Guyana's Transition to Electric Vehicles: a Systematic Review from the Perspective of Developing Countries

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ABSTRACT

The global climate crisis, partly triggered by an overexploitation of fossil fuels to propel transportation sector, obliges Guyana and other countries to substitute internal combustion engine (ICE) vehicles by electric vehicles (EVs). With a focus on Guyana in the context of developing countries, this qualitative review adhered to the guidelines of the Systematic Review in Conservation and Environmental Management. The review confirmed that in response to institutional provisions mainly in the areas of energy, climate change and transport for sustainable development, E2Ws (electric two-wheelers) and E4Ws (electric four-wheelers) EVs are being gradually adopted. In Guyana, E2Ws are more popular. In spite of current institutional programming for a transition to EVs in Guyana and other developing countries, challenges that seem to impede a faster transition range from high costs for infrastructure development, lacking of awareness, insufficient charging stations, range anxiety and even frequent power outages.

Key words: Electric Vehicles (EVs). Developing Countries. Guyana. Transition.

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RESUMO

A crise climática global, em parte desencadeada por uma superexploração de combustíveis fósseis para impulsionar o setor de transporte, obriga a Guiana e outros países a substituir os veículos com motor de combustão interna (ICE) por veículos elétricos (VEs). Com foco na Guiana, no contexto dos países em desenvolvimento, esta revisão qualitativa aderiu às diretrizes da Revisão Sistemática em Conservação e Gestão Ambiental. A revisão confirmou que, em resposta às disposições institucionais, principalmente nas áreas de energia, mudanças climáticas e transporte para o desenvolvimento sustentável, os VEs E2W (veículos elétricos de duas rodas) e E4Ws (veículos elétricos de quatro rodas) estão sendo gradualmente adotados. Na Guiana, os E2Ws são mais populares. Apesar da atual programação institucional para uma transição para VEs na Guiana e em outros países em desenvolvimento, os desafios que parecem impedir uma transição mais rápida variam de altos custos para desenvolvimento da infraestrutura, falta de conscientização, estações de carregamento insuficientes, ansiedade de alcance e até faltas de energia frequentes.

Palavras-chave: Veículos elétricos (VEs). Países em Desenvolvimento. Guiana. Transição.

INTRODUCTION

Internationally, greenhouse gas (GHG) emissions are increasing from the transportation sector (Axsen *et al*., 2020; Dulal *et al*., 2011; Sperling; Salon, 2002). Transport is a major driver for socio-economic development (Sohail *et al*., 2021; World Bank, 2018). The transportation sector helps to improve access to jobs, education, health care and global trade by allowing more efficient movement of goods and services (Sperling; Salon, 2002). Despite these and other benefits, the transportation sector emits GHGs that are damaging to the environment (World Bank, 2018). The continuous usage of fossil fuel driven vehicles remains a major source of GHG emissions across the world today (Hoekman, 2020; U.S. Department of Transportation, 2016). In the long term, these emissions contribute significantly to air pollution and global warming (Liaquat *et al*., 2010). Globally, the transport sector is responsible for 28 % of CO_2 emissions; within this sector, road transport alone accounts for 70 % of CO_2 emissions (Sanguesa *et al*., 2021).

In Guyana, it is estimated that the transportation sector utilizes 35% of the total petroleum products imported (Wood; Rowena, 2020), followed by the electricity sector, which accounts for 36% (DOE, 2019). The sustainability threats such as dependency and over exploitation of fossil fuel at the global level have forced governments around the world, including Guyana, to ratify many international conventions and agreements, including the United Nations Framework Convention on Climate Change (UNFCCC) (Government of Guyana, 2016; Kameyama; Kubota, 2010) and the Paris Agreement (Horowitz, 2016). The main goal of the UNFCCC Convention is to stabilize the concentration of GHGs in the atmosphere at a level that prevents dangerous interference with the climate system (IUCN, 2021). These conventions have established goals and objectives to realign economic activities in accordance with the requirements of the mitigation hierarchy of environmental and social impacts of development activities to mitigate atmospheric pollution and its associated ramifications for environment and development.

Consistent with the global commitment, Guyana's development is expected to be guided by the country's Low Carbon Development Strategy (LCDS) (Government of Guyana, 2021). One of the main goals outlined in the LCDS is to transform Guyana's economy by delivering greater economic and social development, thus, utilizing a low carbon development path. Highlighted in the LCDS is the low carbon transportation option for Guyana, where programmes are expected to be developed with the aim of lowering the cost for transportation, while reducing the carbon intensity of the country's transportation sector (Government of Guyana, 2021). In 2020, the Government of Guyana released the draft LCDS 2030, which further outlines plans to develop a low carbon transport infrastructure (Government of Guyana, 2021). The draft LCDS 2030 outline plans to reduce the dependency of fossil fuel for vehicular transport. This provision could be expected to drive the electric vehicle (EV) industry in Guyana, while enabling electric grid penetration through intermittent renewable energy (Government of Guyana, 2021).

Over the years, concerns about the impacts of climate change from the transportation sector have grown tremendously (Banister, 2011; Cort *et al*., 2013; Hickey; Weis, 2012; Rose; Corbin, 2017). Environmental concerns have pushed technological advancement in the car industry to reduce pollutants and GHG emissions (Teixeira; Sodré, 2018). Dependence on fossil fuel products, rapid urbanization, rapid expansion of the transport sector and urban air pollution have directed researchers and policy makers to seek solutions to internal

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combustion engine (ICE) vehicles within the transportation sector (Delucchi *et al*., 2014). One such initiative is the adoption of BEVs, which emit zero GHG emissions (GHOSH, 2020). Since the 1970's, more developed countries, including Germany, Japan and the USA initiated research and develop EV technology as a response to environmental pollution (Wu; Zhang, 2017). Like developed countries, many developing countries have also embarked on research and development, implementation of policies and plans to foster the development of EVs (Wu; Zhang, 2017).

With a focus on Guyana in the context of developing countries, this qualitative systematic review seeks to explore policies, opportunities and challenges faced while attempting to transition to EVs. The sections that follow detail the Methodology, Results and Discussion, and Conclusions. Recommendations and implications for further research are also presented.

METHODOLOGY

This section details the planning and execution of this systematic review. The process is presented thematically by focusing on the research questions, review protocol and search strategy. Using the guidelines outlined by Pullin and Stewart (2006), emphasis was placed on the formulation and development of the research questions that are relevant to policy and can influence policy formulation and planning given Guyana's situational context, while also reflecting on experiences of other developing countries. In this regard, the questions that have guided the literature research in the systematic review are:

1. What types of EVs are most popular in Guyana and other developing countries?
2. What policies are adopted by Guyana and other developing countries to foster the transition to EVs?
3. What are the opportunities for transitioning to EVs in Guyana and other developing countries?
4. What are the major challenges faced by Guyana and other developing countries in transitioning to EVs?

In conformity with the requirements of the CEBC[2] review guidelines by Pullin and Stewart (2006), elements of these review questions are thus defined in Table 1.

Table1: Elements of Review Questions

Elements of Questions	*Definitions*
Subject	Opportunities and challenges of transitioning to EVs (EV 2 wheelers, EV 4 wheelers and Hybrid EVs) in Guyana from the perspective of developing countries
Intervention	Proposed policy and planning for the transition to EVs in Guyana in the context of developing countries
Outcome	Adoption of EVs

2 Centre for Evidence Based Conservation.

Comparator	Comparing Guyana's transition to EVs against that of other developing countries

Note. Adopted from Guidelines for Systematic Review in Conservation and Environmental anagement (1648), by A. Pullin & G. Stewart, 2006, *Conservation Biology*, 20. https://doi.org/10.1111/j.1523-1739.2006.00485.x

With this focus summarized in Table 1, this review considers published and unpublished literature. Articles reviewed mainly from developing countries were categorized using the United Nations country classification (United Nations, 2020).

SEARCH STRATEGY

This review was conducted using guidelines for Systematic Review in Conservation and Environmental Management outlined by Pullin and Stewart (2006). A search strategy was developed from search terms extracted from the subject, interventions and outcome elements of the review questions. Online search engines and electronic databases such as Google Scholar, ResearchGate, ScienceDirect and JSTOR were utilized in the search for relevant articles. Key terms such as transportation, EVs in Guyana, EVs in China, EVs in Brazil, EVs in India, hybrid EVs, E-bikes, electric cars, electric two-wheeler, electric four-wheeler and EVs in developing countries were used to guide the selection of different journal articles. The search strategy element in the database constituted policies, opportunities and challenges outlined by various journal articles, books, reports and newspaper articles. Articles identified by the search were carefully selected to meet the inclusion criteria, based on their abstracts, introductions, and titles. The list of databases used in the data collection is presented in Table 2.

Table 2: Filtered Publications According to Inclusion and Exclusion Criteria

Database	***No. of Articles Retrieved***	***No. of Articles Included***	***No. of articles Excluded***
ScienceDirect	65	38	27
ResearchGate	10	2	8
SpringerLink	8	2	6
IEEE Xplore	11	2	9
JSTOR	7	3	4
Others	37	29	8
Total	**138**	**76**	**62**

Based on the search strategy, which examined the titles, abstracts and introductions of reviewed articles that followed the inclusion criteria, a total of seventy six (76) published journal articles, two (2) unpublished reports, sixteen (16) published reports, twenty eight (28) other articles including newspaper articles, and information from websites were selected. Also included in the review are data from Guyana Energy Agency (GEA), information from drivers (users) within the transportation sector (public and private) and senior traffic officers (experts) from Guyana Police Force. In this regard, this Systematic Literature Review (SLR) provided a means of exploring, evaluating, interpreting and analyzing literature from published and unpublished sources, as advocated by Pullin & Stewart (2006).

As demonstrated in Table 2, the literature search resulted in a large number of eligible data sources that needed to be evaluated for inclusion in the review against predetermined conditions; that is, the information must include data related to challenges, opportunities and policies as it relates to EVs' development in the perspective of developing countries, with emphasis on Guyana. Given the deficiency of published research on the subject for Guyana, the wider context of developing countries was adopted. With this focus, studies published in English about Barbados, Brazil, Chile, China, Dominica Republic, Guyana, India and Kenya were reviewed. As a result, this review is expected to make an invaluable contribution to the Guyanese literature on this thematic area, while, simultaneously, informing policymakers about the opportunities and challenges as it relates to EVs adoption in Guyana. The following section contains the findings and discussion.

Results and Discussion

In conformity with the CEBC guidelines, this section presents results and discussion of findings in the light of the research questions. Although each research question is discussed separately, there is some level of overlap given the interrelatedness of research questions that guided the review.

Research Question 1: What Types of EVs are Most Popular in Guyana and Other Developing Countries?

EVs can be categorized into battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and Fuel cell electric vehicles (FCEVs) (Pierri *et al*., 2021; Un-Noor *et al*., 2017; Wahid *et al*., 2021). The literature shows that three (3) types of EVs are most popular in developing countries: (1) battery electric vehicles (BEV), (2) hybrid electric vehicles (HEV) and (3) plug-in hybrid electric vehicles (PHEV). However, for the purpose of this systematic review, the BEV (E4W and E2W) and HEV are considered. In this review, E4Ws are referred to as electric cars and E2Ws as electric scooters and E-Bikes. The two types of EVs considered in this review are thus defined.

Battery Electric Vehicles (BEV) - (E4W and E2W) –

Being the first type defined, the BEVs are equipped with battery packs to supply power to the drive train for propulsion and rely solely on the energy stored in the battery packs (Pierri *et al*., 2021). Hence, the range of such vehicles depends on the capacity of the battery. In general, battery capacity ranges from 20 kWh to 60 kWh (Ghosh, 2020). Within this category, we have the E4W and the E2W.

E4Ws. E4W can cover a range of approximately 200 km to 300 km (Rajper; Albrecht, 2020). However, the range depends on several other factors such as driving conditions, driving style, vehicle configuration, road conditions, climate, battery type and age (Salles-Mardones *et al*., 2022; Un-Noor *et al*., 2017). The charging time depends on the configuration of the charger, its infrastructure and operating power (Kim *et al*., 2021). The International Electrotechnical Commission (IEC) and the Society of Automotive Engineers (SAE) have standardized the charging of EVs for various power levels (Das *et al*., 2020). There are three (3) levels: level 1, level 2 and level 3 (Ghosh, 2020). Charger level 1 uses a single-phase alternating current (AC) system with a maximum output of 3kW to charge a 20kWh battery in about 7 to 8 hours (Ghosh, 2020). It is usually located in homes and offices. Charger level 2 consists of a three-phase electric power connection of approximately 24kW charging power and it can take approximately 1 hour to charge a 20kWh battery (Ghosh, 2020). It is mainly found at public charging stations. Charging level 3 consists of 50 kW Direct Current (DC) charging power, which provides fast charging and takes approximately 20 to 30 minutes to charge a 20kWh battery (González *et al*., 2019; Sheikhi *et al*. 2013).

E2Ws. Electric two-wheelers are referred to as electric scooters and E-bikes, which are neither pedal-assisted nor kick-started. They are propelled by energy stored in battery packs. They can reach speeds ranging from 30 km/h to 45 km/h. The power rating of electric motors in these electric two-wheelers varies between 0.25 kW and 4kW (Weiss *et al*., 2015).

Hybrid Electric Vehicles

This second type of EV utilizes both ICEs and battery packs for power (Wahid *et al*., 2021). HEVs use the electric propulsion system when the demand for power is very low. The use of hybrid EVs is very advantageous in low-speed conditions like urban areas, where fuel consumption is reduced as engines shut down during idle periods or while the vehicle remains stationary, for example, during traffic jams and while at stop lights (Rajper; Albrecht, 2020). This feature helps to reduce GHG emissions; whenever higher speed is demanded of the vehicle it switches to the ICE (Rajper; Albrecht, 2020). Hybrids do not require charging from an external power source, as power is generated from a regenerative braking system along with the ICE (Girard *et al*., 2019; Panday; Bansal, 2014). Table 3 presents the major advantages and disadvantages of the types of EVs reviewed when compared to ICE, which they may fully replace.

Table 3: Advantages & Disadvantages of EVs Versus ICE

Types of EVs	Major Advantages Versus ICE	Major Disadvantages Versus ICE
Battery Electric Vehicles (BEV): E4Ws	• No fuel required • Lower maintenance cost • Reduced Noise Pollution • Easier to drive • Reduced Environmental impacts	• More expensive • Battery replacement is necessary
Battery Electric Vehicles (BEV): E2Ws	• No driver's license required in Guyana • Easier to operate • Lower operational costs • Easier to maneuver through traffic congested areas • Better for shorter distances • No air pollution • Easier to access parking in Guyana.	• Increased the number of traffic accidents • Greater risks of overcharging and other battery issues • Less suitable for longer distances • Little or no storage space • Increased danger due to the absence of (adequate) scooter lanes.
Hybrid Electric Vehicle (HEV)	• Energy conservation due to regenerative braking • Possesses dual power • Possesses automatic start/ shut off feature • Less dependent on fossil fuels • Possesses electric drive only	• Possesses less power • Poor handling • Higher maintenance costs required • Battery replacement required • Battery disposal require

Note. Adopted from Rinkesh (2016); Andreas (2022); Girard *et al.* (2019, p.1268); Conserve Energy Future (2022).

As their advantages range from the absence of fossil fuel requirements to energy conservation due to regenerative braking, EVs are proven to be more environmentally friendly and also guarantee greater efficiency. Table 4 outlines further classification of the different types of EVs used in conducting this research.

Table 4: Main Features of Different Types of EVs (E2Ws, E4Ws, and HEVs)

Features	Electric Two Wheelers (E2Ws)	Electric Four Wheelers (E4Ws)	Hybrid Electric Vehicles (HEVs)
Range in km being fully charged/Fueled	20-70 (km)	200-300(km)	862(km)
Charging time	8 hours	3-8 hours	Charges while in use
Speed	>45Km/h	> 150 Km/h	>180 Km/h
Electricity/Gas consumption per kilometer	0.45(km)	0.15(km)	Depends on use
Battery type	Lead-acid and lithium-ion batteries	Lead-acid and lithium-ion batteries	Lithium-ion battery
Battery storage	0.5-15kWh	24kWh	0.8-1.3 kWh

Note. Adopted from Prospects of Electric Vehicles in the Developing Countries: A Literature Review (p. 2), by S. Rajper & J. Albrecht, 2020, *Sustainability, 12(5)*, 1-19. http://dx.doi.org/10.3390/su12051906

Table 4 highlights various features of the types of EVs considered in this review. Some of the main features are charging time, electricity consumption per km, speed, battery type and storage capacity.

Research Question 2: What Policies are Adopted by Guyana and Other Developing Countries to Foster the Transition to EVs?

According to the review, the adoption rates for EVs among developing countries hinge strongly on policy interventions (Curtin *et al*., 2017; Hardman *et al*., 2017; Hardman, 2019; Wahid *et al*., 2021). At present, adoption rates are generally low in developing countries with little too weak policy interventions in this area and higher in countries with stronger policies (HARDMAN, 2019; Rietmann; Lieven, 2019; Sierzchula *et al*., 2014); this suggests that well-defined and carefully implemented policy interventions could be very effective in influencing consumers' behavior for sustainability (Tummers, 2019). These policy interventions include tax rebates, purchase subsidies, parking space privileges and a plethora of disincentives thwarting the acquisition of ICE vehicles. Table 5 summarizes major energy and climate policy interventions adopted by Guyana and other developing countries in the Caribbean, South America, Africa and Asia that could stimulate the EV market.

Table 5: Energy & Climate Policy Interventions Outlined by Guyana & Other Developing Countries

Countries	Energy & Climate Policies	Goals	Year
Barbados	Barbados National Energy Policy	• To change to 100% reliance on renewables and carbon neutrality by 2030	2019
Brazil	INOVA Energia Rota 2030	• To stimulate EV market • Stimulate investment in hybrid vehicles	2013
Chile	National Electro-mobility Strategy National Energy Policy-2050	• To electrify 40% of the private fleet by 2050 • To achieve a 60% energy generation from renewable sources by 2030	2016 2017

China	Development Plan for Energy Saving and New Energy Automotive Industry (2012-2020)	• To increase manufacturing capacity by two (2) million BEVs and PHEVs • To foster Government financial support for charging infrastructure	2012
Dominica Republic	National Energy Plan	• To cut duties and registration fees for EVs by 50%	2017
Guyana	Draft LCDS 2030 Draft National Energy Policy Introduction of more low carbon energy resources/renewable into the energy sector	• To implement a low carbon transport infrastructure • To provide tax exemptions on EVs • To reduce electricity cost to consumers by 50%	Consultation Stage 2017
India	Fast Adoption & Manufacturing of Electric and Hybrid Vehicles (FAME)	• To provide subsidies for EVs production and charging infrastructure	2019
Kenya	National Climate Change Action Plan (NCCAP) A pilot project to support Kenya Power and Lighting Company	• To promote non-motorized transport (NMT) with emphasis on electrification of the transport infrastructure • To widen revenue streams and business diversification • Reduce excise duty on electrical vehicles	2018

Note. Adopted from Government of Barbados (2019); Chino (2021); Salles-Mardones *et al.* (2022, p. 4); Government of Guyana (2021); Ge (2022); Guyana Revenue Authority (2020); Department of Public Information (2022); Clarke (2017, p. 11); ORF (2021); Ali & Naushad. (2022, p.2); Republic of Kenya (2019).

The GEA is actively conducting research on the development of EVs (Clarke, 2017). The findings of this research may guide planning for a transition to EVs in the transport sector. EVs are appealing because they minimize pollution, produce less noise, and require less maintenance because they have fewer mechanical parts (Rajper; Albrecht, 2020). They do, however, require charging stations in convenient locations for car owners and operators, as well as professional mechanics and repair facilities.

In order to stimulate demand for EVs, Guyana imposes tax exemptions on EVs regardless of power rating (Guyana Revenue Authority, 2020). Further, Briggs *et al*. (2015) encourage governments and the private sector to incentivize the use of EVs once needed. Through similar approaches, markets for EVs have been easily created in China and India, which are leaders in policies to support EVs (Rajper; Albrecht, 2020). In this regard, they posit that the Indian government has initiated faster policies for manufacturing and transitioning to EVs since 2015 (Rajper; Albrecht, 2020). In order to achieve these goals, the Indian government exempts consumers from paying registration tax on purchasing battery operated vehicles (Kanuri *et al*., 2021).

Another key player in the development and transition to EVs is China. In China, policies currently restrict the purchase of gasoline-powered two-wheelers in cities where environmental pollution is high (Yang, 2010). Also, there are several tax waivers schemes for EVs owners in China. Studies conducted by Zhang et al. (2011), reveal that tax reductions and incentives such as subsidies by governments also increase awareness about EVs. The introduction of EVs relies primarily on technological improvements and economic incentives (Jones *et al*., 2013). In China, the low price of E2W, in addition to the ban on the purchase of gasoline motorcycles, is expected to have increased the adoption of E2W (Eccarius; Lu, 2020).

Beyond China and India, the governments of other developing countries may be required to implement more rigorous investor-friendly policies to incentivize EVs in their transportation sector. In the Caribbean, the Caribbean Energy Policy of CARICOM outline plans to identify appropriate incentives for promoting technological development in fuel switching as well as the use of electric and hybrid vehicles and collaborate with electric utilities on suitable upgrades to the national grid (CARICOM, 2013). Guyana, being a member of CARICOM, is expected to benefit from these initiatives. However, in the Guyanese context, a more realistic approach seems necessary in accordance with situational planning. To achieve such, detailed case studies and cost-benefit analyses are necessary to determine the most appropriate technologies for Guyana.

The primary means of transportation in many developing countries in Asia and Africa are E2W and E4W EVs; hence, switching to electromobility offers enormous potential for reducing GHG emissions from the sector across developing countries (UNEP, 2022). Currently, governments of some developing counties, including Barbados, Brazil, Chile, China, Dominica Republic, Guyana, India and Kenya have initiated programming through policies and projects to transition from ICE to electric and non-motorized E2Ws. See Table 6.

Table 6: Policy & Project Interventions for Adopting EVs in Guyana & Other Developing Countries

Countries	Programming Activities	Goals	Year
Barbados	• Pilot projects for medium size EV buses • Capacity Building for maintenance EVs • Charging Infrastructure	• To investigate the performances of the buses on hills • To create direct public exposure to EV technology • To work with Samuel Jackson Prescod Institute of Technology to incorporate EV maintenance into its general maintenance course. • Implementation of 45 public charging stations approximately 3 miles apart in order to eliminate range anxiety	2013

Brazil	• São Paulo's City electric bus development pilot project • Municipal law No. 16802, outlined vehicles serving public transport must reduce CO_2 emission • Capacity building in Electric Mobility through vocational education institutes and private companies	• To promote BEV and HEV in Brazil • To reduce CO_2 emission by 50% within 10 years and 100% within 20 years. • To develop training programs • To train the personnel needed to deal with EV technology in the future	2018
Chile	• The Ministry of Energy launched the energy route 2018-2022 • Provision of Fast charging corridors in the Central south zone with 23 charging stations covering 700km and the south zone under construction to cover 1200 km)	• To increase the number of EVs circulating across the country. • To accelerate the adoption of EVs	2018
China	• Tax exemptions • Support for charging infrastructure	• Government exempts EV from sales taxes • To achieve 50%, waive EV Registration Fees • To promote and encourage the development of charging infrastructure. • To achieve a target of 120,000 EV charging stations by 2020.	2019
Dominica Republic	• Electric mobility Strategic Plan (2019-2023)	• To improve the inter-sectorial relationship between the energy and transport sectors	2019
Guyana	• Pilot projects to develop the EV industry	• To install charging infrastructure to facilitate EV development in the transport sector	2022
India	• Charging infrastructure for EVs (Revised guidelines and standards)	• To enable faster adoption of EVs in India by ensuring safe, reliable and affordable charging infrastructure	2019
Kenya	• Policy to support the Kenya Bureau of Statistics (KBS)	• To develop standards and specifications for electric mobility in Kenya	2021

Note. Viscidi et al. (2019, p. 9); Zaparolli (2019); UNEP (2019, p. 36); Bhawan; Marg (2022, p.1); Guide to Chinese Climate Policy (n.d.); Department of Public Information (2022); Federal Ministry for Environment, Nature Conservation and Nuclear Safety (2022).

The transition to a more sustainable, low-carbon transportation industry will be aided by the energy sector (Department Of Public Information, 2022). Guyana must continue to build institutional capacity for the development of an EV industry as the country continues transitioning from fossil fuels (Guyana Chronicle, 2021b). Therefore, priority incentive programmes should continue to promote the adoption of new technologies, raise awareness, and stimulate a shift in behavior toward fuel diversification, non-motorized transportation, and road sharing. In the long run, developing, testing, and enforcing new vehicle and emission standards could help reduce carbon emissions, regulate pollution, and enhance overall vehicle fleet efficiency (Axsen *et al*., 2020). In addition, a sustainable modernization programme may be required to curb the expected growth of carbon emissions from the transportation sector, which is the largest source of carbon emissions in many countries (UNDP, 2012).

Increasing the number of EVs in developing countries can significantly reduce direct emissions of CO_2 and air pollutants from road transport (Gerber *et al*., 2020). However, such benefits could be undermined by additional emissions caused by additional electricity required and continued fossil use in the energy sector.

Research Question 3: What are the Opportunities for Transitioning to EVs in Guyana and other developing countries?

Given the importance of reducing emissions of harmful GHGs from the transportation sector while simultaneously modernizing the sector in alignment with international standards, governments across developing countries are continually committed to realigning transport and energy policies for transitioning to EVs. Based on the literature reviewed, the following are major opportunities for transitioning to EVs in the transport sector of Guyana and other developing countries:

Limited Cost of (Infrastructure Required for E2Ws and Hybrid Electric Vehicles)

The fear of driving EVs and running out of power (range anxiety) may be minimized in developing countries once appropriate charging infrastructures are installed (Rajper; Albrecht, 2020; Mendoza *et al*., 2015). E4Ws require sophisticated charging stations, while E2Ws do not require capital-intensive charging infrastructure (Davidov; Pantoš, 2017). E2Ws have portable batteries that can be charged from standard wall outlets in homes and offices. E2Ws can replace short car trips, which are prevalent across Guyana, thus reducing the large infrastructure investment that is needed for E4Ws (Weiss *et al*., 2015). Similarly, HEVs do not require external charging as they produce power from batteries and engines (Hannan *et al*., 2014). E2Ws and HEVs are more suitable for developing countries such as Guyana that lack the resources to invest in capital-intensive infrastructure for E4Ws.

This mode of transportation is increasingly becoming popular in rural areas and towns in Guyana, particularly in Regions Two, Three, Four, Five and Six. Altogether, these regions account for approximately 74% of Guyana's total population (Bureau of Statistics, 2016). E2Ws and HEVs are more feasible for developing countries due to their low cost of maintenance and low purchase price (Rajper; Albrecht, 2020). For example, the estimated prices for electric two wheelers vary from USD 420 to USD 850 (Gear; Edmondson, 2022) and for HEVs range from USD$ 20,000 to USD$ 100,000 (Edmunds, 2022.), respectively; comparatively, BEVs (E4Ws) prices range from USD 27,400 to USD 187,600 (Kane, 2022). Being less costly, two wheelers are popular in Guyana, and in other developing countries like Barbados, Brazil, Chile, China and India.

Reduction in Emissions of Greenhouse Gases

GHGs include Carbon Dioxide (CO_2), Carbon monoxide (CO), methane (CH_4) and Nitrogen Oxide (NO_2). Within the transport sector, greater emphasis is placed on reducing CO_2 emissions (Wu; Zhang, 2017). EVs contribute minimally to emissions of GHGs from a well-to-wheel energy use perspective, independent of whether the energy mix is dependent on fossil fuel (ORSI *et al.*, 2016). Also, Orsi et al. (2016) showed that HEVs have lower CO_2 emissions when compared to ICEs vehicles. Also, studies in India show that E2Ws and E4Ws emit less CO_2 per kilometer than gasoline vehicles using the tank-to-wheel assessment method (Doucette; Mcculloch, 2011). These studies show that EVs emit less GHG than internal combustion vehicles.

In Kenya, studies have shown that transitioning to E2Ws can help reduce GHG while bringing socio-economic benefits to the people (Bugaje *et al*. 2021). In Barbados, programming for EVs integration is necessary, since they are expected to play a significant role in decarbonizing the transport sector by utilizing energy from various forms of renewables (Taibi *et al*., 2018). In Chile, an increase in electromobility is expected due to policies and trends aimed at reducing polluting gas emissions (Salles-Mardones *et al*., 2022). Dias *et al*. (2014) and Collaço *et al*., (2019) conducted studies in Brazil and concluded that eliminating fossil fuels from public transportation reduces GHG emissions and increasing EVs leads to improved air quality, public health, and traffic congestion. In addition, a 2017 study by Costa *et al*, revealed that the use of EVs is an excellent way to reduce emissions. According to the study, replacing 25% of gasoline powered vehicles with EVs by 2030 would reduce energy consumption by 15% and CO_2 emissions by 26% when compared to 2015 values (Costa *et al*., 2017). While Guyana currently has policies to foster the importation of cleaner ICE vehicles (CORT *et al.*, 2013; Rose; Corbin, 2017), strengthening policies and implementing and enforcing measures for accelerated adoption of EVs could confirm the county's commitment in supporting the global community in mitigating climate change, at least from the transportation sector, which seems to be a major emission source of GHGs.

Energy Saving

EVs provide superior energy saving performances than ICE vehicles (Rajper; Albrecht, 2020). The energy-saving may refer to gasoline or diesel saving, which results from turning on electric power for mobility. A study by Zhou *et al*. (2013) assessed the life cycle of E4W, by the overall energy consumption from vehicle production through end-of-life and the well-to-wheel energy consumption, confirmed that E4Ws saved approximately 35% more energy than ICE vehicles, while hybrid vehicles saved approximately 20% more energy than ICE vehicles. Another study conducted by Orsi et al. (2016) using the well-to-wheel approach, comparing hybrid vehicles to E4Ws revealed that hybrids consumed twice the energy compared to E4Ws. Other studies confirmed that E2Ws are considered to be more energy efficient than conventional two wheelers in that they consume 3-5 times less energy than petrol-based two wheelers (Eccarius; Lu, 2020; Majumdar *et al*., 2016). Table 7 depicts a comparative analysis of different EVs using tank-to-wheel energy use.

Table 7: A Comparative Analysis of Three (3) EVs Considering Tank-to-Wheel Energy Use

Mode	**Tank-to-wheel Energy use (in kWh per km)**
E2Ws (Electric Scooters)	0.045 +/- 0.02

E4Ws (Battery Electric Vehicles)	0.15+/- 0.04
HEV (Hybrid Electric Vehicles)	0.4+/-0.1

Note. Weiss *et al*. (2015, p. 360); Rajper; Albrecht (2020, p. 6).

When considering the most energy efficient mode of transportation among EVs using the tank-to-wheel energy use approach, E2Ws utilize less energy than that of HEVs and E4Ws.

Road Safety

EVs undergo similar safety and test procedures to fossil fuel powered cars (Rinkesh, 2016). An E4W is safer to drive given the lower centre of gravity (CG), which makes the vehicle more stable on the road in the case of a collision (Pastellides *et al*., 2022). In the event of an accident, the electricity supply from the battery will cease or stop. Thus, they are less likely to explode due to the absence of any combustible fuel or gas. Literature has shown that low speed can reduce accidents caused by E2Ws (Weiss *et al*., 2015). Despite massive public sector spending on education and awareness efforts, traffic fatalities remain a serious problem in the transportation sector (Rose; Corbin, 2017). Furthermore, the World Health Organization (Who, 2021) confirms that road users, including pedestrians, cyclists and motorcycles, account for about 50 percent of all traffic deaths globally. Despite having 60 % of the world's vehicles, low and middle-income countries account for 93% of all road fatalities. To reduce the cases of road traffic injuries and fatalities, the pace of legislative change and enforcement must be accelerated, with a greater focus on vulnerable road users such as pedestrians, cyclists and two wheelers (Who, 2021).

Research Question 4: What are the Major Challenges Faced by Guyana and Other Developing Countries in Transitioning to EVs?

EVs are continuously being offered a place in the transportation sector in recent times (Delucchi *et al*., 2014; Liu *et al*., 2018). Based on the literature reviewed, current trends suggest that this form of transportation will soon replace ICE vehicles in the future (Delucchi *et al*., 2014), particularly given the major environmental benefits of reduced CO_2 emissions (Un-Noor *et al*., 2017). Despite these benefits, the following are among the key challenges that developing countries including Guyana must overcome before totally replacing ICE vehicles with EVs.

Limited Range

The wider use of EVs is suppressed by their battery capacity (Sanguesa *et al*., 2021; WU; Zhang, 2017). Batteries can only store a fixed amount of energy based on the manufacturer's specifications. Thus, the distance covered by EVs is contingent upon the energy stored (Komorska *et al*., 2021; Sanguesa *et al*., 2021; Un-Noor *et al*., 2017). The range (distance EVs can travel on a fully charged battery) also depends on several factors such as the load being transported, the terrain over which they are driven, vehicles' speed, driving style and the energy consumption services such as air condition unit (Bartels *et al*., 2020; Kostopoulos *et al*., 2020). In the case of Guyana, there are limited facilities for battery charging as only one known charging facility is available in Georgetown and it is being used to charge the Nissan Leaf purchased by the Government (Newsroom, 2020). At present, plans are being put in place to install six new charging stations in various regions across Guyana (Newsroom, 2022). The installation of these six new charging stations is to expected support other EV adoption measures and to reduce range anxiety and long charging time.

Long Charging Time

Intrinsically linked to the range is charging time. Several studies revealed that one major challenge in the adoption of EVs is the long charging time (Bugaje *et al*., 2021; Ghosh, 2020; Un-Noor *et al*., 2017). Charging an EV battery can range from a few minutes to hours; this is one of the major disadvantages of EVs when compared to ICE vehicles (Un-Noor *et al*., 2017). The charging period varies with EVs, depending on the battery pack and charging mode (Sanguesa *et al*., 2021). E4Ws may take up to 3-8 hours of charging with approximately 1.4 kilowatts (kW) power to ascertain maximum charge (Un-Noor *et al*., 2017). E2Ws, which are more common in developing countries including Guyana, is equipped with a battery capacity of approximately 0.5 kWh -15kWh and require 6-8 hours to recharge once a standard charging outlet is used (Juan *et al*., 2016; Rajper; Albrecht, 2020). The general trend in developing countries is that EV charging is done during the evenings and nights when tariffs are lower and EVs are idle (Shao *et al*., 2017).

Length of charging time will continue to be an issue for EVs until sustainable technology is developed (Delucchi *et al*., 2014). Developing countries still suffer from frequent power outages caused by failures of power generation equipment and other challenges (Kessides, 2013; Saxena *et al*., 2014). One of the causes for frequent power outages in Guyana is the lack of an effective policy in relation to the rising power demands and poor maintenance of current power-generation assets (Guyana Power; Light, 2016). In the absence of fully transitioning to sustainable energy sources, this could be aggravated by international oil crises, and in response to increasing energy demands for development activities during Guyana's current oil boom. Guyana Power and Light's grid has a single 69 KV transmission line that links Demerara to Berbice interconnected system and non-redundancy in 69 KV transmission (Guyana Power; Light, 2016). Guyana still experiences frequent power interruptions. This can increase charging delays associated with batteries for EVs, hence, significantly undermining greater transition to adopting EVs in transport across the country.

Social Acceptance & Lacking of Awareness

New interventions and technologies may not be easily accepted by society, as transition obliges changes in cultural habits that influence consumption (Ronanki *et al*., 2019). The adoption and use of EVs over internal engine vehicles may require changes in refueling habits, driving techniques and driving patterns (Un-Noor *et al*., 2017). Another challenge with EV adoption in developing countries is the lack of awareness. Lack of awareness on EVs may also lead to the public's disapproval of the new technology (Delucchi *et al*., 2014). In Guyana, interviews conducted by the author during the period of this review with some users of EVs revealed that they were unaware of some of the performance features, operation and maintenance of EVs. Thus, it can be assumed that a reduction of information asymmetry could permit increasing access to information regarding cost-benefit, use and maintenance among consumers for making rational choices. In developing countries where information asymmetries prevail, significant awareness measures are critical and necessary for the successful adoption and implementation of EVs within the transportation sector (Egbue; Long, 2012; Rajper; Albrecht, 2020).

Road Infrastructure

Geographically, Guyana may have a good potential for adoption of EVs on the low coastal plain since it covers approximately 9,120 square kilometers (Guyana Lands and Surveys

Commission, n.d.) and is the home of approximately 87% of the country's population (Bureau of Statistics, 2016). EVs seem suitable for the coastal plain, where flat terrain and paved roadways are present, when compared to Bermuda and other small developing islands, where the choice of EVs has to be limited because of narrow roads (Guyana Energy Agency, 2020; Viscidi *et al*., 2019). However, Guyana's current transport network may offer insufficient mobility and accessibility to of E2Ws and E4Ws users. Thus, range anxiety may worsen from massive traffic congestion and charging infrastructure.

High Cost for Charging Infrastructure and Insufficient Charging Stations

The lack of charging infrastructure, load shedding of electricity, unreliability of the grid and a high cost of non-renewable electricity energy are some of the challenges that Guyana must overcome in order to aid the widespread adoption of EVs. Insufficient charging stations limit the widespread acceptance of EVs by users across the world (Alkawsi *et al*., 2021). In an unpublished report by GEA, a proposal was made in 2020 for charging stations to be installed in Regions Three, Four, Five, Six and Ten, all of which account for approximately 83% of the country's population (bureau of statistics, 2016; guyana energy agency, 2020a). The objective of that proposal was to provide a structure for EV charging infrastructure in major towns (Guyana energy agency, 2020a). Unfortunately, the high cost was a major obstacle for implementing the proposal. Another report by Guyana Energy Agency (2020b) revealed that the cost to install a single dual port AC level 2 charging station was estimated at US$8,000 (G$ 1, 677520) (Guyana energy agency, 2020b). As a consequence, Guyana has one (1) charging station, which is equipped with charging ports to support the Nissan LEAF, 2019-year model (E4W). In addition, if the facility is to be utilized by other Models of EVs, appropriate charging modules and adapters will have to be made available to private users. Comparatively, Barbados has 50 charging stations, while other developing counties such as Brazil, and, Dominican Republic have 500 and 62 charging stations, respectively (Chino, 2021; UNEP, 2019).

Increased Demand for Power Generation

It is expected that there will be an upsurge in power demand once there is an increase in E4W usage in developing countries (Doucette; Mcculloch, 2011; lopes *et al*., 2011). Charging of batteries may impact the grid's performance and efficiency (Richardson, 2013). However, a study conducted in India, modeling high EV penetration scenario, revealed that the electricity will not exceed more than 6% of the overall demand (Dhar *et al*., 2017). Engineers contended that smart charging algorithm is one technique that can be used to help reduce limitations on transformers where EVs are connected to the grid (Rajper; Albrecht, 2020).
In Chile, studies are being conducted to determine the benefits of smart charging of EVs from solar energy and to analyse the impacts of massive electrification of vehicles on the power system (Manríquez *et al*., 2020). A study conducted by Zheng and Jian (2016) and another by Kam and Van Sark (2015), about smart charging of EVs, concluded that smart charging can equal the total load by improved usage of base loads with no further installation. However, challenges related to overload could occur in the absence of an appropriate plan for managing the network of battery-powered EVs (Lopes *et al*., 2011). Furthermore, a smart grid that allows for systematic communication between the power supplier (energy price) and the consumer, along with smart meters can help to supply power to the grid during peak demand periods (IEA, 2019). Unfortunately, Guyana does not have a smart grid and plans are being put in place to upgrade 69 KV power line and for introducing smart meters

(Guyana power; Light, 2016). In developing countries such as Guyana, which experience frequent power interruptions, if the electric grid does not supply enough power to charge E4Ws, users may be forced to revert to an alternative means, such as, internal combustions engine (ICE) vehicles, which could give rise to environmental externalities (Saxena *et at*., 2014). Furthermore, the integration of renewable energy sources such as solar and wind energy systems into the power grid, though costly, is technically feasible (Alkawsi *et al*., 2021; Bugaje *et al*., 2021). However, public charging infrastructures that use renewables in residential areas are with face several challenges, including parking availability and building constraints (for e.g., insufficient space for solar panels) (Alkawsi *et al*., 2021).

Road Safety

Opinions among researchers varied regarding safety of EVs (Rajper; Albrecht, 2020). The cost associated with replacement of an internal combustion vehicles is comparable to the cost of an EV (Jochem *et al*., 2016). Other studies indicated that the usage of electric motors increased the risk of accidents (Cocron; Krems, 2013; Kończak *et al*., 2015). The use of heavier weighted lead-acid batteries may increase the severity of accidents due to inertia (Rose, 2012). In many developing countries, the safety of E2Ws is a problem since there are no priority lanes for two wheelers on the road (Rajper; Albrecht, 2020). In addition, a review of laws and regulations of Guyana in relation to electric two wheelers confirmed that they are no laws nor regulations to regulate E2Ws. Existent laws only make provisions for motor cycles 50 cc and above (Constitution of Guyana, 1998). However, the Guyana Police Force and the Guyana Revenue Authority, on the other hand, are formulating rules to govern the usage of electric two-wheelers in 2022 (Guyana Chronicle, 2022).

In Guyana E2Ws or "Electric Bike" is becoming a popular mode of transportation particularly in regions Four, Five and Six, which account for approximately 63% of Guyana's population (Bureau of Statistics, 2016; Guyana Chronicle, 2021a). However, there are serious safety issues regarding their use. First, E2Ws do not have a number plate and users are not required to wear helmets nor required to secure a driver's license (Guyana Chronicle, 2021a). According to the traffic chief, Ramesh Ashram, it is not a requirement for E2W riders to wear a helmet for bikes 49 cc and below (Guyana Chronicle, 2021a). At present, a certificate of fitness and a road service license for motor vehicles are not requirerd for owners of E2Ws in Guyana (Guyana Chronicle, 2021a). To further compound the dangers, these bikes can attain a maximum of approximately 50Km/h, which currently exceeds the maximum speed limit for motor cycles in Guyana (Guyana Chronicle, 2021a).

CONCLUSIONS

Based on the review, the following conclusions can be made about EVs in the context of Guyana and other developing countries reviewed:

1. Battery EVs (BEVs), that is, E4Ws and E2Ws are the most popular EVs in the developing countries assessed. In Guyana, E2Ws are the most popular, particularly in Regions Three, Four, Five and Six.
2. E2Ws and hybrids are more feasible for Guyana and other developing countries reviewed due to their energy saving abilities and potential to reduce GHG emissions, with little or no additional infrastructure investments.
3. Planning for the adoption of EVs is considerably aligned mainly with policies in

the areas of sustainable energy, climate change and sustainable transport in the Guyanese context. The same holds for other developing countries considered in this review. In Guyana, the adoption of EVs in the transport sector has the potential to reduce GHG emissions, while embracing the low carbon development economy.

4. In general, EVs are much cheaper to operate and maintain when compared to internal combustion vehicles. They are environmentally friendly and safer to operate since they are less likely to explode due to the absence of any combustible fuel or gas.
5. In spite of current institutional programming for a transition to EVs in Guyana and other developing countries, challenges that seem to impede a faster transition range from high costs for infrastructure development, lack of awareness, insufficient charging stations, range anxiety and even frequent power outages.
6. Give the paucity of scientific studies on EVs specifically on Guyana, this paper makes important contributions, particularly by widening the existent academic literature and by informing planners and policy makers about opportunities and challenges Guyana and other developing countries face as they embark on programming for transitioning to EVs. Further academic research is needed, particularly from a Guyanese perspective.

Recommendations

The following are recommended regarding transitioning to EVs in the context of Guyana and other developing countries:

1. Strengthen programming for a faster transition to EVs – a situational approach to planning is best while valuing the country context.
2. Embark on or strengthen public awareness about transitioning to EVs in the context of sustainable development.
3. Embark on a multisectoral approach for transitioning to EVs. In this regard, all stakeholders should be meaningfully engaged in policy formulation, planning and implementation of programming activities in order to guarantee a more sustainable transition.
4. Given the lack of regulations governing the use of E2Ws, which are more commonly found in Guyana and most developing counties in general, requisite agencies should consider rigorous transport planning, where enforcing road safety, providing lanes for E2Ws, requiring the use of safety gears (helmets) among users of E2Ws, and licensing for these users should be given greater attention.
5. Guyana and other developing countries should commence planning, at the national, state and/or municipal levels, for recycling or disposal of waste batteries in a sustainable manner. Public, private and/or public-private arrangements could be encouraged depending on the country's context.
6. As Guyana and other developing countries continue to transition to EVs, capacity building and other aspects of institutional strengthening are necessary on all aspects of EVs' lifecycle in the context of sustainable development.

Implications for Further Research

Given that EV technology is relatively new, developing countries are at different stages of transition and there exists a paucity of scientific studies on EVs, particularly in Guyana, the following areas of research could be explored by future researchers:

1. Needs assessment on institutional arrangements for managing wastes from EVs.
2. Needs assessment studies for human capital development and other aspects of institutional strengthening for the EV sector of each country.
3. Feasibility assessment to determine whether the local/national distribution systems meet the required standards for charging EVs. Such studies could also assess the impacts of charging EVs on local/national grids, and to determine the capacities of grids to provide additional power needed in response to changes in energy demands.
4. Studies on the role of renewable energy sources in supporting competing energy demands by the EVs (transport) sector and other sectors of the economy.
5. Assessments of the charging infrastructures to develop suitable business models from a country context perspective.
6. Socioeconomic assessments on transitioning from imports of refurbished vehicles to imports of EVs.

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REFERENCES

ALI, I.; NAUSHAD, M. A study to investigate what tempts consumers to adopt electric vehicles. *World Electric Vehicle Journal*, 2022, *13*(2), 1-15. DOI: ttps://doi.org/10.3390/wevj13020026

ALKAWSI, G.; BAASHAR, Y.; ABBAS U, D.; ALKAHTANI, A. A.; TIONG, S. K. Review of renewable energy-based charging infrastructure for electric vehicles. *Applied Sciences*, 2021, *11*(9), 1-17. DOI: https://doi.org/10.3390/app11093847

ANDREAS. Advantages and disadvantages of electric scooters. 2022. https://environmental-conscience.com/electric-scooters-pros-cons/#Advantages_of_Electric_Scooters

AXSEN, J.; PLÖTZ, P.; WOLINETZ, M. Crafting strong, integrated policy mixes for deep CO_2 mitigation in road transport. *Nature Climate Change*, 2020, 10, 809–818. DOI: https://doi.org/10.1038/s41558-020-0877-y

BANISTER, D. Cities, mobility and climate change. *Journal of Transport Geography*, 2011, 19(6), 1538-1546. DOI: https://doi.org/10.1016/j.jtrangeo.2011.03.009

BARTELS, R. L.; KOWALSKY, D.; JONAS, T.; MACHT, G. A. Ease of EVs: Exploring factors that influence battery consumption. *International Journal of Sustainable Transportation*, 2020, 14(9), 701–709. DOI: https://doi.org/10.1080/15568318.2019.1610920

BHAWAN, S.; MARG, R. Final consolidated EVCI guidelines. Government of India. 2022. https://powermin.gov.in/sites/default/files/webform/notices/Final_Consolidated_EVCI_Guidelines_January_2022_with_ANNEXURES.pdf

BRIGGS, M.; WEBB, J.; WILSON, C. Automotive modal lockin: The role of path dependence and large socio economic regimes in market failure. *Economic Analysis and Policy*, 2015, 45, 58-68. DOI: https://doi.org/10.1016/j.eap.2015.01.005

BUGAJE, A.; EHRENWIRTH, M.; TRINKL, C.; ZÖRNER, W. Electric two-wheeler vehicle integration into rural off-grid photovoltaic system in Kenya. *Energies*, 2021, 14(23), 1-28. DOI: https://doi.org/10.3390/en14237956

BUREAU OF STATISTICS OF GUYANA. 2012 Population & housing census final results. 2016. https://statisticsguyana.gov.gy/wp-content/uploads/2019/10/Final_2012_Census_Count-1.pdf

CARICOM. Caricom energy policy. 2013. https://caricom.org/documents/10862-caricom_energy_policy.pdf

CHINO, D. Electric cars: Can Latin America's nascent EV market cut urban pollution? Dialogo Chino. 2021. https://dialogochino.net/en/climate-energy/44044-latin-americas-nascent-electric-car-market/

CLARKE, R. Draft energy policy of Guyana--Report 2—Green paper. 2017. http://www.electricity.gov.gy/HECI_Docs/Report2_GY_EnergyPolicy_Feb20_17.pdf

COCRON, P.; KREMS, J. F. Driver perceptions of the safety implications of quiet electric vehicles. *Accident Analysis & Prevention*, 2013, 58, 122–131. DOI: https://doi.org/10.1016/j.

COLLAÇO, F. M. de A.; DIAS, L. P.; SIMOES, S. G.; PUKŠEC, T.; SEIXAS, J., BERMANN, C. What if São Paulo (Brazil) would like to become a renewable and endogenous energy -based megacity? *Renewable Energy,* 2019, 138, 416–433. DOI: https://doi.org/10.1016/j.renene.2019.01.073

CONSERVE ENERGY FUTURE. What is a hybrid car? (2022). https://www.conserve-energy-future.com/advantages-and-disadvantages-of-hybrid-cars.php

CONSTITUTION OF GUYANA. Motor Vehicle Road Traffic Act, *Chapter,* 1998, 51:02. http://guyaneselawyer.com/lawsofguyana/Laws/cap5102.pdf

CORT, K. A.; SIMMONS, D. A.; CHANDARPAL, N. An analysis of trends in road transport and policy directives to address emissions. *SEES Research Series: Student Research Articles and Practitioner Essays on the Green Economy*, 2013, 9–22. DOI: https://doi.org/10.52377/ocje3084

COSTA, E.; SEIXAS, J.; COSTA, G.; TURRENTINE, T. Interplay between ethanol and electric vehicles as low carbon mobility options for passengers in the municipality of São Paulo. *International Journal of Sustainable Transportation,* 2017, 11(7), 518–525. DOI: https://doi.org/10.1080/15568318.2016.1276651

CURTIN, J.; MCINERNEY, C.; GALLACHÓIR, Ó. Financial incentives to mobilise local citizens as investors in low-carbon technologies: A systematic literature review. *Renewable and Sustainable Energy Reviews,* 2017, 75, 534-547. DOI: https://doi.org/10.1016/j.rser.2016.11.020

DAS, H. S.; RAHMAN. M. M.; LI, S.; TAN, W. C. Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review. *Renewable and Sustainable Energy Reviews,* 2020, 120, 1-27. DOI: https://doi.org/10.1016/j.rser.2019.109618

DAVIDOV, S.; PANTOŠ, M. Planning of electric vehicle infrastructure based on charging reliability and quality of service. *Energy*, 2017, 1156-1167. DOI: https://doi.org/10.1016/j.energy.2016.10.142

DELUCCHI, M.; YANG, C.; BURKE, A.; OGDEN, J.; KURANI, K.; KESSLER, J.; SPERLING, D. An assessment of electric vehicles: Technology, infrastructure requirements, greenhouse-gas emissions, petroleum use, material use, lifetime cost, consumer acceptance and policy initiatives. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences,* 2014, 372(2006), 1-27. https://www.jstor.org/stable/24502108

DEPARTMENT OF PUBLIC INFORMATION. Guyana to develop an electric vehicle industry – PM Phillips, 2022. https://dpi.gov.gy/guyana-to-develop-an-electric-vehicle-industry-pm-phillips/

DHAR, S.; PATHAK, M.; SHUKLA, P. R. Electric vehicles and India's low carbon passenger transport: A Long-term co-benefit's assessment. *Journal of Cleaner Production,* 2017, 146, 139-148. DOI: https://doi.org/10.1016/j.jclepro.2016.05.111

DIAS, M. V. X.; HADDAD, J.; HORTA NOGUEIRA, L.; COSTA BORTONI, E.; PASSOS DA CRUZ, R. A.; AKIRA YAMACHITA, R.; GONCALVES, J. L. The impact on electricity demand and emissions due to the introduction of electric cars in the São Paulo Power System. *Energy Policy,* 2014, 65(0301-4215), 298–304. DOI: https://doi.org/10.1016/j.enpol.2013.09.052

DOE. Analytical evidence to support Guyana green economy. *Government of Guyana, Department of Energy,* 2019. https://www.doe.gov.gy/published/document/5cd1d69fe5569929a69b35b0

DOUCETTE, R. T.; MCCULLOCH, M. D. Modeling the CO_2 emissions from battery electric vehicles. *Energy Policy,* 2011, 39, 803-811. DOI:https://doi.org/10.1016/j.enpol.2010.10.054

DULAL, H. B.; BRODNIG, G.; ONORIOSE, C. G. Climate change mitigation in the transport sector through urban planning: A review. *Habitat International,* 2011, 35(3), 494–500. DOI: https://doi.org/10.1016/j.habitatint.2011.02.001

ECCARIUS, T.; LU, C. Powered two-wheelers for sustainable mobility: A review of consumer adoption of electric motorcycles. *International Journal of Sustainable Transportation,* 2020, 14, 215-231. DOI: https://doi.10.1080/15568318.2018.1540735

EDMUNDS. Cheapest electric cars: Most affordable EVs for 2022. 2022. https://www.edmunds.com/electric-car/articles/cheapest-electric-cars/

EGBUE, O.; LONG, S. Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy,* 2012, 48, 717-729. DOI: https://doi.org/10.1016/j.enpol.2012.06.009

FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY. Investigating electric 2 & 3 wheelers into existing urban transport system in developing countries. 2022. https://www.international-climate-initiative.com/en/details/project/integrating-electric-2-3wheelers-into-existing-urban-transport-systems-in-developing-countries-17_I_288-2851

GE, A. Electric Vehicle Regulation and Law in China. 2022. https://cms.law/en/int/expert-guides/cms-expert-guide-to-electric-vehicles/china

GEAR, L.; EDMONSON, J. Electric two-wheelers, 2022, 2021-2041. https://escooternerds.com/electric-scooter-questions/

GERBER, M., P.; TEIXEIRA, A. C.; MENDES, F.; HAWKES, A.; MOUETTE, D. Assessment of greenhousegasesandpollutantemissionsintheroadfreightTransportSector:ACasestudyfor São Paulo State, Brazil. *Energies,* 2020, 13(20), 1-26. DOI: https://doi.org/10.3390/en13205433

GHOSH, A. Possibilities and challenges for the inclusion of the electric vehicle (EV) to reduce the carbon footprint in the transport sector: A Review. *Energies,* 2020, 13(10), 1-22 DOI: https://doi.org/10.3390/en13102602

GIRARD, A.; ROBERTS, C.; SIMON, F., ORDOÑEZ, J. Solar electricity production and taxi electrical vehicle conversion in Chile. *Journal of Cleaner Production*, 2019, 210, 1261–1269. DOI: https://doi.org/10.1016/j.jclepro.2018.11.092

GONZÁLEZ, G. L.; SIAVICHAY, E.; ESPINOZA, L. J. Impact of EV fast charging stations on the power distribution network of a Latin American intermediate city. *Renewable and Sustainable Energy Reviews,* 2019, 107, 309-318. https://www.sciencedirect.com/science/article/pii/S1364032119301509

GOVERNMENT OF BARBADOS. National energy policy for Barbados. 2019. https://sandbox.7scorp.com/nrd2020/download/nationalenergypolicy20192030/?wpdmdl=3330&refresh=619116a316dc51636898467

GOVERNMENT OF GUYANA. *LCDS*. 2016. https://www.lcds.gov.gy/index.php/press-releases/item/75-guyana-ratifies-united-nations-framework-convention-on-climate-change-paris-agreement

GOVERNMENT OF GUYANA. Draft low carbon development strategy 2030. 2021. https://lcds.gov.gy/wp-content/uploads/2021/10/LCDS-2030-Final-DRAFT-for-consultation-min.pdf

GUIDE TO CHINESE CLIMATE POLICY. (n.d.). Electric vehicles. https://chineseclimatepolicy.energypolicy.columbia.edu/en/electric-vehicles

GUYANA CHRONICLE. Electric bike, an electrifying new trend, 2021a. https://guyanachronicle.com/2021/04/07/electric-bike-an-electrifying-new-trend/

GUYANA CHRONICLE. Guyanese to be trained to function in low-carbon economy. 2021b. https://guyanachronicle.com/2021/11/21/guyanese-to-be-trained-to-function-in-low-carbon-economy/

GUYANA CHRONICLE. Children under 16 will be barred from using electric bikes. 2022. https://guyanachronicle.com/2022/03/14/children-under-16-will-be-barred-from-using-electric-bikes/

GUYANA ENERGY AGENCY. Proposal for electrical vehicle charging station:Electric vehicle charging station at Giftland Mall (Unpublished Report). Georgetown, Guyana. 2020a.

GUYANA ENERGY AGENCY. Proposal for electrical vehicle charging station (Unpublished Report). Georgetown, Guyana. 2020b.

GUYANA LANDS AND SURVEYS COMMISSION. (n.d.). Natural Regions. https://factpage.glsc.gov.gy/natural-regions/

GUYANA POWER & LIGHT. Development and expansion programme. 2016. https://gplinc.com/pl/plc/media/DE-Programme-2016-2020.pdf

GUYANA REVENUE AUTHORITY. Exemptions on electric motor vehicles. 2020. https://www.gra.gov.gy/exemptions-on-electric-motor-vehicles/

HANNAN, M. A.; AZIDIN, F. A., MOHAMED, A. Hybrid electric vehicles and their challenges: A review. *Renewable and Sustainable Energy Reviews*, 2014, 29, 135-150. DOI: https://doi.org/10.1016/j.rser.2013.08.097

HARDMAN, S.; CHANDAN, A.; TAL, G., TURRENTINE, T. The effectiveness of financial purchase incentives for battery electric vehicles – A review of the evidence. *Renewable and Sustainable Energy Reviews*, 2017, 80, 1100-1111. DOI: https://doi.org/10.1016/j.rser.2017.05.255

HARDMAN, S. (Understanding the impact of reoccurring and non-financial incentives on plug-in electric vehicle adoption – A review. *Transportation Research Part A: Policy and Practice*, 2019, 119, 1-14. DOI: https://doi.org/10.1016/j.tra.2018.11.002

HICKEY, C.; WEIS, T. The challenge of climate change adaptation in Guyana. *Climate and Development*, 2012, 4(1), 66-74. DOI: https://doi:10.1080/17565529.2012.661036

HOEKMAN, S. K. Review of nitrous oxide (N2O) emissions from motor vehicles. *SAE International Journal of Fuels & Lubricants*, 2020, 13(1), 79–98. DOI: https://doi.org/10.4271/04-13-01-0005

HOROWITZ, A. C. Paris agreement. International legal materials, 2016, 55(4), 740–755. http://www.jstor.org/stable/10.5305/intelegamate.55.4.0740

IEA. Global EV outlook 2019 – Analysis. 2019. https://www.iea.org/fuels-and-technologies/electric-vehicles

IUCN. Global Policy. 2021. https://www.iucn.org/theme/global-policy/our-work/united-nations-framework-convention-climate-change-unfccc

JOCHEM, P.; DOLL, C., FICHTNER, W. External costs of electric vehicles. *Transportation Research Part D: Transport and Environment*, 2016, 60-76. DOI: https://doi.org/10.1016/j.trd.2015.09.022

JONES, L. R.; CHERRY, C. R.; VU, T. A., NGUYEN, Q. N. The effect of incentives and technology on the adoption of electric motorcycles: A stated choice experiment in Vietnam. TRANSPORTATION RESEARCH PART A: Policy and Practice, 2013, 57, 1-11. DOI: https://doi.org/10.1016/j.tra.2013.09.003

JUAN, A. A.; MENDEZ, C. A.; FAULIN, J.; DE ARMAS, J., GRASMAN, S. E. Electric vehicles in logistics and transportation: A Survey on emerging environmental, strategic, and operational challenges. *Energies*, 2016, 9(2), 1-21. DOI: https://doi.org/10.3390/en9020086

KAM, M.; VAN SARK, W. Smart charging of electric vehicles with photovoltaic power and vehicle-to-grid technology in a microgrid; A case study. *Applied Energy*, 2015, 20-30. DOI: https://doi.org/10.1016/j.apenergy.2015.04.092

KAMEYAMA, Y.; KUBOTA, I. What are the "objectives" meant to be? A comparative study of multilateral environmental agreements on articles on objectives, with primary attention on the United Nations Framework Convention on Climate Change. *Environmental Economics & Policy Studies*, 2010, 11(1–4), 1–17. DOI: https://doi.org/10.1007/s10018-009-0158-5

KANE, M. US Electric Car Prices: Cheapest To Most Expensive. *Insideevs*. 2022. https://insideevs.com/news/565883/electric-car-prices-us-20220207/

KANURI, C.; MULUKUTLA, P., & RAO, R. A review of state government policies for electric mobility. 2021. https://www.wricitiesindia.org/sites/default/files/Executive_Summary_EV_State_Policy.pdf

KESSIDES, I. N. Chaos in power: Pakistan's electricity crisis. *Energy Policy*, 2013, 55(0301-4215), 271–285. DOI: https://doi.org/10.1016/j.enpol.2012.12.005

KIM, B.; PARK, J. B., KIM, D. J. A study on the power line operation strategy by the energy storage system to ensure hosting capacity of distribution feeder with electrical vehicle charging infrastructure. *Energies*, 2021, 14(21), 1-17. DOI: https://doi.org/10.3390/en14216976

KOMORSKA, I.; PUCHALSKI, A.; NIEWCZAS, A.; ŚLĘZAK, M.; SZCZEPAŃSKI, T., TRIBIOLI, L. Adaptive driving cycles of EVs for reducing energy consumption. *Energies,* 2021, 14(9), 1-18. DOI: https://doi.org/10.3390/en14092592

KOŃCZAK, S. A.; HAGENZIEKER, M., WEE, B. V. Traffic sounds and cycling safety: The use of electronic devices by cyclists and the quietness of hybrid and electric cars. *Transport Reviews,* 2015 35(4), 422-444. DOI: https://doi:10.1080/01441647.2015.1017750

KOSTOPOULOS, D. E.; SPYROPOULOS, C. G., KALDELLIS, K. J. Real-world study for the optimal charging of electric vehicles. *Energy Reports,* 2020, 6, 418-426. DOI: https://doi.org/10.1016/j.egyr.2019.12.008

LIAQUAT, A. M.; KALAM, M. A.; MASJUKI, H. H., JAYED, M. H. Potential emissions reduction in road transport sector using biofuel in developing countries. *Atmospheric Environment,* 2010, 44(32), 3869–3877. DOI: https://doi.org/10.1016/j.atmosenv.2010.07.003

LIU, Z.; HAO, H.; CHENG, X., ZHAO, F. Critical issues of energy efficient and new energy vehicles development in China. *Energy Policy,* 2018, 115, 92-97. DOI: doi:https://doi.org/10.1016/j.enpol.2018.01.006

LOPES, J. A. P.; SOARES, F. J., ALMEIDA, P. M. R. Integration of electric vehicles in the electric power system. *Proceedings of the IEEE,* 2011, 99, 168-183. DOI: https://doi:10.1109/JPROC.2010.2066250

MAJUMDAR, D.; MAJUMDER, A.; JASH, T. Performance of low speed electric two-wheelers in the urban traffic conditions: A case study in Kolkata. *Energy Procedia*, 2016, 238-244. DOI: https://doi.org/10.1016/j.egypro.2016.11.190

MANRÍQUEZ, F.; SAUMA, E.; AGUADO, J.; DE LA TORRE, S.; CONTRERAS, J. The impact of electric vehicle charging schemes in power system expansion planning. *Applied Energy,* 2020, 262, 1–15. DOI: https://doi.org/10.1016/j.apenergy.2020.114527

MENDOZA, J. M. F.; JOSA, A.; RIERADEVALL, J.; GABARRELL, X. Environmental impact of public charging facilities. *Journal of Industrial ecology,* 2015, 20 (1), 54-66. DOI: https://doi.org/10.1111/jiec.12270

NEWSROOM. *Energy Agency to recommend electric vehicle for every Gov't ministry, agency*. 2020. Retrieved November 09, 2021, from. https://newsroom.gy/2020/02/20/energy-agency-to-recommend-electric-vehicle-for-every-govt-ministry-agency/

NEWSROOM. *More than 100 electric vehicles here; tender out for charging stations.* 2022. Retrieved April. 25, 2022, from https://newsroom.gy/2022/04/22/more-than-100-electric-vehicles-here-tender-out-for-charging-stations/

ORF. *Four policy issues to consider for electric vehicles in India*. 2021. https://www.orfonline.org/expert-speak/four-policy-issues-to-consider-for-electric-vehicles-in-india/

ORSI, F.; MURATORI, M.; ROCCO, M.; COLOMBO, E.; RIZZONI, G. A multi-dimensional well-to-wheels analysis of passenger vehicles in different regions: Primary energy consumption, CO2 emissions, and economic cost. *Applied Energy*, 2016, 169, 197-209. DOI: https://doi.org/10.1016/j.apenergy.2016.02.039

PASTELLIDES, S.; GERBER, S.; WANG, R. J.; KAMPER, M. (2022). Evaluation of drive cycle-based traction motor design strategies using gradient optimisation. *Energies,* 2022, 15(3),1-21. DOI: https://doi.org/10.3390/en15031095

PIERRI, E.; CIRILLO, V.; VIETOR, T.; SORRENTINO, M.; HREDZAK, B. (2021). Adopting a conversion design approach to maximize the energy density of battery packs in electric vehicles. *Energies,* 2021, 14(7), 1-24. DOI: https://doi.org/10.3390/en14071939

PULLIN, A.; STEWART, G. Guidelines for systematic review in environmental management. *Conservation Bbiology : The Journal of the Society for Conservation Biology,* 2006, 20, 1647-56. DOI: https://doi.org/10.1111/j.1523-1739.2006.00485.x

RAJPER, S. Z.; ALBRECHT, J. Prospects of electric vehicles in the developing countries: A literature review. *Sustainability,* 2020, 12(5), 1-19. DOI: http://dx.doi.org/10.3390/su12051906

REPUBLIC OF KENYA. Electric mobility in Kenya: The facts. 2019. https://www.changing-transport.org/wp-content/uploads/2019_Electric_Mobility_in_Kenya.pdf

RICHARDSON, D. B. Electric vehicles and the electric grid: A review of modeling approaches, impacts, and renewable energy integration *Renewable and Sustainable Energy Reviews,* 2013, 19, 247–254. DOI: https://doi.org/10.1016/j.rser.2012.11.042

RIETMANN, N.; LIEVEN, T. How policy measures succeeded to promote electric mobility – Worldwide review and outlook. *Journal of Cleaner Production,* 2019, 206, 66-75. DOI: https://doi.org/10.1016/j.jclepro.2018.09.121

RINKESH. Advantages and Disadvantages of Electric Cars. Conserve Energy Future. 2016. https://www.conserve-energy-future.com/advantages-and-disadvantages-of-electric-cars.php

RONANKI, D.; KELKAR, A.; WILLIAMSON, S. S. Extreme fast charging technology—Prospects to enhance sustainable electric transportation. *Energies,* 2019, 12(19), 1-7 DOI: http://dx.doi.org/10.3390/en12193721

ROSE, G. E-bikes and urban transportation: Emerging issues and unresolved questions. *Transportation,* 2012, 39, 81–96. DOI: https://doi.org/10.1007/s11116-011-9328-y

ROSE, S.; CORBIN, H. Prospects and constraints of rehabilitating and expanding Guyana's road network. *PAPERS DO NAEA, UEPA, Belém, Brazil,* 2017, 371, 1-18. https://periodicos.ufpa.br/index.php/pnaea/article/viewFile/11074/7661

SALLES-MARDONES, J., FLORES-MARADIAGA, A., & AHMED, M. A. Feasibility assessment of photovoltaic systems to save energy consumption in residential houses with electric vehicles in Chile. *Sustainability,* 2022, 14(9), 1-26. DOI: https://doi.org/10.3390/su14095377

SANGUESA, J. A.; TORRES-SANZ, V.; GARRIDO, P.; MARTINEZ, F. J.; MARQUEZ-BARJA, J. M. A review on electric vehicles: Technologies and challenges. *Smart Cities,* 2021, 4(1), 372–404. DOI: http://dx.doi.org/10.3390/smartcities4010022

SAXENA, S.; GOPAL, A.; PHADKE, A. Electrical consumption of two-, three- and four-wheel light-duty electric vehicles in India. *Applied Energy, Elsevier,* 2014, 115 C, 582-590. DOI: https://doi.10.1016/j.apenergy.2013.10.043

SHAO, S.; GUAN, W.; RAN, B.; HE, Z.; BI, J. Electric vehicle routing problem with charging time and variable. *Mathematics Problems In Engineering 2017*, 2017, 1-13. DOI: https://doi.org/10.1155/2017/5098183

SHEIKHI, A.; BAHRAMI, S. H.; RANJBAR, A. M.; ORAEE, H. Strategic charging method for plugged in hybrid electric vehicles in smart grids; A game theoretic approach. *International Journal of Electrical Power & Energy Systems*, 2013, 499-506. DOI: https://doi.org/10.1016/j.ijepes.2013.04.025

SIERZCHULA, W.; BAKKER, S.; MAAT K.; WEE, V. The influence of financial incentives and other socio-economic factors on electric vehicle adoption. *Energy Policy,* 2014, 68, 183-194. DOI: https://doi.org/10.1016/j.enpol.2014.01.043

SOHAIL, M. T.; ULLAH, S.; MAJEED, M. T.; USMAN, A. Pakistan management of green transportation and environmental pollution: a nonlinear ARDL analysis. *Environmental science and pollution research international,* 2021, 28(23), 29046–29055. DOI: https://doi.org/10.1007/s11356-021-12654-x

SPERLING, D.; SALON, D. Transportation in developing countries. 2002. https://www.c2es.org/wp-content/uploads/2002/05/transportation_overview.pdf

TAIBI, E.; FERNÁNDEZ DEL VALLE, C.; HOWELLS, M. Strategies for solar and wind integration by leveraging flexibility from electric vehicles: The Barbados case study. *Energy,* 2018, 164, 65–78. DOI: https://doi.org/10.1016/j.energy.2018.08.196

TEIXEIRA, C. A.; SODRÉ, R. J. Impacts of replacement of engine powered vehicles by electric vehicles on energy consumption and CO2 emissions. *Transportation Research Part D: Transport and Environment,* 2018, 59, 375-384. DOI: https://doi.org/10.1016/j.trd.2018.01.004

TUMMERS, L . Public policy and behavior hange. *Public Admin Rev,* 2019, 79(6), 925-930. DOI: https://doi.org/10.1111/puar.13109

UNEP. Electric two and three wheelers. Clean air and reduced greenhouse gas emissions with electric two and three wheelers. 2022. https://www.unep.org/explore-topics/transport/what-we-do/electric-mobility/electric-two-and-three-wheelers

UNEP. Electric mobility: Status in Latin America and the Caribbean and opportunities for regional. 2019. https://movelatam.org/wp-content/uploads/2020/09/Report-of-Electric-Mobility-in-Latin-America-and-the-Caribbean-2019-LQ.pdf

U.S. Department Of Transportation. Transportation GHG Emissions and Trends. 2016. https://www.transportation.gov/sustainability/climate/transportation-ghg-emissions-and-trends

UNDP. Guyana second national communication to the United Nations Framework Convention on Climate Change. 2012. https://unfccc.int/sites/default/files/resource/guync2.pdf

UNITED NATIONS. *World economic situation and prospects.* 2020. https://www.un.org/development/desa/dpad/wpcontent/uploads/sites/45/WESP2019_BOOK-ANNEX-en.pdf

UN-NOOR, F.; PADMANABAN, S.; MIHET-POPA, L.; MOLLAH, M.; HOSSAIN, E. A comprehensive study of key electric vehicle (EV) components, technologies, challenges, impacts, and future direction of development. *Energies,* 2017, 10(8),1-84. DOI: http://dx.doi.org/10.3390/en10081217

VISCIDI, L.; GRAHAM, N.; MADRIGA, M.; MASSON, M.; PRADO, V. R.; MONTICELLI, J. C. Electrified Islands: The Road to E-Mobility in the Caribbean. Washington, DC: Inter-American Dialogue, Inter-American Development Bank, Organization of American States. 2019. https://ecpamericas.org/wp-content/uploads/2020/12/Electrified-Islands-Final-2.pdf

WAHID, M. R.; BUDIMAN, B. A.; JOELIANTO, E.; AZIZ, M. A Review on Drive Train Technologies for Passenger Electric Vehicles. Energies, 2021, 14(20), 6742. DOI: https://doi.org/10.3390/en14206742

WEISS, M.; DEKKER, P.; MORO, A.; SCHOLZ, H.; PATEL, M. K. On the electrification of road transportation – A review of the environmental, economic, and social performance of electric two-wheelers. *Transportation Research Part D: Transport and Environment,* 2015, 41, 348-366. DOI: https://doi.org/10.1016/j.trd.2015.09.007

WOOD, S.; ROWENA, C. National energy efficiency monitoring report of Guyana. Project Documents, Santiago, Economic Commission for Latin America and the Caribbean (ECLAC). 2020. https://repositorio.cepal.org/bitstream/handle/11362/45476/1/S2000163_en.pdf

WORLD BANK. The World Bank annual report 2018. 2018. https://openknowledge.worldbank.org/handle/10986/30326

WORLD HEALTH ORGANIZATION. (2021, June 21). Road traffic injuries. Who.int; World Health Organization: WHO. 2021. https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries

WU, Y.; ZHANG, L. Can the development of electric vehicles reduce the emission of air pollutants and green house gases in developing countries? *Transportation Research Part D: Transport and Environmrnt,* 2017, 51, 129-145. DOI: https://doi.org/10.1016/j.trd.2016.12.007

YANG, C. Launching strategy for electric vehicles: Lessons from China and Taiwan. *Technological Forecasting and Social Change,* 2010, 77(5), 831-834. DOI: https://doi.org/10.1016/j.techfore.2010.01.010

ZAPAROLLI, D. Electric buses on the horizon. 2019. https://revistapesquisa.fapesp.br/en/electric-buses-on-the-horizon/

ZHANG, Y.; YU, Y.; ZOU, B. Analyzing public awareness and acceptance of alternative fuel vehicles in China : The Case of EV. *Energy Policy,* 2011, 39, 7015–7024. DOI: https://doi.org/10.1016/j.enpol.2011.07.055

ZHENG, Y.; JIAN, L. Smart charging algorithm of electric vehicles considering dynamic charging priority. *2016 IEEE International Conference on Information and Automation (ICIA),* 2016, 555-560. DOI: https://doi.10.1109/ICInfA.2016.7831884

ZHOU, G.; OU, X.; ZHANG, X. Development of electric vehicles use in China: A study from the perspective of life-cycle energy consumption and greenhouse gas emissions. *Energy Policy,* 2013, 59, 875-884. DOI: https://doi.org/10.1016/j.enpol.2013.04.057