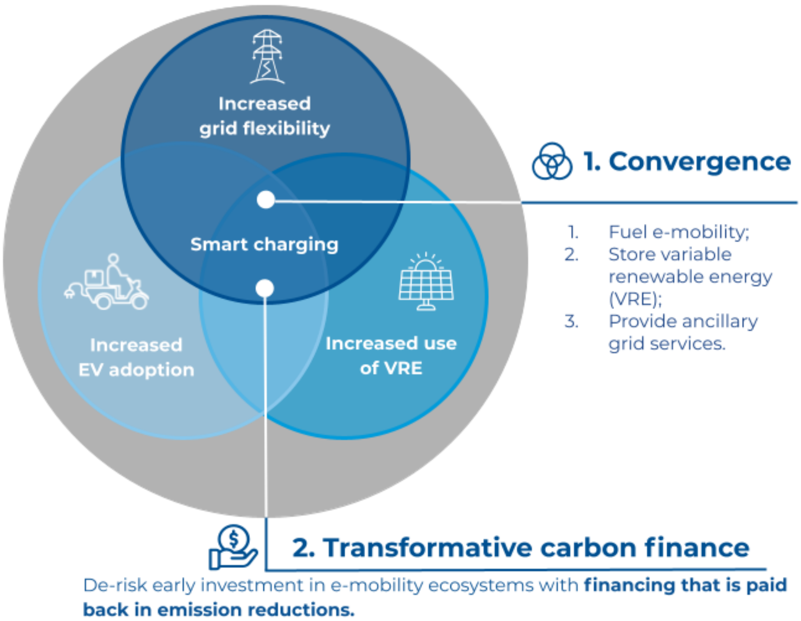

Figure 6: Convergence of energy and transport as an opportunity for increased emission reductions from convergence

(Source: South Pole, 2020)

Because of the relatively high grid emission factor of the Rwandan grid, a shift to charging EV batteries with renewable energy would make a great difference in emission reductions per vehicle (see Table 14). Greater emission reductions would mean greater revenue from carbon finance to support the project. The tables below show the projected marginal carbon revenues at different emission levels, including 100% renewable energy, and the multiple price points mentioned in section 0.

Table 14: Estimated annual carbon revenues per vehicle at different emission levels and different carbon prices

Carbon credit price point (USD per tCO_2e)	**504 kg/MWh** (2021, government acknowledged)	**328 kg/MWh** (2013, World Bank estimate)	**137 kg/MWh** (2018, World Bank estimate)	**0 kg/MWh** (100% renewable energy)
$4.00	$6	$7	$9	$10
$8.50	$12	$15	$19	$22
$15.00	$21	$27	$34	$38
$20.00	$29	$36	$45	$51
Carbon revenue increase	**100%**	**127%**	**157%**	**178%**

(Source: South Pole, 2021)

Table 14 shows that charging vehicle batteries with 100% renewable energy, increases the amount of carbon revenue by about 178% compared to the current baseline. Over an average carbon crediting period of 10 years, that could make a significant difference. Especially in combination with an increasing carbon price. Revenues per vehicle could range from USD 60 per vehicle over the crediting period – as in the current situation of carbon prices and emission factors – to USD 510 (and above) per vehicle over the crediting period.

At the level of a project fleet, that could mean the difference between USD 1.7 million and 15.9 million accumulated over the crediting period – the difference between 2% or 17.7% of the projected investment needed to electrify the fleet, respectively.

A lower emission factor also impacts the break-even point for carbon projects, making the initial investment required for a carbon project financially viable at lower volumes of vehicles on the road.

Table 15: Vehicle year break-even point (at different emission levels)

Carbon price (USD)	Vehicle year break-even point			
	504 kg/MWh (2021, government acknowledged)	**328 kg/MWh** (2013, World Bank estimate)	**137 kg/MWh** (2018, World Bank estimate)	**0 kg/MWh** (100% renewable energy)
$4.0	14,100	11,100	9,000	8,000
$8.5	6,700	5,200	4,300	3,700
$15.0	3,800	3,000	2,400	2,100
$25.0	2,300	1,800	1,400	1,300

(Source: South Pole, based on case study emission data)

9.1.4 Recommendation on renewable energy

In South Pole's view, e-mobility has great potential to yield high-quality carbon projects. Because of the relatively high grid emission factor of the Rwandan grid, combined with the benefits of the energy-mobility convergence, a shift to charging EV batteries with renewable energy would make a great difference in emission reductions per vehicle and thus in carbon revenue. It is worth exploring the technological and financial benefits of integrating solar technology with battery-electric systems.

10 Conclusions

Carbon credits from e-mobility are an overlooked (potentially massive) contributor to implementing net-zero strategies

Considering that transport is responsible for over a fifth of global CO2 emissions, decarbonising the transport sector is crucial to meet the Paris Agreement and keep temperature rise below 2ºC relative to pre-industrial levels. A number of automobile and logistics companies have made commitments to increase their share of EVs, either in production or use. Some have committed to phasing out the production of internal combustion vehicles entirely and several companies have joined the EV100 scheme and committed to switch their fleet to EVs and/or install charging for staff and/or customers by 2030. To date, over 106 members have made such a pledge.

As companies improve their climate strategies in the short term, it is expected that they will increasingly invest in carbon credits to offset their unavoidable short-term emission and will look for credits related to their industry. Historical data of carbon registries shows that the buyers of transport-related carbon credits are mostly from the transportation and petrochemical industry. However, while transaction volumes of carbon credits towards energy and transport sector players run in the millions, the total supply volume of carbon credits from the transport sector issued up to this date is less than 2% of the total market. Due to the low supply of carbon offsets from the transport sector, most buyers seem to divert to the closest related sector: energy. Because renewable energy is now more mainstream and affordable than when carbon markets started, the additionality argument for carbon finance fades and there is scope for e-mobility carbon projects to take its place.

Carbon market mechanisms can pave the way for transforming the transport and energy sectors. Investments in electric mobility are transformative in the sense that they replace fossil fuel for transport use and at the same time have the potential to add storage capacity to the electricity grid. This allows a more flexible and resilient electricity grid that is able to buffer electricity from renewable energy sources, allowing an increased share of renewable energy to be generated and used. Transport and energy companies can strengthen the credibility of their net-zero claims and other environmental targets, through purchasing sector-related carbon offsets. There are strong reasons to believe that these forward-thinking companies will seek to further decarbonise their operations and offset unabatable emissions by resorting to electric mobility carbon credits, where possible. This marks a significant opportunity to scale e-mobility carbon projects.

Supporting early-stage movers in this space – especially when linked to a strong digital platform – can accelerate the unlocking of this potential

Carbon markets are well placed to support the development of emerging technologies such as electric mobility. Today, these technologies are too expensive to be scaled but carbon finance could change that. We anticipate that carbon credits from e-mobility and transport projects will be price competitive with small-scale, high-quality, renewable energy projects.

However, carbon methodologies are by definition conservative in their emission reduction calculations; on a per-unit basis, the emission reductions of for example e-motorbikes are around 1.5 tonnes of CO_2 equivalents per vehicle per year. At current prices on the voluntary carbon market, these volumes hardly justify the costs of developing such carbon projects.

Scale, improved (baseline) monitoring and lower transaction costs are some of the most important improvements that need to be made to justify the costs of developing e-mobility carbon projects while generating substantial revenues for the project operator. An integrated digital MRV process for emissions and emission reductions would:

1) significantly lower the costs for MRV and enable e-mobility carbon projects to scale at a lower cost to the project developer/owner;
2) improve the integrity of the carbon credits, thereby increasing their value and the revenue earned by the project activity operator;
3) allow for more detailed emission monitoring for both baseline and project vehicles, most likely increasing the emission reductions monitored and issued in the project;
4) increase the number of e-mobility carbon credits on the market, which would in turn fuel demand and unlock more opportunities for early-stage e-mobility enterprises; and
5) enable faster MRV cycles, reducing the time between the generation of the emission reductions and payment to the activity operator.

Meanwhile, national governments can now take steps to improve the integrity of the carbon credits and increase their value. Bilateral agreements on carbon cooperation between countries seeking to source carbon credits and countries that host emission-reducing activities, could significantly improve the value of a carbon credit. Rwanda has shown interest in carbon market mechanisms and in serving as a host country for international carbon cooperation.

The further exploration of digital MRV systems – combined with the development of a bilateral carbon cooperation programme to unlock the potential of carbon markets for early-stage e-mobility enterprises – is recommended.

11 Looking ahead – from concept to reality

Bilateral Article 6 pilot is worth exploring

A relationship with a buyer under a bilateral Article 6 pilot should be explored due to the higher perceived value of such a transaction. However, as these transactions have substantial lead times, the preparation phase (including request-for-proposals submissions) should commence immediately. We propose submitting this project for upcoming tenders (e.g. the Swiss KLIK foundation in November). The fourth quarter of 2021 will be very important if we want to pursue this. As KLIK requires a host country Letter of Intent (LoI) for consideration, this LoI needs to be addressed with the Rwandan Government before a submission under Article 6 can be considered. Furthering discussions with MININFRA and REMA is one of the most essential next steps. REMA has already made significant progress in experimenting with Article 6 and we need to explore the potential for e-mobility to be part of the so-called 'positive list' of technologies that Rwanda wants to consider for international carbon transaction projects.

It is possible to already structure a transaction

In parallel, it is possible to already structure a transaction, even at the early stage (pre-registration), with a pioneer in the voluntary carbon market – although this is associated with higher risk. We believe that an early transaction, even if for a small quantity is an important proof of concept.

South Pole's SHIFT platform

South Pole's SHIFT platform is currently the most advanced third-party platform for e-mobility at this stage.47 We have already made two successful submissions to KLIK (Thailand and Laos) and we believe that an African country SHIFT programme would be received positively. A substantial amount of the grant is raised from the buyer.

Measuring co-benefits as a function of parameters that we already capture

We propose defining and measuring co-benefits as a function of parameters that we already capture for carbon quantification: i.e. kilometres driven on an e-motorbike directly translate to cost savings for the driver and reduction of local pollution.

[47] SHIFT receives an origination fee of EUR 1.50 to 2.50 (added to the transaction price – this range is applicable as long as volumes are low and it is likely to drop as economies of scale kick in) as well as a readiness grant to onboard/launch a new country programme.

Annex I: Primary baseline testing – example set-up

Annex I describes the example set-up for baseline vehicle testing, as discussed with the case study proponent, Ampersand. Baseline vehicle testing can be done using a survey approach (i.e. asking the driver) or a more technical approach. Both approaches would need to use the same calculations to determine the sample size.

Primary testing

Previous research used testing data from studies abroad, rather than studies based in Africa. Such studies used different vehicles in different geographical landscapes under different use case conditions. If practical testing/sampling of fuel consumption and emission factors were to be done under the selected carbon standard (VCS) and carbon methodology (VM0038), the CDM guidelines for sampling and surveys apply (CDM-EB67-A06-GUID[48]). This methodology describes general sampling procedures allowed under all types of carbon projects and has been adopted by many of the larger carbon standard frameworks, including VCS. The methodology is not tailored to e-mobility projects specifically and does not lay out any specific tools or testing methods that need to be applied by the case study proponent. Ampersand can use surveys, technical measurements or other approaches to assure the auditors (also known as the validation-verification body that results are reliable and verifiable.

> **Example: In a comparable two-wheeled e-mobility project in India, on the ground surveys were used for baseline testing. In this case, a simple random sample of motorcycle riders was asked to fill out a questionnaire that included questions about fuel type, vehicle type, vehicle cc, mileage (distance travelled per litre of fuel), daily running distance and year of purchase.**

Note that to determine baseline parameters, a technical instrument approach is not required as per the CDM or VCS methodologies. It is not a common practice, and thus, the carbon standard or auditor may have questions on the:

1) testing methodology used;
2) selection of the number of samples for practical testing;
3) calibration of testing equipment; and
4) the practical testing skills of the staff.

If, however, practical testing is desired, the following testing approach is suggested to establish the baseline average fuel consumption, and potentially, the emission factor.

Real-world testing of fuel consumption

Practical testing approach:

- GPS tracking: either
  - GPS tracker programmed to take readings every 0.5 seconds. A GPS tracker that can be easily installed and powered by the motorcycle battery is best. Bring any necessary tools for installation (e.g. spanners, screwdrivers).
  - Alternatively, mobile phones running a GPS app such as MotionX GPS can be used, connected to a power bank. Cord connections should be taped in place to prevent them from coming loose. Placed into a ziplock bag.

[48] CDM (2015) *Sampling and surveys for CDM project activities and programmes of activities*. Online at: https://cdm.unfccc.int/Reference/Guidclarif/index.html, accessed March 2021.

- Fuel-safe 20-litre Jerry-can containing 5 litres of fuel per test vehicle but not more than 15 litres. Note down the fuel octane rating, place and time of purchase, and purchase price per litre. Bring a spare empty jerry can in areas with more than one petrol fuel grade or where kerosene-supplemented fuel is available on the street.
- Large fuel-safe measuring vessel (some plastics will crack or dissolve).
- Fuel-safe filling funnel
- Paper notebook/ iPad etc.
- Pliers
- Masking tape
- Cash or mobile money to pay the driver
- Optional: belt pouch

Method

The researcher arranges to meet with the motorcycle taxi driver at the driver's home at the beginning of the workday, about 45 minutes before they would like to start the work (maybe 1 hour the first time this is done). The researcher recommends that the driver comes with a tank that is nearly empty.

The fuel tank is drained completely by disconnecting the fuel hose at the carburettor end and draining the fuel tank into the measuring jug. If the jug becomes full, then place the fuel into the jerry can. In areas with more than one available octane or where kerosene is bought, pour the fuel from the driver's tank into the spare jerry can. Balance the motorcycle on its kickstand to get the last drops of fuel out. The driver will know how to do this. It can take time to drain the tank, so an inverted pot or planks of wood can be useful to rest the measuring jug on.

When the tank is completely empty, reconnect the hose to the carburettor. Start the motorcycle until the last fuel is burnt from the carburettor. This can take 3-5 minutes.

Measure exactly 5 litres from the fresh fuel in the measuring jug. Carefully pour it into the fuel tank without spilling. Close the tank and tape it up with 2-3 strips of masking tape. This is to remind the driver not to forget not to buy fuel (this happens). Note the motorcycle age, make, model and fuel octane. If the odometer is functional, note the odometer reading.

Initiate the GPS tracking. Ask the driver to drive normally and not do anything differently from a normal day. Inform the driver that the driver can keep the fuel that the driver does not use so there is no reason to drive more just to use it up. It can be helpful to have GPS tracks from that driver from previous days to control for behaviour change. The researcher asks the driver to call them when they have finished their working day, regardless of when they finish. The driver then leaves and commences their workday.

Once the driver has returned home, the researcher meets them at the driver's home. The researcher confirms that the driver has not purchased more fuel. Then, the researcher drains the fuel into the measuring jug – as was done in the morning – and measures and notes the exact amount remaining. The difference between this measurement and the 5 litres poured into the tank that morning is the driver's fuel consumption for that day. Retrieve the GPS tracks. Note the odometer reading (if functional) and retrieve the GPS tracker/phone. Download the KML file and note the total distance travelled. Compare with odometer reading (if available). A variance of ±1-2% is normal. Any more than this should prompt further investigation that the GPS tracking was working properly. This can also be done over two days with 10 litres of fuel.

Sample size calculation

The CDM guidelines provide options for five different sampling approaches for selecting the baseline units (in this case ICE motorcycles and their riders). In the case of Ampersand, South Pole recommends using the 'Simple Random Sampling' approach as 1) it can apply to pieces of equipment; 2) it can apply to relatively homogenous populations (e.g. two-wheeled vehicles for motorcycle taxi use); 3) it is conceptually straightforward; and 4) is easy to implement. Simple random sampling would be an appropriate method to select internal combustion engine motorcycle vehicles and their riders that are operating in Kigali.

To calculate the sample size for practical testing – regardless of the testing methodology – CDM guidelines use the following equation:

$$n \geq \frac{1.645^2 N \times p(1-p)}{(N-1)\times 0.1^2 \times p^2 + 1.645^2 p(1-p)}$$

Where:

n = Sample size

N = Total number of two-wheelers in Kigali (30,000)

p = Our expected proportion of operational units at the time of survey (0.5)

1.645 = Presents the 90% confidence required

0.1 = Presents the 10% relative precision (0. 1X 0.5 = 0.05 = 5% points either side of p)

$$n \geq \frac{1.645^2 X\ 30{,}000\ X\ 0.5\ X\ 0.5}{(30{,}000-1) X\ 0.1^2 X 0.5^2 + 1.645^2 X 0.5 X (1-0.5)}$$

$$n\ \geq\ (20295.19)/(74.9975+0.6765)$$

n ≥ 268.19 ≈ 269

Therefore, the required sample size for this particular baseline study – regardless of the applied testing method – is at least 269 two-wheelers.

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