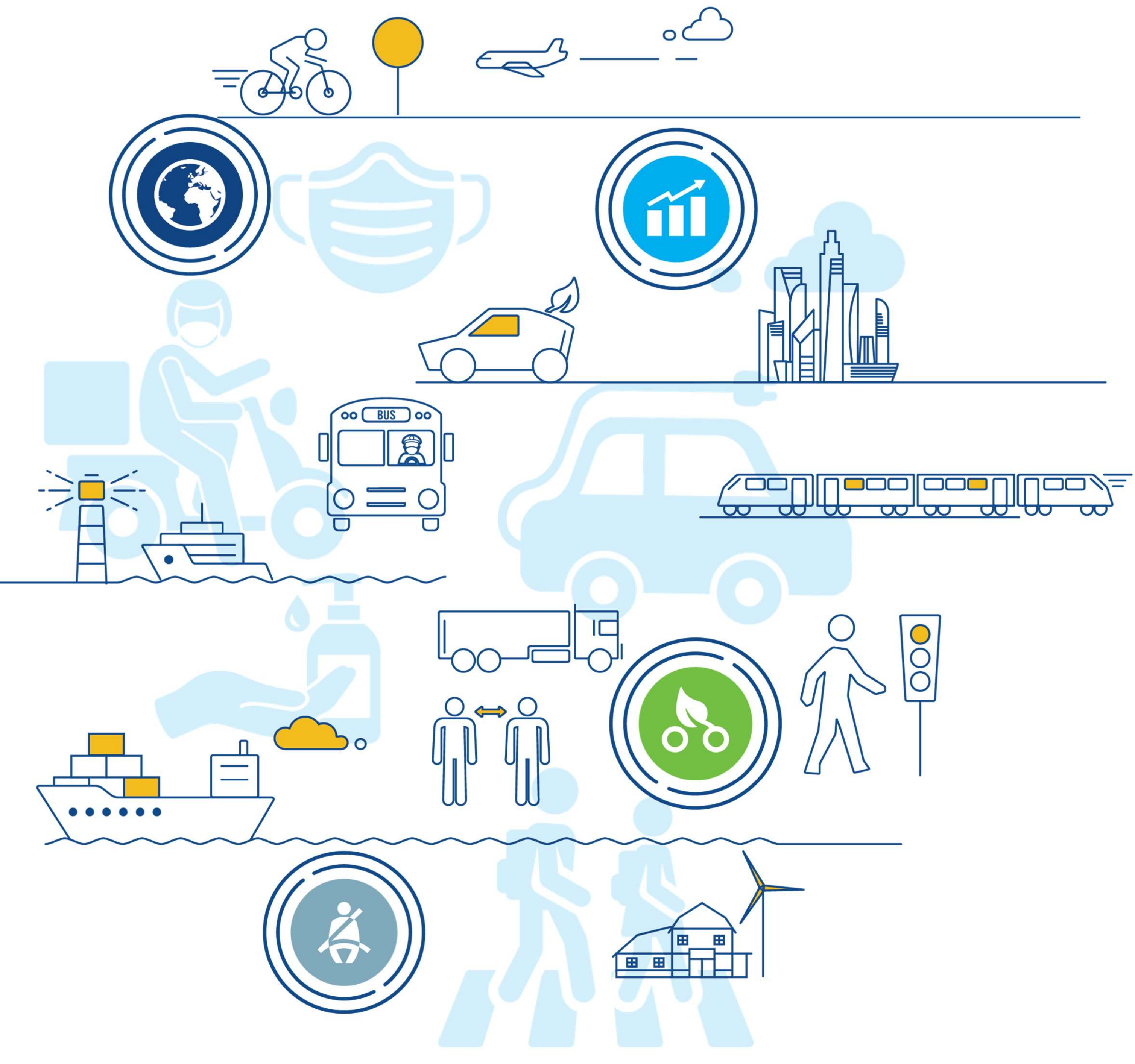
ELECTROMOBILITY IN THE GLOBAL SOUTH:

An Equitable Transition toward Road Passenger Transport Decarbonization

SUSTAINABLE mobility FOR ALL™



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List of Abbreviations

2/3W	Two- and three-wheeler
2W	Two-wheeler
ADB	Asian Development Bank
BMZ	German Federal Ministry for Economic Cooperation and Development
CCG	Climate Compatible Growth
CCTV	Closed-Circuit Television
CIF	Cost, Insurance, and Freight
COP26/COP27	26^{th} / 27^{th} United Nations Climate Change Conference: Conference of the Parties
DRC	Democratic Republic of Congo
E2/3W	Electric two- and three-wheeler
E2W	Electric two-wheeler
EV	Refers to road passenger transport vehicles powered directly by electricity, including passenger cars, electric scooters and pedal assisted e-bikes, fully powered 2/3W, such as e-rickshaws and electric cargo bikes, and minibuses, buses, and light 4-wheelers.
Electromobility	The systems, services, and equipment that support the movement of road passengers by electric-powered powered technologies.
FAME II	Faster Adoption and Manufacturing of Electric Vehicles
FCDO	Foreign Commonwealth and Development Office
FIA	International Automobile Federation
GDP	Gross Domestic Product
GHG	Greenhouse Gases
Global North	Refers to the richest and most industrialized countries, which are mainly in the northern part of the world: an alternate designation for “developed” countries or High-Income Countries (HICs)
GRA	Global Roadmap of Action
Global South	Defined as low income, lower middle income, and upper middle income countries as per World Bank Atlas method classification [1]. An alternate designation for “developing” countries or Low and Middle-Income Countries.
HAI	Human Assets Index
HIC	High-Income Country
HVT	High Volume Transport Applied Research

ICE	Internal Combustion Engine
ICT	Information and Communications Technology
IEA	International Energy Agency
IsDB	Islamic Development Bank
ITDP	Institute for Transportation and Development Policy
LDC	Least Developed Countries
LMIC	Low and Middle-Income Country
MBT	Minibus taxi
MDB	Multilateral Development Bank
MW	Megawatt
NDC	Nationally Determined Contribution
PAYG	Pay-As-You-Go
PEP	Philippine Energy Plan
PIARC	World Road Association
PM	Particulate Matter
PV	Photovoltaic
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
SEforALL	Sustainable Energy for All
SLOCAT	Partnership for Sustainable, Low Carbon Transport
SuM4All	Sustainable Mobility for All
TRL	Transport Research Lab
TUMI	Transformative Urban Mobility Initiative
UCL	University College London
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
V2G	Vehicle-to-grid
VAT	Value Added Tax
WBSCD	World Business Council for Sustainable Development
WGI	World Governance Indicators

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Foreword

This discussion paper is the result of an overall effort undertaken by the *Sustainable Mobility for All* partnership[i], in conjunction with the UK Foreign, Commonwealth and Development Office (FCDO) and the Climate Compatible Growth (CCG) Programme. It questions whether the Global North's approach to electromobility is suitable for countries in the Global South, particularly Least Developed Countries (LDCs). It complements two other policy papers by the SuM4All partnership: (i) *The Digital toolkit for Energy and Mobility,* which provides useful resources to integrate policy measures toward sustainable mobility; and (ii) *Sustainable Electric Mobility: Building Blocks and Policy Recommendations* on policy barriers to electromobility and essential building blocks for public policy in this area.

Released under the Global Roadmap of Action series (GRA)[ii], these papers contribute to a deeper understanding of the comprehensive policy framework required to transition to sustainable mobility. The series intends to stimulate an informed discussion on policy choices in transport and position the SuM4All partnership more prominently in the run-up towards COP26 and beyond. This will contribute to the debate on transport decarbonization, while considering the other goals of sustainable mobility: universal access, efficiency, and safety. The SuM4all partnership outlined this comprehensive policy framework in the GRA[iii], which is now being piloted in South Africa.

This paper shows that the model for transitioning to electromobility in the Global North will not work for all countries, and therefore new, innovative approaches are needed so that countries in the Global South are not left behind. Many countries understand the issue and are willing to transition but the poorest countries often face demanding technological, financial, and social pressures. These current circumstances make this transition extremely difficult or not timely. The Global North has a responsibility, as the historic high emitter of carbon, to help these countries bridge the Green Divide [2].

The paper seeks to raise questions and issues for dialogue focused on the role of electromobility as a solution to decarbonize the transport sector. It is intended as a unique discussion document, which will contribute to the international debate at COP26 and beyond, regarding the right pathway to decarbonize the sector by taking the perspective of the LDCs in the Global South.

[i] The SuM4All consortium consists of over 50 Member organizations that have pledged to a shared vision on sustainable mobility anchored on the 4 goals of universal access, efficiency, safety, and green mobility and have agreed to work together toward its implementation. Member organizations fall into five broad categories: (i) Multilateral Development Banks; (ii) UN/ Intergovernmental Organizations; (iii) Bilateral Partners; (iv) Private Sector/ Business Associations; and (v) Global Civil Society Organizations. https://www.sum4all.org/consortium-members

[ii] The GRA in Action series contains actionable guidelines developed from the recommendations made in the *Global Roadmap of Action toward Sustainable Mobility* (GRA) Policy Tool developed by the Sustainable Mobility For All (SuM4All) initiative. Drawing from the Catalogue of Policy Measures, these papers take a deep dive into policies and global experience available to enable policymakers to take action on the ground.

[iii] The GRA included a dedicated Green Policy Paper which was uniquely the first-ever comprehensive effort to consolidate global knowledge and experience on the best available policy and investment options for countries to progress toward green mobility, across all modes of transportation.

Executive Summary

Meeting the targets set in the UN Paris Agreement and the Sustainable Development Goals (SDGs) will require low emission pathways to decouple economic growth from long-term GHG emissions. An increasing number of countries in the Global North are pushing for domestic ‘net zero’ targets and zero-emission vehicles (ZEV). It is projected that a rapid increase in the uptake of electric vehicles (EVs) will significantly reduce carbon emissions. Electromobility is emerging as the dominant model to decarbonize the transport sector.

The electrification of transportation is portrayed, largely by the Global North, as an opportunity waiting to be seized by *all* countries. Behind this enthusiastic narrative, two questions need to be addressed:

- Is this model adequate for *all* countries, or will the poorest countries be left behind in this transition to electromobility?
- If the uptake of EVs is massive in Global North countries, what are the implications and impacts on the poorest countries?

These questions are highly relevant in the context of a growing **Green Divide** between High-Income Countries (HICs) and the Least Developed Countries (LDCs). On the one hand, the Global North are historically responsible for the bulk of global emissions and climate change: G20 countries have contributed four-fifths of global emissions. On the other hand, the poorest countries in the world – those least responsible for climate change – are often the most affected. In the current circumstances, these countries are at significant risk of being left behind in the transition to decarbonized road transportation.

This paper is intended as a unique discussion document, which will contribute to the international debate at COP26 and beyond regarding the most appropriate way to decarbonize the road transport sector by representing the perspective of the LDCs in the Global South. It highlights six key issues that need to be addressed to ensure an equitable decarbonization of road passenger transport in the Global South. These six issues need to be considered in tandem: for example, one cannot explore new business models and finance or funding mechanisms separately, these should be considered along with governance, policies, and regulation to help build the capability and capacity needed to ensure an equitable transition to electromobility.

1. **Electricity Supply**: Carbon intensity and reliability of electricity supply varies in the Global South. Benefits of electromobility include zero exhaust emissions, lower cost of fuel per km travelled, reduced maintenance costs, and new jobs. Weak and unreliable electricity grids are key obstacles to electromobility in LDCs; however, the additional electricity demand from electromobility can provide an incentive to grid developers to build more infrastructure. This can help high carbon and unreliable electricity systems transition to low carbon and reliable systems and potentially increase electricity access.

2. **Economic**: There is a need to develop new business models and appropriate tax policies that encourage the adoption of suitable mobility solutions and incentivize consumers to switch to EVs. Most Sub-Saharan African (SSA) countries subsidize fossil fuels to protect consumers from high costs. These subsidies could be spent elsewhere in a more equitable manner, and appropriate tax policies need to be developed to support the transition to electromobility.

3. **Financing**: The current investment and funding gap is high in the Global South, so targeted finance needs to provide incentives for further public and private investment to ensure a transition to electromobility. The Global North has a responsibility to enable the transfer of knowledge and technology together with the funding that would allow countries in the Global South to develop electromobility projects that are most appropriate for their needs. Without these resources, countries in the Global South are unlikely to be able dictate their own terms of development, and this will deepen the Green Divide and exacerbate inequalities.

4. **Social**: Gender equality and social inclusion considerations will determine the success of any transport decarbonization strategy. Community engagement is needed so that consumer attitudes in the Global South are factored into electromobility planning policies. In addition, electromobility and urban planning must be coordinated to help ensure accessibility, affordability, inclusivity, security, and safety of transport infrastructure for commuters. The lack of technical knowledge and required skills in LDCs for the electromobility transition needs addressing, but it also presents an opportunity to provide jobs for local populations. Electromobility has the potential to improve air quality, which has associated health benefits.

5. **Governance and Regulation**: Capacity for regulation and enforcement of emission standards in the Global South is varied. There is a need to build capacity and support National Environmental Management Agencies and relevant ministries. A substantial proportion of LDCs depend on the import of used vehicles from the Global North, which has a significant effect on mobility and emissions. A reduction in second-hand vehicles could distort the market in the Global South or have the perverse impact of keeping older, more polluting vehicles on the road for longer. Strengthening the regulation and enforcement of vehicle emission standards in the Global South could be used to encourage the adoption of EVs.

6. **Material**: Electromobility requires materials for new EVs, batteries and their chargers, and key infrastructure (e.g., roads and parking facilities); material extraction (e.g., mining), production, and vehicle manufacturing facilities; and additional electricity generation and distribution infrastructure. Mining in the Global South can involve questionable environmental and social practices with harmful working conditions. As the monetary value of materials extracted increases towards the end of the supply chain, the Global South often does not benefit fully. Despite increasing demand for materials raising prices, little profit trickles down to the mining communities in the Global South, especially the LDCs, further exacerbating inequalities.

Ensuring an Equitable Transition

We call for a greater understanding of the unique challenges LDCs face in the transition to electromobility and the responsibility that the Global North has in ensuring the fair and equitable transition to low emission mobility in the Global South.

The Global North should **provide additional funding** for capital investment in EV infrastructure and manufacture, as well as financing for renewable energy projects. Other support, such as institutional strengthening and technical capacity, is needed to enable the LDCs to consider alternatives to internal combustion engine (ICE) vehicles.

Over the coming years, Global South countries will need to make policy decisions and investments to decarbonize road passenger transport. At the same time, the proposed widespread adoption of EVs in the Global North, including financial mechanisms and regulation, material for EVs, and the second-hand vehicle market, will have an impact on the decisions and pathways of the Global South.

Most countries in the Global South, including LDCs, should seek to **improve and increase accessibility, affordability, inclusivity, security, and safety** of a range of mobility options such as paratransit, e-bikes, electric two- and three-wheelers (E2/3W), and non-motorized transport, especially for low-income and disadvantaged groups. A future electromobility strategy must ensure that the benefits of an electromobility transition can be enjoyed by all, without an associated inequitable financial burden placed on the country.

The issues highlighted in this paper could be used to initiate a dialogue at the UN Framework Convention on Climate Change (UNFCCC) conference of the parties (COP) 26 to address the equitable transition to electromobility of countries in the Global South, including the LDCs. It is proposed that a dedicated working group, as part of a SuM4All Partnership, conduct deep dives into some of these issues to gain a better understanding and to develop an action agenda for COP27 and beyond.

1. Context

The 2015 United Nations (UN) Paris Climate Agreement set out an action plan to limit global temperature rise to well below 2°C, preferably to 1.5°C, when compared to pre-industrial levels. This will require a strong and sustained reduction in carbon dioxide (CO_2), and other greenhouse gases (GHGs) to further limit climate change [3].

Although global GHG emissions have increased, emissions from the Global South are heavily concentrated. 10 countries contributed 78% of the emissions while 34 LDCs, most of them in Sub-Sahara Africa (SSA), contributed only 1% of the total emissions from the Global South total [4].[iv] High-Income Countries (HICs) in the Global North have been responsible for this rise in GHG emissions [5]. In contrast, many poorer countries in the Global South will be disproportionately affected by the impacts of a changing climate. Therefore, there is an ethical responsibility for the Global North, as historic emitters of CO_2, to assist the Global South, especially the LDCs, in the decarbonization of the road passenger transport sector.

To meet the UN Paris Agreement targets, transport CO_2 emissions will need to be reduced by between 70% to 80% by 2050 compared to 2015 levels [6]. In 2020, around 77% of global transport emissions were from on-road transport, especially passenger cars [7]. The United States, China, India, and European Union Member States have the largest vehicle markets and are responsible for 46% of global transport CO_2 emissions [7].

Reducing transport emissions will require an immense international effort as road transport is currently one of the fastest growing emission sectors, responsible for 30% of energy-related global GHG emissions [8]. It is further hindered by rapid population growth, urbanization, and motorization experienced in many cities around the world. Meeting growing transport demand while reducing emissions will require the use of cleaner fuels and new low carbon vehicle technologies as well as changes in travel behaviour.

In the Global North, electromobility is emerging as the dominant model to decarbonize the transport sector. An increasing number of countries in the Global North are pushing for domestic 'net zero' targets; it is envisaged that a rapid increase in the uptake of electric vehicles (EVs) will significantly reduce carbon emissions. The systems, services, and equipment that support the movement of road passengers by electric-powered technologies is often referred to as electromobility.[v]

Projections, evidence, and data on the benefits of moving in this direction for HICs in the Global North are abundant [9]. Over the next few years, the uptake of EVs is expected to grow rapidly in many countries, driven by reduced costs and improvements in battery technology, extensive charging

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[iv] According to the report 'Asymmetric Demographic Transitions and North-South Capital Flows' from the Brookings Institute (2006), "The South" is defined as lower-income, less developed countries while "the North" is defined as higher-income developed countries. The terms the Global North and the Global South, when used in a global context, are alternative designations for "developed" and "developing" countries or High-Income Countries (HIC) and Low or Middle-Income Countries (LMIC) [120]. **We recognize that within the Global South there is a significant variation based on size, geographic location, socioeconomics, population, and per capita income such that one size does not fit all**.

[v] Electric means of transport include all types of road transport powered directly by electricity, especially passenger cars, electric scooters and pedal assisted e-bikes, fully powered two- and three-wheelers (2/3W), such as e-rickshaws and electric cargo bikes, and minibuses, buses, light 4-wheelers, and cars [47]. We use the term electric vehicles (EVs) to mean all electric road passenger vehicle including passenger cars, buses, mini-buses, electric two- and three-wheelers (E2/3W), electric bicycles, and electric micro-mobility.

networks, and greater promotion of electromobility through subsidies or initiatives to phase out internal combustion engine (ICE) vehicles.

In this discussion paper we focus on the poorest countries in the Global South (with an analysis excluding China and India). Using United Nations Conference on Trade and Development (UNCTAD) criteria,[vi] 47 countries, mostly in SSA, can be identified as Least Developed Countries (LDCs). A larger number of countries in the Global South have a low per capita income (<$5,000 GDP per capita) [10], and the majority of these would also have difficulty affording a rapid transition to EVs and adoption of electromobility in the near term.

Models of electromobility that are focused on the passenger car and thus more relevant for wealthy nations do not necessarily apply to countries in the Global South [11]. Many LDCs depend on cheap paratransit public transport, which is often informally run and demand responsive. In addition, non-motorized transport such as walking, cycling, and pedal-powered two- and three-wheelers (2/3W), tend to be the main transport modes for many low-income and disadvantaged groups [11].

Whether electromobility is appropriate for the Global South is a contested issue. At one extreme, there are views that the Global South cannot afford to decarbonize their transport systems without this process becoming another form of neo-colonialism by the Global North, as the high costs of electromobility have the potential to increase debt, and finance mechanisms can be inappropriate or unjust. There are also concerns about the practicalities of imposing the Global North model of electrification on the Global South [12, 13].

At the other extreme, there are views that this is an opportunity for some countries in the Global South to leapfrog the Global North and reduce the time spent locked in to high carbon transport, and that there are co-benefits to this pathway (e.g., improved air quality, increased political independence, reduced demand on foreign exchange reserves, lower noise pollution, job creation, etc.) [14, 15].

Within these two extremes, there are more nuanced views questioning the timing for this transition for poorer countries. There is a call to identify factors and criteria that will help to determine the most suitable pathways for countries in the Global South to adopt electromobility and ensure EVs are an asset instead of a burden. This timeline and approach should be determined by the Global South and not imposed from the Global North.

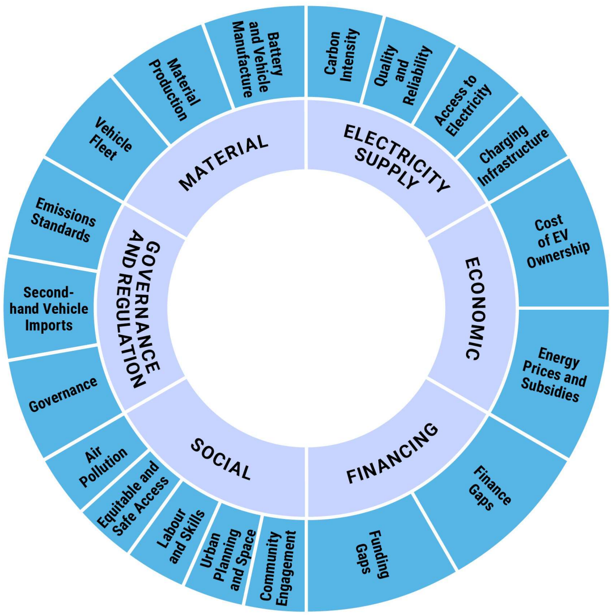
A key objective of this discussion paper is to rebalance the debate on electromobility. It highlights the differing challenges and potential opportunities of EVs for countries in the Global South. It discusses the actions countries in the Global North and South can take to ensure a just and inclusive transition to electromobility. The electromobility debate can be controversial, often lacking data and evidence to support policy choices. This discussion paper presents six key issues to guide the decision-making process during the transition toward electromobility in the short to medium-term. It raises a series of questions that should be considered by both the Global South and the Global North, although the focus is on concerns of the Global South and the impact on the LDCs in particular.

[vi] 3 criteria have been chosen [84]:

- A per capita income criterion, based on a three-year average estimate of the gross national income (GNI) per capita, with a lower threshold of $1,018 [7];
- A human assets index (HAI), consisting of a health sub-index and an education sub-index.
- The economic and environmental vulnerability index.

These six key issues cover Electricity Supply, Economic, Financial, Social, Governance and Regulation, and Material considerations (**Figure 1**). By nature, they are not comprehensive and should be read with the view that not all considerations are relevant for a given country. With the six key issues comes a set of questions that should be considered by national decision-makers (e.g., Transport, Energy, Finance, or Business Ministries) to gauge the suitability of the electromobility model for immediate action or at appropriate stages according to the needs of the country.

Figure 1 Electromobility Considerations in the Global South



At the end of the document (**Section 9**), short country specific cases have been provided to showcase the diversity of opportunities and challenges and highlight the varied solutions needed in differing contexts in the Global South.

1.1. Scope of the Paper

This discussion paper examines several challenges that Global South countries, and LDCs in particular, face as they strive to transition to electromobility in the road passenger transport sector. Although highly important in the decarbonization debate, this paper does not consider freight transport, rail, aviation, or inland waterway transport.

It focuses on road passenger vehicles as major contributors to transport emissions. While the importance of road freight transport is recognized, it is not considered in detail here, as currently EV technology is not sufficiently commercialized for heavy-duty vehicles, especially in the Global South. The focus is also on battery EVs, so hybrid and alternative fuel vehicles are not considered

The paper does not seek to offer solutions but instead raises questions at the end of each sub-section that require further consideration and discussion.

2. Energy Supply Considerations

Technological advancements in EV charging systems and batteries – together with policies being adopted by governments to divest from fossil fuels and address the climate crisis – are driving the electromobility agenda in the Global North. However, the practicality of the Global North's model of electromobility adoption for countries in the Global South must be considered prior to adoption. Transport and electricity systems in the Global South are different to those of the Global North in terms of transport modes, governance and regulation, and electricity generation and supply.

For some countries, the additional demand that EVs will place on electricity supply has the danger of widening the energy poverty gap and deepening social inequalities, especially amongst the LDCs (see also **Section 5**). However, if the opportunities of innovative business models are seized, the growth of flexible demand from electromobility can also be used as an 'anchor load' to incentivize development in low-cost variable renewables and grid infrastructure – with the potential to improve energy access reliability of supply.

There are also important local equity considerations: in countries where energy access and reliability are still an issue, low-income and/or rural households are disproportionally affected compared to urban, higher-income households [16, 17]. Electromobility requirements, constraints, and solutions must be considered within the context of the local transport and energy system.

Here, we review the most important technical areas at the interface of electricity and transport. These are carbon intensity, quality of electricity supply, access to electricity, and charging infrastructure.

2.1. Carbon Intensity of electricity generations

The carbon intensity of the electricity system is crucial, as it will determine the global carbon emissions associated with powering EVs. In the Global South there is significant diversity in the carbon intensity of the electricity grid [18, 19]. Countries that rely on high carbon systems to produce electricity are less likely to make a significant dent in emissions through electromobility alone. In contrast, countries with low carbon systems are well equipped to reduce emissions through electromobility.

There is a "break-even" point[vii], whereby electricity generation is sufficiently clean, such that the transition to electromobility will reduce overall emissions in a country. This breakeven point is shown in **Figure 2** (below), in which the carbon intensity[viii] of electricity generation is plotted against the

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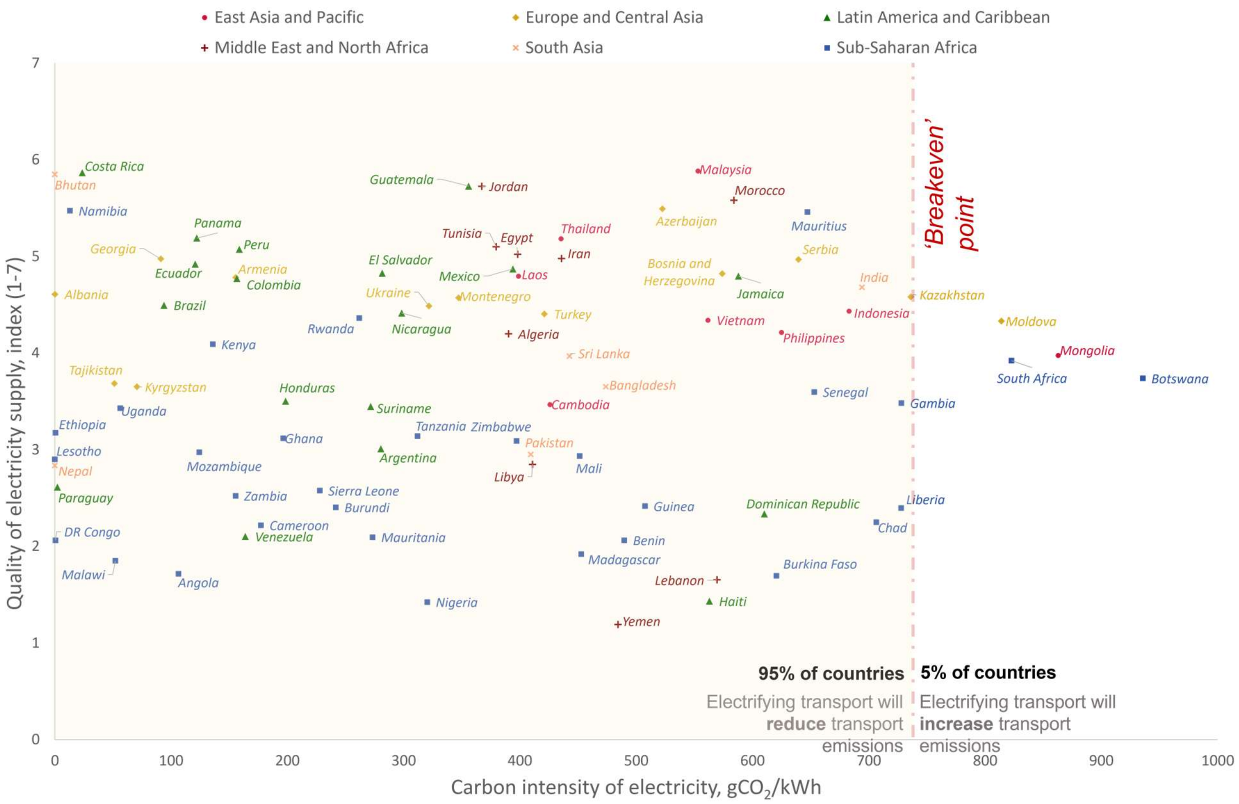
[vii] The "break-even" point, at which electrification can decarbonize a road transport system without any alteration to the electricity generation mix, can be found by consideration of the energy consumption of comparable-sized vehicles. This depends on the type of vehicles under consideration. For example, in a Sub-Saharan African context, where 50–98% of automotive passenger trips in cities are made by paratransit [121], the energy consumption of an electrified 16-seater minibus [122] at 0.42 kWh/km can be compared to the CO2 emissions of a diesel-powered 16-seater minibus [123] at 312 gCO2/km. Therefore, for the emissions of an electrified minibus fleet to breakeven with a diesel minibus fleet, the CO2 intensity of the electricity mix would have to be around 740 gCO2/kWh or lower. This breakeven point, superimposed onto Figure 2, is relatively constant for the case where one type of vehicle is being electrified (conversely to a type of vehicle being replaced by an electrified form of another type of vehicle – for instance, the replacement of a minibus fleet by a private car fleet). Note that this analysis covers only "tailpipe" emissions and not upstream emissions - resulting from fuel processing, materials extraction, manufacturing, and disposal/recycling – for both fossil-fuelled and electrified vehicles.

[viii] Grid carbon intensity is derived from the generation mixes of each country (data from Our World in Data [18]) using the same methodology as National Grid ESO [19].

quality (reliability) of supply (index 1–7). In Figure 2, 95% of countries in the Global South sit before this breakeven point and have the potential to reduce emissions by transitioning to electromobility, while keeping the carbon intensity of their electricity grid system unchanged. However, some of these countries are relatively low emitters of carbon, and the gains that could be made will have to be considered in the context of the financial upfront cost to poorer countries.

What impact does grid carbon intensity have on a country's ability to reduce emissions through a transition to electromobility?

Figure 2 Low carbon generation (%) vs. carbon intensity of electricity (gCO_2/kWh) for 85 LMICs



Note: Data courtesy of Our World in Data [18]; conversion to carbon intensity done using methodology from National Grid ESO [19]. LMICs defined as low income, lower middle income, and upper middle income countries as per World Bank Atlas method classification [1]

2.2. Quality and reliability of electricity supply

Electricity systems (including generation and grid infrastructure) in the Global South tend to be unreliable and insufficient to cater for increased electricity demand or provide basic energy access, compared to those in the Global North. For example, the quality of supply index is above 6 in countries such as Japan (6.66), Canada (6.58), and France (6.76). However, **Figure 2** (shaded area) demonstrates that the quality of supply index is below 6 for many countries in the Global South and below 4 for most of the LDC in SSA. For example, in Sierra Leone (2.57) there were 53 unplanned blackouts per day throughout 2017 [20].

It is important to note that reliability is not dependent on the carbon intensity of electricity generation. High carbon systems are not more reliable; and renewable energy does not provide an unreliable electricity supply. Four types of electricity systems can be identified (**Figure 2** for data; **Figure 3** for schematic):

(i) Low carbon, reliable systems;
(ii) High carbon, reliable systems;
(iii) Low carbon, unreliable systems;
(iv) High carbon, unreliable systems.

Electromobility requires a reliable supply; however, as will be seen in Section 2.3, it can also be used to encourage investment to improve both quality of supply and access to electricity.

How can electromobility help transition electricity systems in the Global South so they are both low carbon and highly reliable?

2.3. Access to electricity

It is estimated less than 50% of SSA's population have access to electricity [21]. By 2030, an estimated 660 million people worldwide will still not have access to electricity [22]. There are also frequent disruptions of supply, sometimes lasting many hours. This has a detrimental effect on business productivity, non-farm employment, and health services [23]. The transition to electromobility, if carefully implemented, can provide the impetus to improve energy access as well as reliability of supply. Electromobility can act as an 'anchor load', providing a predictable amount of electricity use, encouraging investment in the electricity grid and renewables for purposes beyond transport [24]–[26]. Paraguay is an example of a country which could benefit by using electromobility to create an anchor load, thus creating a domestic market for its renewable electricity and improving its energy export rates (**Country Case 1**). Certain technologies can also be employed to aid the electromobility transition and improve accessibility. Vehicle-to-grid (V2G) systems allow EV batteries to provide a flexible electricity supply for other purposes when there is high demand, but this technology is untested in a Global South context, especially for electric two- and three-wheelers (E2/3W).

Microgrids are small networks of electricity users with a local source of supply (for example, powered by hydro or solar energy). These can be attached to a centralized national grid but can also function independently. Microgrids have significant potential to be combined with charging infrastructure networks to supply electricity in remote areas [27]. Microgrids can support EV charging and EVs can in turn support microgrids as their batteries can be used as an energy resource to balance the grid. Because of their low demand, E2/3W can be more easily powered by microgrids than conventional vehicles and could provide useful transport services and electricity access in more remote locations.

Can electromobility provide an impetus to increase the access to electricity for all and improve the affordability of electricity?

2.4. Charging infrastructure

Consumer surveys have shown that charging time and range anxiety are important concerns [28]–[31]. Given that the poor in Global South countries often commute long distances to make a living, the range of the vehicle (and the reliability of this range in extreme heat or poor road conditions) is a critical issue (see **Country Case 6: South Africa**). Vehicle range can be affected by vehicle load (i.e., luggage or number of people), driving style, ambient temperature, road conditions, and tyre quality. For example, electric two wheelers (E2Ws) are often used to carry multiple people and freight, which can reduce the actual range achieved [32]–[34]. A reliable and efficient charging infrastructure, appropriate to the local context, is therefore needed in the Global South.

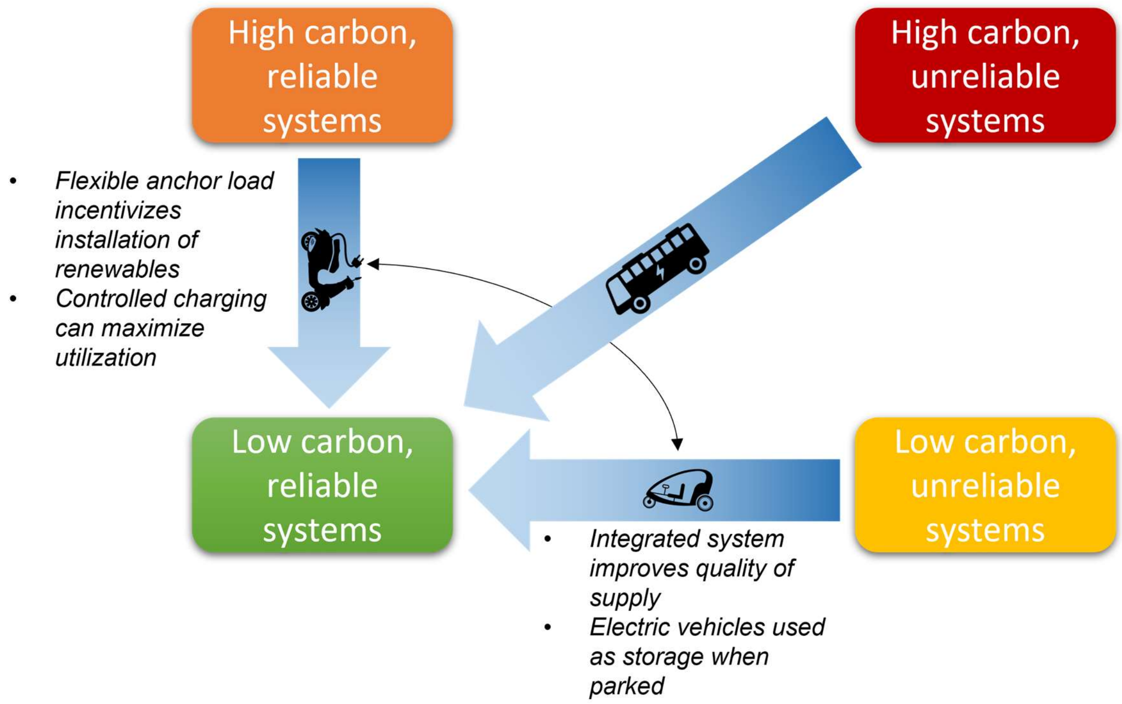
There is also a gap in the availability of data in the Global South for key factors, such as potential demand from EVs, vehicle locality, and usage patterns. Where data exist, they are often poorly defined. This is particularly the case for those systems dominated by paratransit (also known as informal or community transport [35]), a situation common in the Global South. A report by SuM4All, *Policy Making for Data Sharing* [36] sets out the role of policymakers in filling this gap: establishing data protection regulations; ensuring service providers report standardized data; developing data repositories and data collection guidelines; and ensuring the use of data to support decision-making. Advanced data collection and analyses enable the design, planning, and operation of sustainable transport solutions, such as efficient and effective implementation of charging infrastructure.

Electromobility provides a potential pathway to transition from high carbon and unreliable electricity systems to a low carbon, reliable system as part of climate compatible growth (as shown in **Figure 3**). This is because electromobility can provide an 'anchor load': a new electrical demand that provides the operators of electricity generation and grid infrastructure with additional revenue, and thus an incentive to build. Furthermore, the flexibility of charging demand, whether this be done via battery swap stations or charge points, naturally favours low-cost variable renewable generation like wind and solar as it can maximize use of these resources when other demands are low. Electromobility charging can respond in real time to the needs of a grid, providing an integrated system with improved stability and quality of supply. There are further benefits to the electromobility transition, including job creation and reduced reliance on oil imports, which could have cost savings and improve energy security.

However, the issue of affordability remains, both in terms of increased initial infrastructure cost to a country as well as the cost of electricity to the population, where many, especially in the LDCs, experience fuel poverty [37]. This will be discussed further in Section 4 on Financing.

What data is needed to ensure charging infrastructure is efficient and effective?

Figure 3 Schematic summarizing electromobility as a route out of high carbon and/or unreliable electricity systems



3. Economic Considerations

The potential impacts of a transition to electromobility on an economy are manifold, especially for countries in the Global South. These include development and investment in infrastructure, manufacture, or procurement of EVs and the development or reconfiguration of energy and transportation systems that require long-term changes in the value chain.

Two areas of economic consideration are explored in greater detail below, the cost of EV ownership and the impact of energy price and subsidies.

3.1. Cost of EV Ownership

Because of their low battery requirements, (and hence low relative cost) E2Ws dominate the global EV market. China and India have the largest fleets; in 2019 it is reported that China had close to 300 million E2Ws, while India had 600,000 E2Ws. In contrast the global stock of electric passenger cars was around 7.2 million [38].

In Kenya the costs of a new ICE motorcycle and a new electric motorcycle are very similar (**Country Case 2**). Apart from 2/3W, most light and heavier EVs are currently more expensive than their equivalent ICE counterpart. However, in the next few years there is likely to be a significant increase in the adoption of EVs. This is because the price of batteries is forecast to continue to fall, so that by 2026 electric passenger cars and other light vehicles are expected to reach price parity with new ICE vehicles. In addition, energy density will increase, leading to greater vehicle range [39]. However, because of the current reliance on cheaper second-hand vehicles, the choice for many Global South consumers looking for EV solutions is stark. Kenya provides an example of the costs of ownership for electromobility projects as well as attempts to implement legislation promoting electromobility investment (**Country Case 2**). The cost of electromobility, or associated technologies such as battery swapping, is a barrier that is magnified in the Global South where a large percentage of the population rely on affordable transport to make a living. There is also a stronger and direct link between accessibility via road transport, economic prosperity, and improved prospects for low-income groups.

The transition to electrification of road transport must therefore be accompanied with appropriate policies to ensure that accessibility for the poor is not compromised (see Section 5.5). For example, there is a risk that higher public transport vehicle costs will be passed on to low-income commuters who need these services. Therefore, affordable and context-specific electromobility is necessary (e.g., minibuses, e-Jeepneys, paratransit, and 2/3W) and needs to be considered in conjunction with active travel solutions. If the capital costs are reduced, then for service vehicles, payback times of under 2-years are possible [40] due to the lower cost per km of running an EV. The total cost of ownership (capital expenditure and operational expenditure) needs to be considered and communicated to local populations. Costa Rica is an example of one attempt to create taxes and subsidies promoting the ownership of EVs, but creating subsidies in an equitable fashion is challenging (**Country Case 3**).

There is a need for the development of new business models along with the appropriate finance, governance, regulation, and policies that can encourage the adoption of electromobility solutions that are relevant for a country's needs. This must include the Global South where the benefits of electromobility (such as improved air quality and lower operating costs) can also be realized.

How can EVs be made affordable for vehicle operators and users?

3.2. Energy Prices and Subsidies

The difference in energy price per km between ICEs and EVs represents one of the main incentives for consumers to switch to an EV. However, the relative prices are not static; there are a variety of taxes, charges, and subsidies that are levied on fossil fuels, and consumer prices can change as the international price of oil changes. The decline in the price of oil in 2020 reduced the price of petrol and diesel to consumers across the world. Because fuel is more expensive in the Global North, the absolute savings of switching to EVs are approximately 60% more per litre consumed compared with the Global South. There are large differences in relative prices within both groups of countries. Particularly low petrol and diesel prices were found in oil exporting countries such as Venezuela, Iran, and Nigeria.

Although many Global South governments have expressed intentions of meeting climate objectives, reducing air pollution, and encouraging the adoption of EVs, there has been a reluctance to implement and enforce unpopular measures relating to the transport sector [41]. Fossil fuel prices are politically sensitive. The majority of SSA countries subsidize fossil fuels to protect consumers from high costs [40]. In some instances, these subsidies can be as high as US $800 per capita [35] placing a huge burden on the public purse. The International Monetary Fund highlights the extent of fossil fuel subsidies and the impact that this has in reducing the incentive for investment in energy efficient or cleaner energy solutions such as electromobility [42].

By reducing the consumption of fossil fuels for mobility, these subsidies could be spent elsewhere by the government, improving a country's geopolitical independence by decreasing its dependence on fuel imports. Alternatively, subsidies could be reduced as a mechanism to encourage a shift to another energy source. However, this must be undertaken with careful consideration as raising fossil fuel prices has led to riots in many countries and has been a contributing factor in forcing changes in Government (e.g., Indonesia in 1997). In addition, countries in the Global South often have fossil fuel taxes in place in conjunction with subsidies. By reducing import of fossil fuels, these tax revenues may be diminished. If there is a switch to EVs, then there will be a need for many countries to consider how to replace lost fuel taxes through other means such as road pricing. Nevertheless, fluctuations in oil prices are a major issue, and it is generally recognized that electricity prices are far more stable (often closely following the consumer price index). This, in itself, could be an important long-term advantage in planning the future adoption of EVs.

What incentives or disincentives are needed to promote the adoption of EVs?

4. Financing Considerations

Electromobility is capital intensive. Significant investments generally are needed both for vehicles and the associated infrastructure (e.g., charging points). As a result, finance and funding are important but difficult challenges that could be a key driver to the transition of electromobility and a low emission economy for many countries in the Global South, if developed appropriately [43]. Finance, which is more available, requires a financial commitment such as project bonds or project loans to repay the initial amount of financial support and potentially a financing cost such as interest or equity return. Funding, which is less available, does not require a direct financial commitment or repayment and is often delivered through grant mechanisms.

Countries in the Global South have the potential to generate revenue from direct and indirect users of electromobility and financial support from development assistance institutions as well as the private sector, but this must be done in an equitable manner. The financial models and the sources of financing and funding that are needed by the Global South to engage in a transition to electromobility need to be considered, including the challenges poorer countries such as the LDCs may have in being able to participate in this transition in the near term [44].

Lao PDR provides an example of a country where electromobility makes environmental and business sense, but it is held back by an inability to access proper financing (**Country Case 4**). There are several schemes in existence, but it is not always straightforward for the Global South to access finance, especially for transport. This section considers financial models for EVs and Global South financial needs, which are split into (a) a funding gap (covered by, for example, grants) and (b) a financing gap covered by credit.

What are the most appropriate financial mechanisms to support the transition to electromobility, and what is the role of government, subnational bodies, and the private sector?

4.1. The Funding Gap

The financing requirements for electromobility include project development, operating costs, technical assistance, and so on: the amount of funds needed are significant.

By funding, we mean 'covering a deficit'. For the funding gap, historically, there has been a focus on carbon offsets and carbon markets; however, the move to net zero offsets will have to be considered. Net zero offsets require carbon removal and not just emission avoidance, as is often the case with carbon credits.

There is potentially a more prominent role for funding through Multilateral Development Banks (MDBs), particularly where results-based financing will play an important role.

One possible model would combine both low-cost financing and international crediting to pay the cost of interest payments. Concessional lending can cover both aspects; that is, it has an element of financing and an element of concessions or grants. There is an increasing focus on 'transformative' projects [45, 46], whereby electromobility can transform transport sectors and help countries achieve sustainable development and decarbonization goals [47]. Therefore, a proposed approach would emphasize the transformative nature of such models for the Global South. Arguably, such investment in electromobility projects could also have dramatic transformative effects through showing a working financial model and demonstrating the use of new technologies or existing technologies in new combinations. Since the needs of the Global South are different from the Global North, it could also create a technological niche that allows local manufacturing to be developed. Such arguments will become increasingly important in attracting international financing. MDBs should recognize the potentially transformative role of electromobility when done well.

There will likely be high levels of attention from private sector companies wishing to create global standards (for example, in battery swapping). One option that combines carbon markets/offsets and finance for climate mitigation is to use the climate offsets to finance the interest payments on low-cost lending. A better understanding of the timing of the funding needed for electromobility is crucial in aligning this payment profile with potential mechanisms to make the funding available to support these initiatives. As technology advances and markets and value chains mature, there is a risk that without appropriate funding the LDCs will become observers of this transition whereby opportunities to realize the benefits of electromobility will be missed.

How do we prevent the Global South becoming even more financially beholden to the Global North due to the transition to EVs?

4.2. The Financing Gap

In addition to the funding gap, there is a financing gap. By financing, we mean access to lending or investment. Action is needed to tap into local and regional financing in Global South countries. A crucial part of success would lie in developing local financial models and capital markets. However, LDCs have some of the largest Sustainable Development Goal (SDG) financing gaps, occasionally larger than their GDP [48].

A Pay-As-You-Go (PAYG) financial model developed in East Africa allows solar panels on a private household's roof to be paid for as the equipment is used, rather than upfront [49, 50]. Scaling up this model is vital not only for solar power but possibly also for electromobility. However, issues of equity and access for all will need to be considered (see Sections 2.3 and 5). Alternative models could also be considered such as using information and communications technology (ICT) integrated with smart communications in the vehicle and in electric charging infrastructure to optimize vehicle charging and to improve efficiency [51].

To mobilize further finance, low-risk financial products could be made available to people in Global South countries. Another option is that, increasingly, providers of electromobility operate across different countries and are able to access international sources of financing and encourage financial markets and systems to develop. Thus they can offer companies or individuals finance at low interest rates. Entrepreneurs from the Global South could play a role in creating investment products for people in the Global North and South. MDBs can also facilitate the creation of such markets.

Electromobility provides an opportunity for the 'learning by doing' model of catch-up development, as exemplified by the Chinese development model [52] but without the potential regional inequalities.

There is a need for the development of some technological capabilities as well as the skills and expertise to scale-up to meet electromobility demand in the Global South [see Section 5.4]. Many LDCs currently lack the critical scale to establish indigenous EV, solar, or battery industries. One option would be for countries to develop trade zones and reduce trade frictions so as to capture some of the development benefits internally to a region. There could be specialisms by country, combined with coordinated targets for scale-up (similar to India's EV scale-up targets) [53].

Paratransit [54] and E2/3W [55] and electric bicycles could play a significant role in the contexts of the Global South and finance mechanisms to fund the business models for these EVs need to be developed. There are multiple potential models, including standard EVs or swappable battery EVs – each with advantages and disadvantages. As the Global South has generally high solar resources, combined with low and falling photovoltaics (PV) prices, there is an obvious potential for 'solar filling stations' to charge EVs [56]. But this leads to various complexities, including the effects of heat or fast charging on battery life and the need to charge batteries in sunlight hours if solar charging is utilized (conflicting with when vehicles need to be used). These factors could lead to payments for an efficiency cost (the time required to charge) or additional investment cost of spare batteries (if a swappable battery model were employed) [57, 58]. The Global South could trial different models without prejudging which is the most promising nor assuming the same technological model that becomes dominant in the Global North is appropriate in the Global South. However, the projects that are developed on electromobility will have to demonstrate that there is an acceptable return on investment to encourage further investment from both the Global North and the Global South.

It has been suggested by many that current approaches verge on neo-colonialism – in this case climate colonialism – as there is a risk that such schemes perpetuate the power divide between the

Global North and Global South [59]. For example, it is cheaper to establish carbon offsetting projects in the Global South, but this may come at the cost of the rights of local people, women, or the socially disadvantaged or may be on land that would be better used for meeting local community needs.

Thus, the Global North has a responsibility to enable the transfer of knowledge and technology, together with funding that would allow countries in the Global South to develop electromobility projects that are appropriate for their needs. Without these resources, countries in the Global South are unlikely to be able dictate their own terms of development, and this will deepen the Green Divide,

How should a country best use the long-term, low-cost loans available from Multilateral Development Banks to de-risk investment in electromobility?

5. Social Considerations

There are several social considerations that need to be analysed when transitioning to electromobility. It is crucial that the needs of people be factored into any transition to ensure that the opportunities can be realized while ensuring that the poorest and socially disadvantaged groups of a country are not adversely affected.

5.1. Community Engagement

Walking and cycling are often the main modes of transport for many in the Global South, especially the LDCs. There is a need to improve safety and strengthen infrastructure and services for walking, cycling, and public transport in the Global South.

A holistic approach should be taken to include active travel in any electromobility strategy to ensure that investments in infrastructure will enable a reduction in carbon in the transport sector. Likewise, context-specific cultural norms need to be factored into decision-making. For example, the car remains a symbol of prosperity in the Global South, and in many countries, women tend not to drive ICE-powered 2/3W. The incentives to switch to EVs must be communicated in a way which engages with these cultural factors, as driver preferences are not necessarily driven by a concern for the environment.

A study showed that poor understanding of alternative (low carbon) vehicle technology and a lack of related policies was seen as a major challenge in Bangladesh [60]. This leads to prejudices, misinformation, and lost opportunities. Perceptions relate to cost of purchase, operation and maintenance costs, availability of maintenance capacity, vehicle emission levels, carbon footprint, and knowledge in-country. A better understanding of the wide range of consumer perceptions and attitudes in the Global South is therefore key to ensuring that electromobility projects are designed to target different segments of commuters.

What communication and community engagement are needed to ensure an appropriate and successful transition to electromobility?

5.2. Urban planning and space

Different vehicle modes and active travel require different planning considerations. For example, E2/3Ws, if substituting car trips, can help reduce traffic congestion; measures such as exclusive lanes, wait and turn boxes at signalized junctions, and dedicated parking could also help, as is seen in South Asian cities

Space is often a limited resource in Global South urban areas, and the space allocated to charging infrastructure competes against public transport stops, bus lanes, cycle lanes, public spaces, and pedestrian space. Home charging infrastructure in multi-family buildings such as flats could increase the rent, disproportionately affecting low- and middle- income households. Likewise rural populations will have different transport infrastructure needs, especially in LDCs where larger distances may need to be travelled.

Electrification policies, such as targeted subsidies, must be designed hand in hand with urban planning policies that ensure accessibility and affordability is maintained, or even improved (see Section 3.2 and Country Case 3).

What urban planning policies are needed to create a just transition to electromobility?

5.3. Air Pollution

Road transport is a major emitter of polluting air emissions in cities. In 2015, transport tailpipe emissions were responsible for an estimated 11% of global deaths from fine particulate emissions ($PM_{2.5}$) and ground-level ozone: a total of 385,000 deaths. The global health damages from transport tailpipe emissions are valued at approximately USD 1 trillion (2015). The health risks of air pollution are serious; poor air quality increases respiratory ailments such as asthma and bronchitis, heightens the risk of life-threatening conditions like cancer and burdens health care systems with substantial medical costs. Almost half of all deaths by air pollution from transport are caused by diesel emissions [20].

Studies have suggested that the poor suffer more from poor air quality than the rich due living in polluted places. There is evidence to suggest that sulphur dioxide (SO_2) emissions and particulate matter ($PM_{2.5}$) partly explain the large differences in child and infant mortalities between and within developing countries [61].

Despite progress in adopting more stringent vehicle emission standards, transport emissions remain a major contributor to urban air pollution. It has been estimated that the accelerated adoption of clean vehicle and fuel policies would save 25 million years of life cumulatively by 2030 and reduce early deaths by more than 210,000 in 2030. Emission standards have driven a decline in transport-related air pollution deaths in the Global North but remain a growing issue in China, India, and the Global South. [62]. A transition to electromobility provides an opportunity to reduce the impact of air pollution in the Global South.

How can emission standards be implemented across the Global South as part of national transport planning?

5.4. Labour and skills

In a transition to electromobility, jobs will shift away from those in oil, gas, and ICE vehicle maintenance. But what they shift towards could vary. Some countries in the Global South will have an opportunity to make use of the material resources and renewable energy to possibly 'leapfrog' past car-dependant transport systems to multimodal systems that are both safer, cleaner, and more relevant to their local environment.

Opportunities and infrastructure independence could be realized by manufacturing or retrofitting in country; however, upskilling the workforce in electric drivetrain maintenance, EV charge point installation, vehicle retrofit, electromobility manufacture, battery management, battery swap system logistics, and installation of renewable energy generation (e.g., solar PV) may be necessary. With training, there is no reason why these high-skilled jobs could not be filled by local residents. In addition, supply chains will need to be established, which could provide job opportunities in co-ordinating and conducting international trade.

Although at this stage it is difficult to predict how much assembly and manufacturing of EVs will take place in the Global South in the longer term, large countries such as China and India clearly have an advantage because of the size of their markets and manufacturing capability. Because of their relatively simple construction, and market growth, smaller countries are likely to initially develop assembly and retrofit of 2/3Ws. Currently Kenya provides an example of this (**Country Case 2**).

However, for many of the LDCs that may have the material resources and renewable energy that are needed for the transition to electromobility, there is often a lack of the technical knowledge and skills that are also needed in the labour force. The lack of a skilled workforce, together with the challenge in acquiring these skills in the near term, is likely to delay the transition to electromobility in the LDCs.

What are the existing local skill sets and what investment is needed to fill any skills gaps?

5.5. Equitable and Safe Access

The transition to electromobility in the Global South has implications for gender equality and social inclusion issues, which are different or vary in severity to those in the Global North. These include, but are not limited to, the affordability of transport services, security and safety of commuters, and access to facilities. While these could be viewed as existing issues in the Global South and separate to the transition to electromobility, they go together with the planning and implementation of EV charging infrastructure. This transformation provides an opportunity to: (i) improve social inclusion (by removing systemic barriers to access services); (ii) address violence towards vulnerable groups; (iii) improve safety, and (iv) introduce equity measures to achieve equal access. For instance, in Nepal it has been show that a shift to E2/3W has helped women to become financially independent (**Country Case 5**). If the transition to electromobility is undertaken without such considerations, then existing inequality issues will continue or possibly be exacerbated.

- *Affordable access to transport services*: This is an important concern in the Global South, where passengers would be unable to accommodate further fare increases. For example, in Nigeria, 77% of commuters deemed fares for minibus taxis unaffordable [35]. In addition, access to transport services can differ greatly between socioeconomic groups. Low-income groups tend to live in sprawling peri-urban areas where accommodation is affordable yet work in the central urban areas making them dependant on public transport (within this term we include paratransit). This can be seen in the example of South Africa's 40x40x40 club (**Country Case 6**).
- *Security:* There is gender-based and general discriminatory violence on public transport (including paratransit) in the Global South. Although under-reported, studies have found harassment levels of women taking public transport as high as 50% in Delhi, 78% in Pakistan, 81% in Azerbaijan, 89% in Chile, 92% in Egypt, and 97% in Nepal [63]. These numbers are significant, unacceptable, and must be addressed. This high threat of violence can prevent girls from attending school; women and those with disabilities participating fully in the labour market; and vulnerable groups from accessing healthcare services [63]. The infrastructure planning associated with a transition to electromobility presents an opportunity to address these issues: live vehicle tracking of public transport could reduce waiting times; and street lighting and CCTV could improve both the perception and reality of safety. Electromobility infrastructure could be utilized to provide power for such safety measures [63, 64].

- *Safety:* A World Health Organization report noted that the number of annual road traffic deaths has reached 1.35 million globally [65]. The burden is disproportionately borne by pedestrians, cyclists, and motorcyclists, in particular those living in the Global South. The issue of road safety needs to be addressed in the Global South and the transition to electromobility poses some challenges. For example, low cost E2/3Ws with heavy lead-acid batteries or overloaded with people and freight can be a safety issue, inevitably affecting lower income households more. However, the opportunity exists to improve road safety conditions for all road users.
- *Accessibility*: Those with disabilities require good access to the transport hubs. For example, the need for pavements to be clear of local traders and adequate ramps, handrails, and other accessibility facilities. When using public transport, wheelchair space and sufficient boarding and alighting time are paramount for mobility [66]. A EV registration process could aid the integration of appropriate measures imposing vehicle standards and licencing requirements. Due to a lack of disaggregated data on transport use in the Global South, transportation systems are not well designed to meet the needs of disadvantaged groups. However, a transition to electromobility could present an opportunity to rethink the way in which people's mobility needs are met and to address the failings of the current system.

Social inclusion, equal access, improved safety, and reduced violence needs to be part of mainstream thinking in the transition to electromobility. Vulnerable groups should be consulted to inform decision making throughout the evolution and development of the system.

How can the electromobility transition avoid perpetuating existing inequities?

6. Governance and Regulation Considerations

Government effectiveness and regulatory quality are important factors to ensure that electricity and transport systems are robust enough to deal with the challenges that electromobility may pose to countries in the Global South.

6.1. Governance

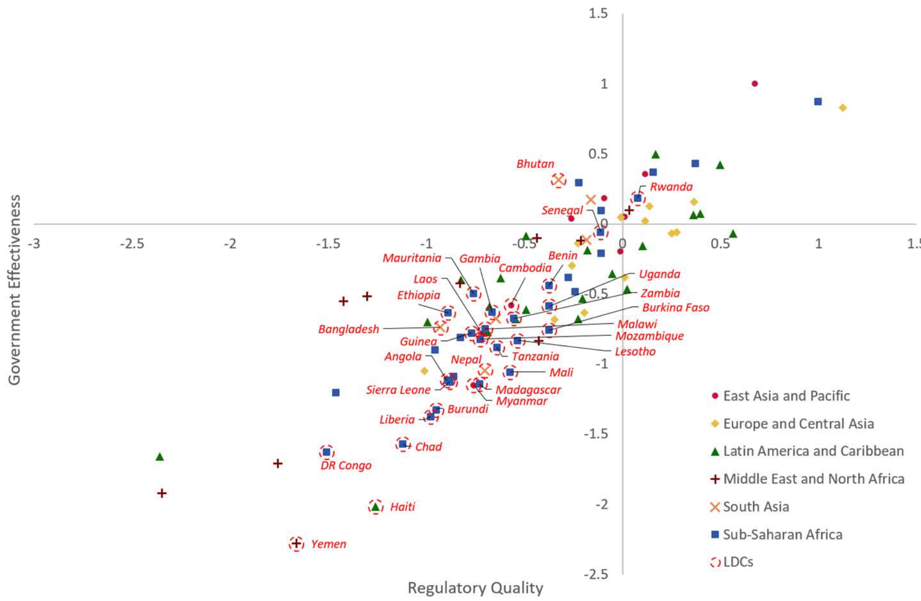
There are six Worldwide Governance Indicators (WGIs) [67]: voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law, and control of corruption. The WGI reports individual and aggregate governance indicators for over 200 countries and territories,

These aggregate indicators combine the views of a large number of enterprises, citizen, and expert survey respondents in industrial and developing countries. They are based on over 30 individual data sources produced by a variety of survey institutes, think tanks, non-governmental organizations, international organizations, and private sector firms.

Although broad principles of governance can be universal, issues of governance and regulation often are not, and tend to be very specific to certain countries or localities. For electricity and transport systems, government effectiveness and regulatory quality could be considered amongst the most important indicators.

Figure 4 shows a strong positive correlation between these variables. Many of the poorest countries, highlighted as LDCs, lie in the quadrant (bottom left) that shows low government effectiveness and weak regulatory quality. Similarly, it can be shown that countries with low government effectiveness are more likely to have low gross national income (GNI) per capita.

Figure 4 Government effectiveness vs. regulatory quality, LMICs



Issues of governance are important in the Global South, where the development, application, and implementation of standards, legislation, and regulation are needed to ensure a successful transition to electromobility.

There has been an emergence of international standards in EV charging, in terms of electrical connections and communications protocols, which has helped the adoption of EVs in the Global North [68, 69]. However, there is a gap in knowledge and experience when applying the principles of these standards and regulations to Global South contexts.

To ensure the successful adoption of EVs, it is important that each country has in place an appropriate policy framework. This will require widespread consultation between regulatory officials, customs, the police, local government, the electricity supply industry, vehicle manufacturers and dealers, banks, garages, transporters and public transport bodies, trade associations, universities, training institutions, and civil society. There is also a need for greater global cooperation and coordination on these issues as they cannot be done in isolation.

Key regulations will need to be examined. These include vehicle import regulations and duties; vehicle specifications, inspections and use regulations; charging infrastructure; and vehicle and battery disposal. A training programme for installing charging infrastructure and for the maintenance of EVs will need to be established.

How can countries learn lessons for the development of their national standards? How can greater global cooperation and coordination on governance and regulatory issues be fostered?

6.2. Second-hand vehicle imports

A substantial proportion of the Global South are dependent on the import of used vehicles from Western Europe, the United States, and Japan. For example, most vehicles imported into Ghana, Ethiopia, and Egypt are 12 to 13 years old while for Uganda it is 15 years [70]. The vast majority of these vehicles are ICEs. This results in the Global South having aged, high carbon emitting vehicle fleets. Several countries in SSA have imposed bans on second-hand vehicles over a certain age, or, in some cases, entirely; but the effectiveness of these bans is unclear [71].

Vehicle lifespans are also increasing and, in general, the richer the country the lower the vehicle lifespan [72]. With generally lower environmental and safety standards and car mechanic costs, Global South vehicles are kept running by cannibalizing other vehicles for parts, using non-standard parts, or fabricating parts. As an example, in Harar, Ethiopia, Peugeot 404s and 504s that are nearly 70 years old are still used as taxis [73]. This keeps high emitting vehicles in circulation for longer. A better inspection regime would help to reduce air pollution, improve energy efficiency, improve road safety, and help promote the adoption of new vehicles.

A supply of used ICE passenger cars is likely to continue well beyond 2040, and hybrid vehicles after that. Over the coming decades, as the Global North transition to EVs, the second-hand vehicle market for EVs may grow. It is vital that the imported vehicles are fit-for-purpose. The Global South must not become the dumping ground for older, unsafe, and more polluting vehicles from the Global North. Although the overall responsibility for vehicle imports, remains with the importing country, there is greater interest in increasing the responsibility of the exporting country. Current European Union regulations prevent the export of the worse quality "wrecks". However, a recent report has drawn attention to the very low quality of many exported vehicles, including manipulated odometer readings, fake dismantling, and removed catalytic converters, amongst other problems. The report calls for more proactive measures to be adopted. It is now understood the European Commission will now evaluate and revise the regulations governing the export of used vehicles [74].

Nevertheless, it is important to recognize that a complete ban on second-hand vehicles from the Global North could have a significant and detrimental impact on many of the poorest countries in the Global South, including the LDCs, who for the next couple of decades are likely to continue to need these vehicles to meet their mobility needs.

Global cooperation and coordination are needed to ensure that vehicle manufacturers address the full life cycle impacts of ICEs or EVs. This will ensure that the Global South and the LDCs are not bearing the burden of disposal of second-hand vehicles.

The Philippines is an example of a country that has recognized that supporting the uptake of electromobility to realize decarbonization requires regulation and legislation (**Country Case 7**).

How can the market for second-hand vehicles be properly regulated?

6.3. Emission Standards

Vehicle emission standards have been shown to improve air quality (see Section 5.3) but can also be used to address issues that goes hand-in-glove with second-hand vehicle imports and could be used to encourage the adoption of new EVs.

However, in most of the Global South, emission standards are generally weak and in 61 countries there is no age limit on the import of vehicles and 100 countries have no emission standards on imported vehicles [70]. Furthermore, as vehicle emission standards in Europe have become more stringent so exports of used diesel vehicles to central Asia and West Africa have increased. Without further regulation or price disincentives this trend is expected to continue [70]. Furthermore, borders in the Global South are often less regulated; for example, vehicle smuggling appears to have been common into Nigeria [75]. In fact, 85% of used vehicles imports into Benin ended up in Nigeria [76], making standards harder to enforce.

This complexity grows as a new vehicle imported into the Global South, where there are lower standards, may have higher emissions than that of a second-hand vehicle from a country with high emission standards. Stronger emission standards for vehicles could improve the transition to electromobility and reduce the emissions on the importation of both new and second-hand vehicles in the Global South. To achieve this requires regulation, robust institution, technical capacity, and the ability to enforce measures.

How might vehicle emission standards deter the import of second-hand ICE vehicles? What is the likely impact of these actions?

7. Material Considerations

Transitioning to electromobility will have significant material requirements in terms of:

- extraction (e.g., mining), production, and vehicle manufacturing facilities;
- production of new EVs, batteries, and their chargers; and
- additional electricity generation and distribution infrastructure.

The extraction and processing of materials is often overlooked in the pathway to road passenger decarbonization models. The Global South has vast material resources and technological solutions often exist, but not the infrastructure to manufacture vehicles and/or build associated infrastructure. The alternative, to buy in this capacity, is often expensive or risks handing control of important assets to foreign entities that have the technological knowledge and financial investment that is required. This could exacerbate the Global South's ability to operate on a level playing field. Industrial, material, and infrastructure policy must therefore be considered together.

The transition to electromobility in the Global South needs to consider the following factors: vehicle fleet, material production, and battery and EV manufacture.

7.1. Vehicle Fleet

The type and quality of EVs will affect material demand:

Vehicle Lifespans in the Global South are often longer than in the Global North. This is due to the export of second-hand vehicles from North to South and the disparity in repair costs (as a result of low-cost labour). Extending the lifespan of vehicles, as a strategy, reduces material demand but may delay the transition to more efficient vehicles that can bring benefits, such as improving air quality and reducing the environmental harms of ICE transport.

Choice of Materials: EVs require a range of new materials for batteries (e.g., lithium, cobalt, nickel, manganese, graphite) as well as electrical and body components (e.g., copper, aluminium) which are more emissions-intensive to produce. Resources are finite, and consequently the increasing demand for EVs in the future is likely to place a strain on the supply chains and non-renewable natural resources, particularly for battery materials. This insufficiency could delay the widespread adoption of EVs [77]. It could also drive increased production that could cause environmental and social harm and exacerbate existing inequalities in the Global South

How should the development and design of EVs be adapted for the needs of the Global South to ensure a more sustainable use of materials?

7.2. Material Production

Mineral extraction often occurs in several countries in the Global South: China has the highest extraction of rare earth materials, and the Democratic Republic of Congo (DRC) has the highest extraction of cobalt [78]. However, mineral refining does not often take place where the mining occurs (for example, China processes cobalt mined in the DRC: see **Country Case 8**). There is an opportunity for clusters of Global South countries to invest in infrastructure and additional material processing and manufacturing to maximize economies of scale in mineral refining.

Mining frequently involves questionable environmental and social practices [79]. Metals and minerals are collected in places with little security and are known to exacerbate harmful working conditions. The monetary value increases towards the end of the supply chain [80] and hence the Global South often does not benefit fully. Despite increasing demand for materials raising prices, little profit trickles down to the mining communities in the Global South, especially the LDCs [81].

How can the Global South take full advantage of its material resources while ensuring environmental and social standards are met?

7.3. Battery and Vehicle Manufacture

Regarding EVs and their batteries, the technology, patents, manufacturing infrastructure, and skills are concentrated in the Global North, with some of these factors found in wealthier Asian and Latin American nations. Therefore, there is a need to support the development of manufacturing industries in the Global South. As an example of a potential pathway, India has a national policy called *Faster Adoption and Manufacturing of Electric Vehicles (FAME II)* for 2/3W, buses and cars, including the domestic manufacture of EVs. Other Global South countries could adopt similar measures, up-skill the labour force, and stimulate job creation.

If vehicles are imported from the Global North, without local manufacturers, the Global South will rarely have the capacity to safely recycle vehicle components and materials, further aggravating the need for new materials and the environmental pollution associated with the inadequate disposal of vehicles. A framework of cooperation is needed between the Global North and South to regulate this trade and avoid these environmental impacts [81].

Mechanisms need to be put in place to ensure safe recycling, particularly of batteries, to prevent ecological damage [82]. However, it would not be just for the poorest nations to bear this financial burden. International regulations, for example Extended Producer Responsibility laws [83], which place the liability of product disposal on the producer, will need to be developed and enforced. This may incentivize battery manufacturers to 'design for recycling', which means that cost of a product's end of life is considered during the design phase.

To mitigate some of the above challenges, clear guidance on the future direction of material strategies for electromobility is required. This can provide decision-making tools to assess the material efficiency, impacts, co-benefits, and trade-offs of the technology, behavioural, economic, and policy interventions possible.

What will enable the Global South to develop in-country manufacturing and recycling for electromobility?

8. Rebalancing the Electromobility Debate

Meeting the challenge of the UN Paris agreement and the Sustainable Development Goals (SDGs) will require low emission pathways to decouple economic growth from long-term greenhouse gas (GHG) emissions. Although most countries in the Global South are not major contributors to global heating, they are being asked to adopt low carbon policies that offer both opportunities and challenges.

The Global North is promoting electromobility as a key element of road passenger transport decarbonization strategies. China and India are making rapid progress in the adoption of electric vehicles (EVs), especially electric two- and three-wheelers (E2/3W) and buses. However, for some countries, especially the Least Developed Countries (LDCs), the same model of electromobility as used in other countries may be inappropriate for their current development stage due to number of factors.

Over 50% of the population (about 550 million people) in Sub-Saharan Africa (rural and urban combined) do not have access to basic electricity for cooking or lighting, let alone for transport [21]. There is significant potential for renewable energy for some countries to address this need. However, the initial investment required is often out of reach of the poorest countries.

The COVID-19 pandemic has had a disproportionate impact on poorest countries, with less resources to protect against health and economic crises and invest in the transport and energy sectors. The pandemic is exacerbating existing high levels of debt in LDCs. Despite significant progress in certain areas, LDCs still face structural impediments to eradicating poverty through economic growth, structural transformation, building productive capacity, or increasing their share of exports [84]. Most LDCs still experience growth rates below the levels needed to eradicate extreme poverty by 2030. In November 2020, six LDCs were classified as debt distressed, with an additional one in external debt distress, and 16 LDCs faced a high risk of debt distress [85].

A UK Foreign, Commonwealth and Development Office (FCDO) scoping exercise on low carbon transport priorities in Bangladesh, Pakistan, Nepal, Uganda, and Zambia found that each country has unique challenges in the transition to electromobility. Stakeholders identified several key priorities for action to facilitate the move to EVs. These ranged from the poor understanding of alternative vehicle technology and lack of related policies in Bangladesh [60] or insufficient infrastructure and underdeveloped markets for EVs in Nepal [86], to the high cost of electricity in Pakistan [87] and the need to attract private sector investment in EVs in Uganda [88] and Zambia [89].

In addition, informal transport plays a key role in cities in the Global South [90], responding to consumer demand and providing hubs for informal economic activities. The transition to electromobility must complement the usage patterns of these services, so as not to negatively impact low-income, vulnerable groups [91].

LDCs cannot afford a rapid transition due to the need for substantial capital investment. Finance is therefore needed to invest in the electromobility sector as well as in EV projects through grants. One way of meeting these financial needs would be to combine low-cost financing and international credit to cover interest payments.

Global South countries that undergo a rapid transition to electromobility based on the Global North model of electromobility are at risk of becoming locked into unsuitable vehicle technologies.

Therefore, a systematic approach to evidence generation and data collection on mobility requirements is urgently needed to enable an effective transition.

The Global North has been responsible for the majority of historic GHG emissions, and thus it has a responsibility to help the Global South in transport decarbonization. Promoting the Global North's model of electromobility to certain Global South countries could not only exacerbate the 'Green Divide' but can be seen as a form of neo-colonialism. This is especially the case if the Global North does not reduce its emissions or help fund the climate mitigation and adaptation strategies that are needed to prevent a rise in temperature above 1.5°C.

A decade ago, countries in the Global North committed to provide US $100 billion a year by 2020 for climate adaptation and mitigation in the Global South. However, not only have they failed to deliver on this promise, but 80% of the funds they are putting forward is as loans or private finance, instead of grants [92]. It is therefore essential that the Global North provides additional funding and support, such as institutional strengthening and technical capacity to enable the LDCs to consider alternatives to internal combustion engine (ICE) vehicles. There is a need for additional financial resources for capital investment in EV infrastructure, manufacture, and financing of renewable energy projects as an incentive to the transition from fossil fuels.

Over the coming years many countries in the Global South will make policy decisions and investments to decarbonize road passenger transport. At the same time, the proposed widespread adoption of EVs in the Global North will have impact on the second-hand vehicle market and the decisions and pathways of the Global South.

We call for a greater understanding of the unique challenges LDCs face in the electromobility transition and the responsibility Global North has in ensuring the fair and equitable transition to low emission mobility in the Global South.

In the short-term, electromobility is unlikely to meet the mobility needs of most LDCs. Therefore, consideration should be given to improving and increasing access to a range of mobility options such as paratransit, e-bikes, electric two-and three-wheelers (E2/3W), and non-motorized transport for low-income and disadvantaged groups. Consideration should also be given to the planning of a future electromobility strategy that ensures that the benefits of an electromobility transition can be enjoyed by all, without an associated inequitable financial burden being placed on LDCs.

To ensure an equitable decarbonization of the road passenger transport sector, a dialogue is needed to develop a new electromobility narrative that recognizes these unique challenges. This includes the following:

- Supporting differing timelines for the decarbonization of transport for some countries in the Global South, especially the LDCs.
- Expanding the horizon for collaboration, cooperation, and coordination between the Global North and the Global South (e.g., on second-hand vehicles, standards, additional financing)
- Developing Nationally Determined Contributions (NDCs) that are appropriate pathways to decarbonize road passenger transport in countries in the Global South, especially the LDCs. This will require joined up policy development that promotes low emission mobility and a transport system that meets the mobility needs of all societal groups.
- Identifying short- and medium-term action to reduce transport GHG emissions while ensuring economic development. This may include waiting for the development of suitable electromobility technology or planning and investing in charging infrastructure, improving

access to electricity grid, and improving the energy mix to achieve cleaner energy. In addition, it will also require exploiting low carbon transport quick wins, which offer sustainable development benefits (e.g., universal access, efficiency, safety, and green mobility) and include measures that reflect the local transport system context of countries in the Global South [93].

- Improving infrastructure and services to move to low carbon transport alternatives, such as active travel or personal electromobility in terms of active travel, non-motorized transport, E-bikes, and E2/3Ws.
- Considering the impact of the Global North policies on the Global South and the LDCs, in particular regarding the export of second-hand vehicles and paying for the lifetime costs of a vehicle (including end of life). Tariffs should not be imposed on countries that are not able to comply with certain reductions in CO_2 in the near term.
- Financing and funding from the Global North to de-risk the transition to electromobility, while developing more equitable and sustainable finance mechanisms.

The GRA *Sustainable Electric Mobility: Building Blocks and Policy Recommendations* policy paper outlined seven essential building blocks of successful public policy for the development of sustainable electromobility [47]:

1. Building momentum: the power of vision and targets
2. Raising awareness: a narrative based on transparent information and multi-stakeholder engagement
3. Setting the right policy framework: regulating the market and stimulating action
4. Integrating mobility and energy policy for mutual benefit
5. Pilot projects: the benefits of local experience
6. Providing knowledge: capacity building and exchange of experience
7. Developing the financing tools: financing mechanisms and business models fit for purpose

This report contributes to these building blocks by highlighting key issues that need to be addressed to ensure an equitable decarbonization of the road passenger transport in the Global South. By highlighting these six key issues, this paper aims to facilitate dialogue and contribute to rebalancing the current electromobility debate. This will ensure the unique challenges that some LDCs may face in their efforts to decarbonize road passenger transport are considered in climate change negotiations.

Due to their historic GHG emissions there is a responsibility on the part of the largest economies in the Global North to assist countries in the Global South in the electromobility transition. This can be done by providing finance, access to advanced vehicle technologies, capacity to build and operate EVs, and regulating the export of polluting ICE second vehicles in the Global South. At the same time, Global North countries need to be mindful of the direct and indirect impact their policies will have on the Global South including the LDCs.

In contrast, countries in the Global South should aim to increase access to transport, connecting all people and communities to economic and social opportunities. Improvements to the existing transport system can be made to optimize reliability and cost-effectiveness while reducing road fatalities and injuries. In addition, finance should be sought to build capacity in electromobility while developing and improving the existing transport infrastructure to enable the electromobility transition.

8.1. Key Messages for Electromobility in the Global South

1. Electricity Supply: Carbon intensity and reliability of electricity supply varies in the Global South. Benefits of electromobility include zero exhaust emissions, lower cost of fuel per km travelled, reduced maintenance costs, and new jobs. **Weak and unreliable electricity grids are key obstacles to electromobility in LDCs; however, the additional electricity demand from electromobility can provide an incentive to grid developers to build more infrastructure. This can help high carbon and unreliable electricity systems transition to low carbon and reliable systems and potentially increase electricity access.**

- *What impact does grid carbon intensity have on a country's ability to reduce emissions through a transition to electromobility?*
- *How can electromobility help transition electricity systems in the Global South so they are both low carbon and highly reliable?*
- *Can electromobility provide an impetus to increase the access to electricity for all and improve the affordability of electricity?*
- *What data is needed to ensure charging infrastructure is efficient and effective?*

2. Economic: There is a need to develop new business models and appropriate tax policies that encourage the adoption of suitable mobility solutions and incentivize consumers to switch to EVs. **Most Sub-Saharan African (SSA) countries subsidize fossil fuels to protect consumers from high costs. These subsidies could be spent elsewhere in a more equitable manner, and appropriate tax policies need to be developed to support the transition to electromobility.**

- *How can EVs be made more affordable for vehicle operators and users?*
- *What incentives or disincentives are needed to promote the adoption of EVs?*

3. Financing: The current investment and funding gap is high in the Global South, so targeted finance needs to provide incentives for further public and private investment to ensure a transition to electromobility. **The Global North has a responsibility to enable the transfer of knowledge and technology together with the funding that would allow countries in the Global South to develop electromobility projects that are most appropriate for their needs. Without these resources, countries in the Global South are unlikely to be able dictate their own terms of development, and this will deepen the Green Divide and exacerbate inequalities.**

- *What are the most appropriate financial mechanisms to support the transition to electromobility, and what is the role of government, subnational bodies, and the private sector?*
- *How do we prevent the Global South becoming even more financially beholden to the Global North due to the transition to EVs?*
- *How should a country best use the long-term, low-cost loans available from Multilateral Development Banks to de-risk investment in electromobility?*

4. Social: Gender equality and social inclusion considerations will determine the success of any transport decarbonization strategy. **Community engagement is needed so that consumer attitudes in the Global South are factored into electromobility planning policies. In addition, electromobility and urban planning must be coordinated to help ensure accessibility, affordability, inclusivity, security, and safety of transport infrastructure for commuters.** The lack of technical knowledge and required skills in LDCs for the electromobility transition needs addressing, but it also presents an opportunity to provide jobs for local populations. Electromobility has the potential to improve air quality, which has associated health benefits.

- *What communication and community engagement are needed to ensure an appropriate and successful transition to electromobility?*
- *What urban planning policies are needed to create a just transition to electromobility?*
- *How can emission standards be implemented across the Global South as part of national transport planning?*
- *What are the existing local skill sets and what investment is needed to fill any skills gaps?*
- *How can the transition to electromobility avoid perpetuating existing inequities?*

5. Governance and Regulation: Capacity for regulation and enforcement of emission standards in the Global South is varied. There is a need to build capacity and support National Environmental Management Agencies and relevant ministries. **A substantial proportion of LDCs depend on the import of used vehicles from the Global North, which has a significant effect on mobility and emissions. A reduction in second-hand vehicles could distort the market in the Global South or have the perverse impact of keeping older, more polluting vehicles on the road for longer. Strengthening the regulation and enforcement of vehicle emission standards in the Global South could be used to encourage the adoption of EVs.**

- *How can countries learn lessons for the development of their national standards? How can greater global cooperation and coordination on governance and regulatory issues be fostered?*
- *How can the market for second-hand vehicles be properly regulated?*
- *How might vehicle emission standards deter the import of second-hand ICE vehicles? What is the likely impact of these actions?*

6. Material: Electromobility requires materials for new EVs, batteries and their chargers, and key infrastructure (e.g., roads and parking facilities); material extraction (e.g., mining), production, and vehicle manufacturing facilities; and additional electricity generation and distribution infrastructure. **Mining in the Global South can involve questionable environmental and social practices with harmful working conditions. As the monetary value of materials extracted increases towards the end of the supply chain, the Global South often does not benefit fully. Despite increasing demand for materials raising prices, little profit trickles down to the mining communities in the Global South, especially the LDCs, further exacerbating inequalities.**

- *How should the development and design of EVs be adapted for the needs of the Global South to ensure a more sustainable use of materials?*
- *How can the Global South take full advantage of its material resources while ensuring environmental and social standards are met?*
- *What will enable the Global South to develop in-country manufacturing and recycling for electromobility?*

The issues highlighted in this paper could be used to initiate a dialogue at the UN Framework Convention on Climate Change (UNFCCC) conference of the parties (COP) 26 to address the equitable transition to electromobility of countries in the Global South, including the LDCs. It is proposed that a dedicated working group, as part of a SuM4All Partnership, conduct deep dives into some of these issues to gain a better understanding and to develop an action agenda for COP27 and beyond.

9. Country Cases

Country Case 1: Paraguay and using electromobility to create market value for hydropower

(lower carbon, less reliable system)

The Itaipu Treaty of 1973 [94] between Paraguay and Brazil will be renegotiated in 2023. Itaipu is the second largest power plant in the world and is owned equally by Paraguay and Brazil. 85% of its power is sold to Brazil at cost price [95]. Its sales are captive, and it is selling at below the market rate.

Meanwhile, Paraguay imports oil (at high cost) to meet transport demand. A large proportion of that oil is used to fuel motorcycle transport [96]. To maximize economic activity, a motorbike assembly and servicing industry has been established in the country.

If Paraguay were to move to E2W (where trip lengths allow), it may increase its domestic demand for power. Together with accelerated industrialization, this can provide an alternative new consumer for Itaipu. This in turn provides potential leverage to increase prices of electricity exported to Brazil to reflect their market value [95].

To achieve all this Paraguay must navigate a complex reskilling of its gasoline motorbike support services to electric; create a new firm local electricity demand; and simultaneously renegotiate the Treaty.

Paraguay can take advantage of its lower carbon hydropower and reduce its reliance and expenditure on fuel imports.

Country Case 2: Kenya and the high upfront cost of EVs to complement renewable grids

(lower carbon, more reliable system)

In 2019, Kenya had 3.6 million registered vehicles of which motorcycles and three wheelers (3Ws) accounted for 1.7 million; cars 1.3 million; utilities and van pickups 340,000; trucks 172,000; and buses and minibus 112,000. Over the last four years, the growth rate of motorcycles and 3Ws has been 14.6% and for cars 7.5% with lower growth rates for other vehicle types [97]. It is not generally known how many EVs there are currently in Kenya, although one estimate indicates there were 350 EVs in 2018 [98].

To address climate change issues, the Kenya Government has announced a number of measures in the road transport sector, including electromobility technical standards, pilot projects, and incentives. 21 technical standards for EVs were introduced by Kenya Bureau of Standards and excise duty for electromobility was reduced from 20% to 10% in 2019.

A range of light EV projects are being implemented by both private and government organizations (for example e-motorcycles, e-tuk-tuks, e-tricycles), including the United Nations Environment Programme and the Kenya Power and Lighting Company. A Finnish company, EkoRent, has introduced a ride sharing e-car taxi service (Nopia Ride) in Nairobi and a small number of charging stations have been set up [91]. The Opibus factory in Nairobi currently converts older ICE vehicles to electric. Safari vehicles and pickups with a 140 km range cost $39,900. Several Safari companies use these vehicles because they are quiet and no doubt appeal to eco-conscious clients. Medium-sized buses with a 120 km range can be converted for $45,000, while motorcycles with 160 km range, can be converted for $1,300 using a battery swap approach [99].

The Ministry of Energy has set a target that, by 2025, 5% of cars registered in the country will be electric. This appears very optimistic. Although excise duty has been reduced for EVs, import duty, VAT, and other charges are still in place on EV imports, which increase the price by 60%. In fact, 95% of vehicles imported into Kenya are second-hand; however, imported vehicles must be under 8 years old [70].

For a new Nissan leaf the average price is around US $37,700, while in contrast a 7-year-old ICE saloon costs around $8,700 [100]. In current conditions in Kenya, it is estimated that an EV will save around $790 in fuel costs for a vehicle undertaking 22,700 km, per year. Although there are other costs and benefits involved, it is unlikely that buying a new electric car, compared with a second-hand ICE vehicle, would be worthwhile, at present, because the difference in fuel savings would be less than the difference in depreciation and interest charges.

However, in contrast to the overwhelming use of second-hand cars, in Kenya most motorcycles are imported new. A new ICE motorcycle such as the Bajaj Boxer costs $1,125 [101] while Opibus now plan to sell a new electric motorcycle for $1,300. Opibus estimates that to fuel an ICE motorcycle costs about $0.25 for 10 km, while it only costs around $0.08 in electricity to cover the same distance in an Opibus electric motorcycle [102]. With maintenance costs lower for the EV, the overall costs of running an electric motorcycle are now likely to be significantly lower than a comparable conventional motorcycle.

Overall, Kenya has made a useful start to introduce electromobility using renewably energy. Experience has been gained from the various trial initiatives and policy changes. In the short-term E2Ws are most likely to catch on. However, because of their high initial costs electric passenger cars will be slower to be adopted. A faster adoption of EVs could take place if the programme of tax incentives can be improved.

Kenya generates over 2,700 MW, of which over 80% is renewable, compared with a demand of 1,860 MW. Demand falls to 1,000 MW during off-peak hours, which would be an ideal time for charging many EVs. However, around 25% of the population do not have access to the grid.

Solar energy could be used to provide electricity for those not connected to the grid as well as helping to provide power for electromobility [98].

Country Case 3: Costa Rica and the possibility of perverse outcomes from EV subsidies

(lower carbon, more reliable system)

Costa Rica produces over 98% of electricity based on renewable sources with transport being the main GHG emitting sector. In 2018, it established ambitious electromobility targets to decarbonize transport, including the Law No. 9518, "Law on incentives and promotion for electric transportation" [103]. Tax incentives for EVs are defined relative to the value of the vehicle and include the sales tax, the selective consumption tax, and the customs value. For vehicles with a Cost, Insurance, and Freight (CIF) value of less than US $30,000 no tax is due. Beyond a price tag of $60,000 no tax incentives are given. Nonetheless, this still means that a vehicle which costs, for example, $80,000 profits massively from tax incentives for the cost component of up to $60,000.

Conversely, fossil fuel vehicles pay 13% sales taxes, 1% customs duties, and an excise tax of 30% for new vehicles and 48% for vehicles older than seven years. As a result, the Audi e-tron is one of the most sold EVs in Costa Rica as its selling price is lower than that of an ICE Audi in the same category. The tax subsidies are not fiscally neutral: the tax income losses from lower duties on EVs are not compensated through increased taxes on ICEs. This raises a question as to whether it is fair that public transport users paying VAT should subsidize the purchase of luxury EVs. This demonstrates that even well-intentioned financial policies to incentivize transport decarbonization need to consider equity issues.

Country Case 4: Lao PDR and the need for Finance

(higher carbon, more reliable system)

Lao PDR has high renewable energy potential. But it has an underdeveloped power grid. A high proportion of its vehicle fleet are 2/3Ws that use gasoline and travel for relatively short trips. The same is true of much public bus transport.

Over the lifetime of the 2/3W vehicles, as well as other public transport, it would be cheaper for vehicle owners to use electric alternatives – as the cost of electricity to fuel trips is much lower than that of gasoline. That would increase local profits.

Were that electricity to be charged to cover costs, it would pay for the lifecycle charging, distribution, transmission, and generation of the power system. Moving transport fuel expenditure from imported oil to locally generated electricity has positive economic impacts and reduces GHG emissions and local pollution.

In the region, total lifetime ownership costs of E2/3Ws are thus lower and make business sense [104]. Energy costs would also be lower for the country and make economic sense [105] and reduce emissions.

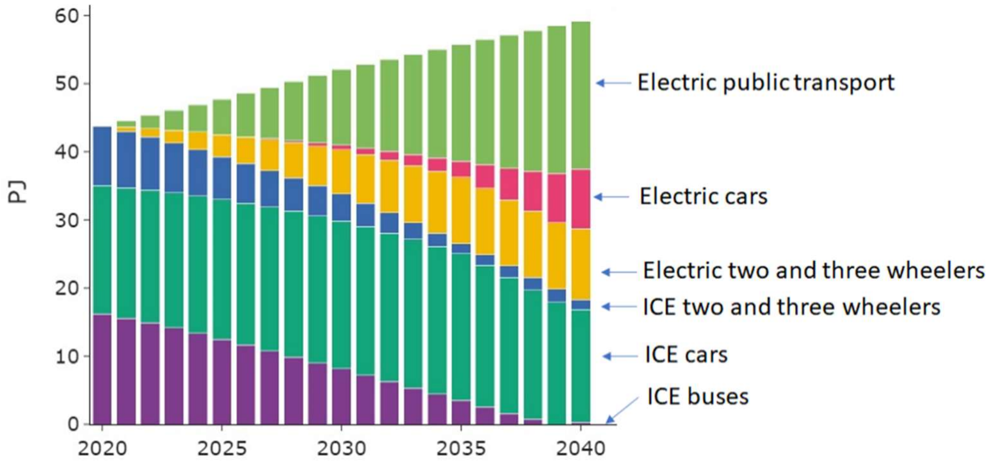
Figure 5 shows the most cost-effective way of transforming the transport system in Lao PDR.

A focus on electrifying public transport and 2/3Ws could have a significant contribution to decarbonizing the energy system. However, this all requires initial investment and the upfront cost of electromobility is often prohibitive. The power grid requires strengthening, and there is a need for new renewable supply investment capital. This is hindered by the lack of capital investment.

It is unclear how the country will develop an integrated proposal to access climate finance. A reason for this is that there are no clear methodologies available to allow Lao PDR to access the levels of capital required for integrated transport and power system transformation. This is even though emissions levels would be reduced, and carbon and concessionary finance markets are well endowed.

Without a clear pathway to finance, it will be difficult to create a transition to electromobility. Stronger grids and renewable energy would be profitable and improve livelihoods.

Figure 5: Fuel and vehicle transformations in Lao PDR transport system by the least cost integrated (power and transport) transitions from a cost optimization model



(Source: Allington et al. 2021) [105]

Country Case 5: Nepal and opportunities in lower carbon systems

(lower carbon, medium reliability system)

Electric three-wheeled (E3W) vehicles (Safa Tempos) were introduced in Kathmandu in the mid-1990s to fight pollution [106]. A move towards EVs away from diesel powered 3Ws was motivated by the latter being largely blamed for the increase in pollution. To encourage Safas' manufacture and sale, the government slashed tariffs on parts from 60% to 1%, and major banks set up loan incentives for entrepreneurs [107]. Residents of Kathmandu welcomed the new vehicles, local manufacturing was set up, and production took off in the late 1990s.

By 2000 the city had more than 600 zero-emission Safas, locally manufactured. Total investment stood at some $5 million, which had resulted in 750 jobs and vehicles serving about 100,000 people every day. They constituted the largest fleet of battery-powered public transport vehicles in the world, and they turned one of the world's poorest cities into a pioneer for innovative public transit.

However, this revolution did not last. Each vehicle required 12 batteries, imported from California for $1,720 with a life of just 2 years. This expense, transport cartels, and government subsidies for switching from diesel 3Ws to petrol micro-buses essentially killed off the EV revolution in Nepal. This has subsequently led to increased fossil-fuelled vehicles in Kathmandu, with the overall fleet increasing from 100,000 in 2010 to 1.2 million in 2019. Pollution rose to five times the World Health Organization guidelines in 2019 and Kathmandu remains as one of the World's most polluted cities.

This was a missed opportunity. However, the government recently initiated a campaign to transition to electromobility with lower tariffs and the aim of halving fossil fuel use by 2050. This includes replacing all public transport with EVs by 2030, and even Safa Tempos are making a comeback, with many being owned and run by women [108]. In Lumbini, the Asian Development Bank (ADB) also has trialled e-pedicabs (pedal assisted bikes for two passengers) from 2017 with the hope of replacing other journeys from more polluting vehicles [109]. These could also be supplemented by converting motorcycles from petrol to electric, a technology that is established but not practiced on a large scale. Motorcycles account for 80% of Nepal's modal share of traffic [86], they are popular, affordable, and have the ability to cut through congested city streets. Many are ageing with high emissions [110], so the benefits of conversion would be high.

Any transition to EVs needs to be mindful of the limitations of the road network, particularly in Kathmandu. Increases in private modes of transport will aggravate urban transport congestion, so a subsidy for electric cars has the potential to have adverse effects. A focus on public transport, such as e-buses, to meet demand and provide an alternative to paratransit would be a valid transport policy.

Nepal is now fast approaching self-sufficiency in hydropower and expects to have a surplus soon [111]. The impact of EV journeys on carbon emissions will be negligible [109]. Combined with moderately high fuel prices and more efficient and cost effective battery technology, there is capacity to support a rapid transition to electromobility. This would also reduce Nepal's reliance on imported fuel, helping the economy to be more independent. This situation presents a clear opportunity for transformation to clean energy in the transport sector in Nepal.

Country Case 6: South African Minibus taxis and the opportunity to address transport inequality

(higher carbon system)

In the 1970s and 80s the South African Black Taxi Association and the Transport Deregulation Act of 1988 took control of the unregulated industry. By 1990, 38,317 permits had been issued and 50,000 minibus taxis (MBTs) were operating on the roads of South Africa [112]. Today there are 200,000 MBTs operating on South Africa's roads, employing 300,000 drivers, 100,000 taxi marshals providing work for approximately 100,000 car washers, 150,000 vendors and taxi ranks [113]. This demonstrates the importance of MBTs to job creation, the people, and the economy of South Africa, and MBTs place at the top of the hierarchy in the South African transportation ecosystem.

MBTs in South Africa came into popularity through necessity due to the long travel distances resulting from the apartheid-era spatial planning. This process assigned different areas to different racial groups. The majority of black South Africans were located far from city centres with inadequate service provision. As a consequence black South Africans continue to be underserved in terms of access to both transport and energy, and often live further from their places of work [114].

As a result, South Africa has become known as the 40x40x40 club; 40 percent of South Africans live more than 40 km from their place of work and spend 40% of their income on transport. The low coverage of formal public transport services resulted in the informal operation of MBTs. MBTs function as demand responsive transport, which is extremely effective in providing for the mobilization needs of marginalized communities in peri-urban areas with a lack of formal services.

Minibus taxis remain the dominant form of public transport, used by 70% of South Africans, providing 75% of work/educational trips.

Country Case 7: Philippines and Regulation to promote EVs

(higher carbon, more reliable system)

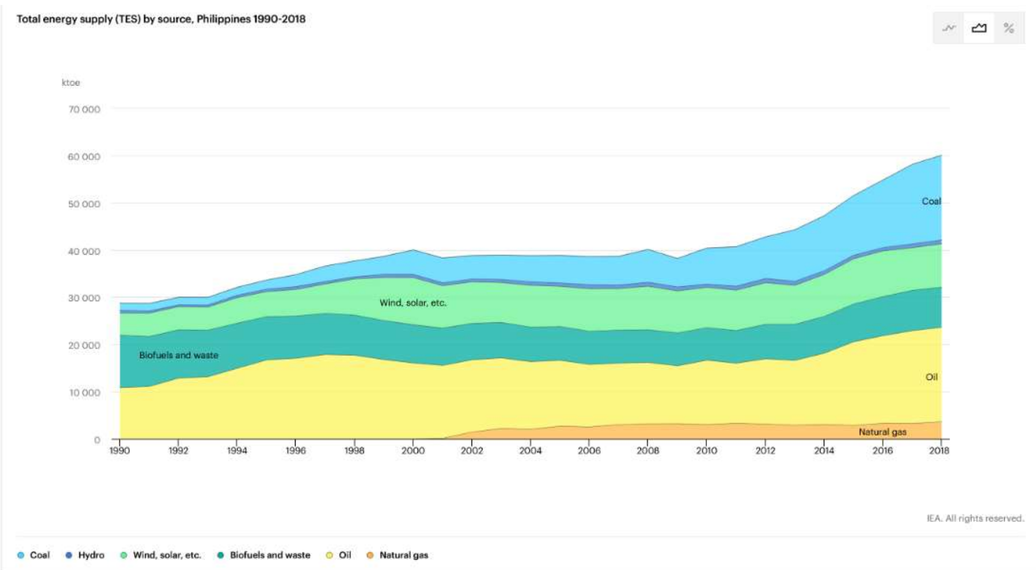
The Philippines is one of Asia's fastest growing economies, with the vehicle market forecast to grow very rapidly – especially the two-wheeler market. The energy mix in the country is given below: fossil fuels dominate but there is a growing use of renewables (**Figure 6**).

Air quality is negatively impacting the health of the nation and land transport is seen as a key source of this pollution. Several legislative bills have been developed to incentivize the manufacture, importation, and use of electromobility including:

- The Philippine Energy Plan (PEP) 2018–2040, which aims to increase the production of clean and local sources of energy to support growing economic development and promote environmental protection. It has a target of 10 per cent penetration rate of electromobility for road transport (motorcycle, cars, and Public Utility Vehicles) by 2040.
- Senate Bill No. 1382: The Electric Vehicles and Charging Stations Act (2020) has yet to be enacted. This legislation intends to mainstream the use of EVs in the private and public sectors by addressing the main barriers to improving adoption of electromobility. The Bill outlines the regulatory framework for the use of EVs and policies to improve demand generation for electromobility as well as the industry development of EVs and charging infrastructure.

It is hoped that a strong legislative and regulatory framework that supports electromobility will help drive electromobility uptake and industry developments together with foreign and domestic investment.

Figure 6 Total Energy Supply by Source, Philippines 1990–2018 [115]



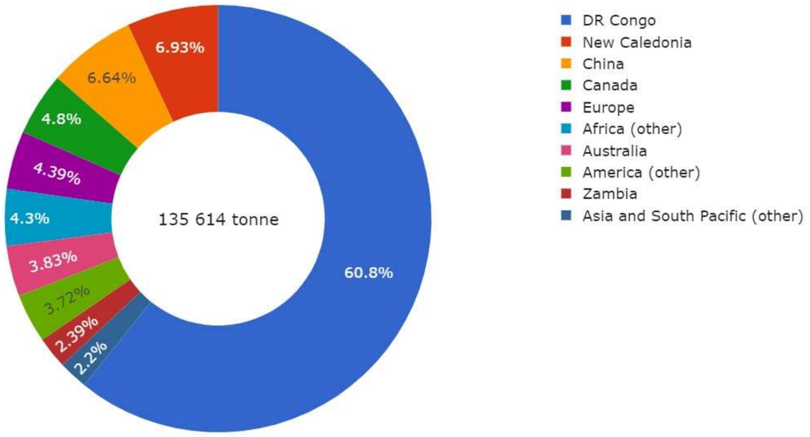
Country Case 8: Democratic Republic of Congo (DRC) and Cobalt – Equity and Global South Resources

(lower carbon, less reliable system)

Cobalt is an essential mineral used in medicine for imaging, cancer radiotherapy, and sterilizing medical equipment. It is also used in consumer products such as the rechargeable batteries in smartphones and laptops. It is a core component of lithium-ion batteries for EVs as well as energy storage systems for solar, wind, and other renewable sources, giving it an essential role in the transition from fossil fuels to green energy.

More than 60% of the current global supply of cobalt is extracted from deposits found in the DRC (**Figure 7**) and its deposits of raw minerals are estimated to be worth in excess of US $24 trillion. Yet this wealth has not yet filtered down to the people of the DRC, as almost three quarters of the population live in poverty [116].

Figure 7 Global Cobalt production (2017).



Note: Cobalt data from 2017 and in tonne of metal content [117].

Mining of cobalt is carried out by both large-scale industrial mining and artisanal and small-scale mining, although there is extensive interaction and interface between the two [118]. Artisanal and small-scale mining can provide a living for many but also exacerbates inequalities, child labour, safety, and environmental issues. Cobalt mining can have a negative impact on human health and the environment: lung disease and heart failure have been linked to high levels of this element, while the mines that produce it are responsible for devastated landscapes, water pollution, contaminated crops, and a loss of soil fertility.

The negative impact of Cobalt mining is experienced most by those in the DRC and the country's environment, yet the increased value in the supply chain is rewarded further up the supply chain. The Global North needs to support the DRC in transitioning to low emission energy to power its mining and material processing. Otherwise the DRC will be accredited for the high emissions that make 'low emission' transport in the Global North possible. These are major inequity issues that remain to be addressed.

Considerable uncertainty still exists over the reserves of critical materials, such as lithium and cobalt, that may be economically recoverable, and the speed at which mining production can be ramped up [119].

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