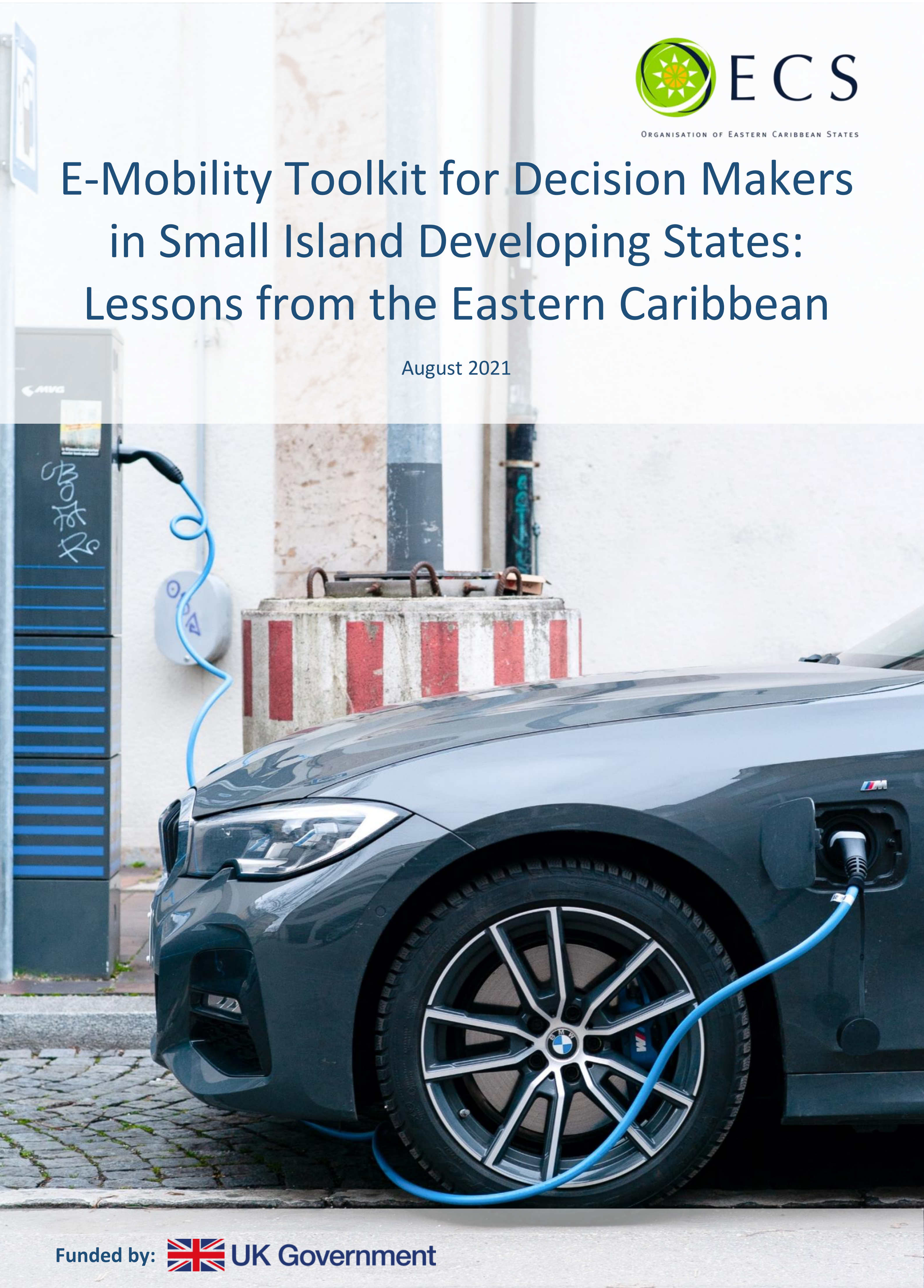
ORGANISATION OF EASTERN CARIBBEAN STATES

E-Mobility Toolkit for Decision Makers in Small Island Developing States: Lessons from the Eastern Caribbean

August 2021



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Glossary

Battery Electric Vehicle (BEV): A vehicle that purely uses chemical energy stored in rechargeable battery packs with no secondary source of energy.

Electric Vehicles (EVs): A vehicle powered through off-vehicle sources or with a battery, solar panels, fuel cells or an electric generator to convert fuel to electricity. For the purpose of this report, EVs refer to battery and plug-in electric vehicles and excludes hybrid vehicles.

Hybrid Electric Vehicle (HEV): A vehicle that has both a conventional internal combustion engine as well as an electric propulsion system. Here we distinguish between HEVs, which we understand as those without the capability of being externally charge. (See Plug-in Hybrid Electric Vehicles below.)

Internal Combustion Engine Vehicles (ICEVs): A vehicle in which the engine partially converts energy from the combustion of the fuel to work. Fuels may be either fossil- or biomass-based but are usually gasoline or diesel.

Neighbor effect: The tendency of a person to get directly or indirectly influenced by their neighborhood to induce a behavior or outcome.

Net social benefits: A representation of the total lifetime cost of a project or initiative in terms of the current monetary value.

Plug-in Hybrid Electric Vehicle (PHEV): A vehicle that uses battery-powered electricity that can be recharged by plugging it into a source of electricity as well as powered by an internal combustion engine.

Solar Photovoltaic (PV): PV devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material, called semiconductors.

1. Introduction

This Toolkit for Decision Makers on E-mobility in the Eastern Caribbean Region provides an assessment of options for fiscal incentives to encourage electric vehicle (EV) uptake, an exploration of non-fiscal incentives, and recommendations for an e-mobility policy at the regional level. In addition, a suite of tools has been developed for visualizing vehicle stock turnover of internal combustion engine vehicles (ICEVs) and electric vehicles (EVs), and for comparing lifetime costs between internal combustion engine vehicles (ICEVs) and EVs.

The objective of this Toolkit is to assist policymakers in identifying and selecting measures that can accelerate the decarbonization of the transportation sector in the Eastern Caribbean region. For the purposes of our analysis, we consider "EVs" to be those vehicles that are fully battery driven (BEVs). Hybrid electric vehicles (HEVs) that use a battery for only a limited amount of driving time and are not plug-in capable are considered to be ICEVs. Plug-in hybrid electric vehicles (PHEVs) are a grey area; often they end up being used in ICEV mode much more than in EV mode[1] since they have limited ranges of 20-40 miles, and have the additional disadvantage of added weight due to having both an internal combustion engine as well as sizable battery packs.

Following this objective, the Annex of this report contains references for more literature on the "neighbor effect" to nudge people into adopting a new technology, a "manual" for instructions to operate a Microsoft Excel costing tool, and cost-benefit exercises for practice. Similarly, two other tools described in this report are the 1) Electric Vehicle Visualization Tool and 2) model of payback between solar PV + EV vs. ICEVs and household electricity bills – both are available separately. Essentially, this report provides the narrative that binds the tools together with the analysis of potential fiscal incentives and policy recommendations.

2. Background on the Transition to E-mobility

For more than a century, transportation globally has been dominated by internal combustion engines powered by fossil fuels such as gasoline and diesel fuel, and to a much smaller extent, by biofuels. At the beginning of the 20th century, this outcome was not obvious, with battery-powered electric vehicles sharing the road with gasoline and even steam-powered cars and trucks. Many complex reasons led to the primacy of ICEVs even though the efficiency of combustion engines is very low, at approximately 20% conversion of energy in the fuel to vehicle motion. In contrast, battery electric vehicles can have efficiencies of 80% or more. Replacing ICEVs with electric vehicles can therefore lead to a significantly lower use of energy for the same level of service to the end user.

ICEVs unavoidably result in the emission of carbon dioxide (CO_2) at the tailpipe, along with other pollutants including noise. In addition, the inefficiency of the combustion engines means that the chemical energy in the fuels is mostly converted to heat that is given off to the surroundings. Battery electric vehicles result in no CO_2 emissions, very little heat, and much less noise. Of course, one must take carefully into account the source of electricity used to power the vehicle to understand the total impact on emissions reductions for the combined power and transport sectors. As a general rule, however, increasing efficiency of ICEVs can lead to incrementally lower CO_2 emissions over time, whereas BEVs coupled with renewable energy sources can, in principle, lead to emissions reductions toward zero. Left out of this discussion are the life-cycle energy use and emissions from manufacturing

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[1] (Plötz, et al. 2020)

of vehicles, both for ICEVs and BEVs; these are of less direct relevance for the Caribbean, with no production facilities.

Globally, electric vehicles (EVs), including full battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are gaining traction due to their multiple environmental, societal and health benefits. While the transition to electric mobility is still in an early phase in most countries, the EV fleet is expanding at a rapid pace in others. Reduction in the cost of batteries, increase in the installation of EV infrastructure, and effective policies have helped in the rapid growth of EVs.[2] In 2019, EV sales reached 2.2 million, the highest ever share in the global car market at 2.6%.

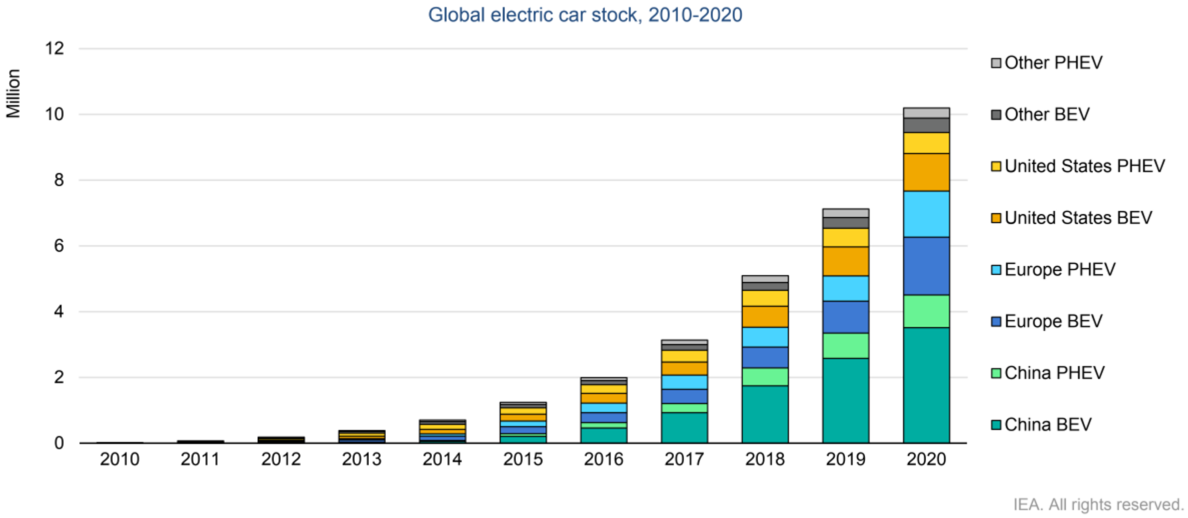

Figure 1 The stock of electric vehicles of all types has been growing rapidly over the past decade, even during the "pandemic year" 2020. (From IEA Global EV Outlook 2021)

In 2020, sales of electric vehicles continue to grow:[3] a 43% increase compared to 2019 and representing 1% of vehicle stock.[4] Overall, 3 million new electric cars were registered in 2020; Europe led this with 1.4 million registrations, followed by China with 1.2 million registrations and 295,000 electric vehicles in the USA.[5]

While the number of EVs may currently not be a large share of sales, it is ten times more than just six years ago, doubling in volume roughly every two years. According to the International Energy Agency's (IEA) recently released roadmap for achieving the Paris Agreement's 1.5°C target,[6] the share of electric vehicle sales must reach 60% globally by 2030 and sales of new internal combustion engine vehicles (ICEVs) must be phased out globally by 2035.

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[2] Global EV Outlook (2020).

[3] "As the Covid-19 crisis hammers the auto industry, electric cars remain a bright spot", IEA (18 May 2020).

[4] "Global Plug-in Vehicles Sales Reached over 3.2 Million in 2020", EV Volumes (2020).

[5] "Trends and developments in electric vehicle markets", Global EV Outlook (2021).

[6] Net Zero by 2050, IEA, 2021.

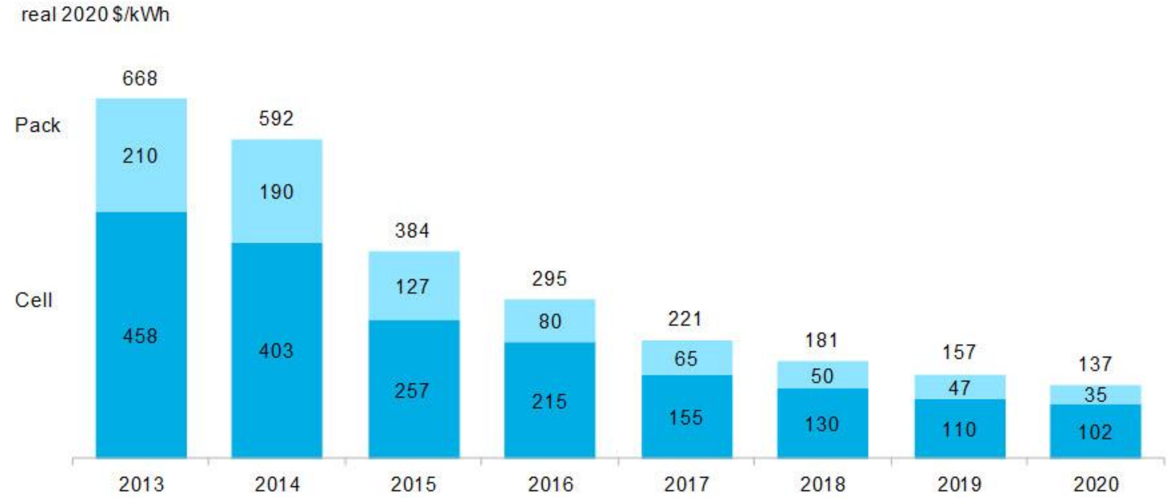
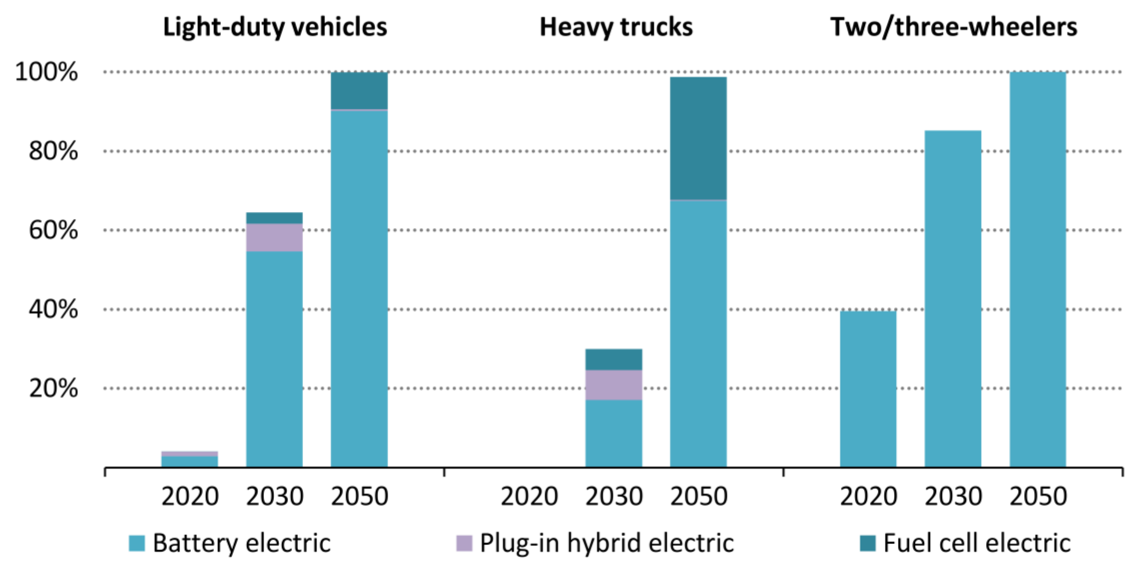


Figure 2 Volume-weighted average pack and cell price split. Battery costs have decreased by 80% in the past seven years. (From: Bloomberg New Energy Finance https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/)

The transition to e-mobility will accelerate over time with technological innovation and the cost for parts decreasing at economies of scale. Figure 2 shows the decreasing trend of batteries, which tends to be one of the more expensive parts of an EV. Furthermore, as EVs gain more popularity in the consumer base, parts of old EVs can be refurbished and sourced for newer EVs.



IEA. All rights reserved.

Sales of battery electric, plug-in hybrid and fuel cell electric vehicles soar globally

Note: Light-duty vehicles = passenger cars and vans; Heavy trucks = medium- and heavy-freight trucks.

Figure 3 (From IEA NZE2050 Report, Fig. 3.23) – Shares of EVs in total vehicle sales for a scenario that meets the Paris Agreement 1.5°C long-term temperature goal.

These global trends form the backdrop for this analysis of electric vehicle trends and goals in the Eastern Caribbean region. With many automobile manufacturers having announced target dates for phasing out production of ICEVs that fall in the 2030s, the Caribbean region faces at least two challenges that arise from the dynamics in other, larger countries. First, the infrastructure for vehicle electrification will have to be built out in parallel with increasing sales of vehicles. If global trends are moving toward a decreasing fraction of ICEVs being manufactured, this will necessarily impact the type of vehicles available in the Caribbean.

The second, perhaps more challenging area will be that of policies needed to control the import of both ICEVs "discarded" from other countries as used vehicles as they themselves transition to EVs, and the incentives and policies needed to encourage the uptake of EVs in the Caribbean region. Although EVs are becoming more affordable over time, they are still more expensive in up-front cost than comparable ICEVs. Balancing this to some extent is the lower operating cost of EVs, even in a region like the Caribbean with relatively high electricity prices.

With no known indigenous fossil fuel source, the transport sector along with the electricity sector currently both rely entirely on imported fossil fuels, thus making Eastern Caribbean SIDS vulnerable to international oil market fluctuations. In 2016, the International Monetary Fund (IMF) estimated that the transport sector accounted for 36% of the total primary energy consumed in the Caribbean Community (CARICOM), which exceeds the global average.[7] Transitioning to electric vehicles can potentially help the Caribbean countries lower their transport emissions and reduce their vulnerability to international oil markets. On the other hand, import duties on fuels make up a significant source of revenue for many countries, income that will decrease over time as EV stocks increase; this dynamic points again to the need for long-term planning initiatives to ensure a successful transition.

3. Cost-Benefit Analysis Tool

A Cost-Benefit Analysis (CBA) tool has been developed to help policy-makers decide on e-mobility interventions based on quantifiable indicators as found in a CBA that includes Net Social Benefits and Benefit/Cost ratios with the possibility to compare different scenarios.

The tool includes a model manual found in

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[7] Promoting energy efficiency in government transportation systems – A transition roadmap and criteria for a readiness analysis, ECLAC, 2017.

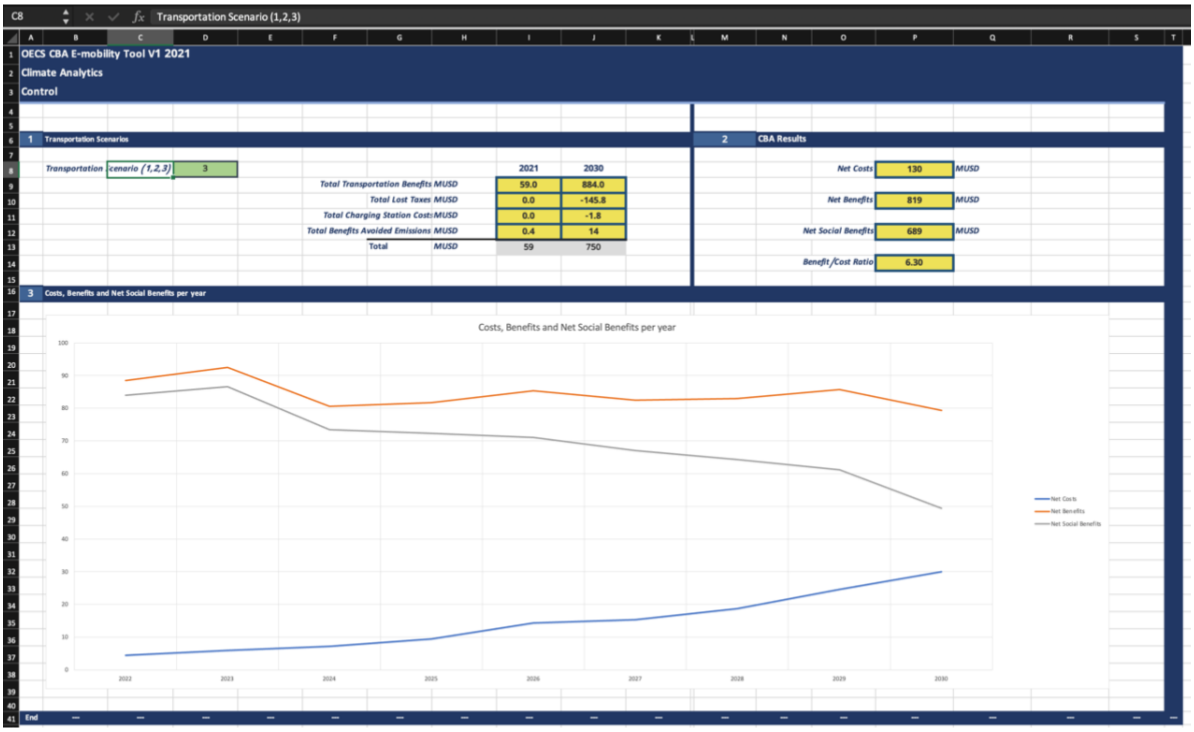
Annex 2 – CBA Tool Manual and some exercises to help the user become familiar with the functionalities of the model in Annex 3 – CBA Toolkit Exercises.

This tool has the possibility to program 3 different scenarios and it calculates different types of costs and benefits in real USD and in net present value which include:

- Costs from lost revenues from lower taxation schemes for electric vehicles
- Costs from electric vehicles charging infrastructure
- Benefits from taxes collected by vehicles sold and fuel consumption for Internal Combustion Engine vehicles
- Benefits from avoided emissions using the social cost of carbon

Figure 4 shows a screenshot of the model results in the *Control* sheet as it can be seen in the model. In this same sheet, the different scenarios can be chosen by changing the value found in cell **D8**. More detailed instructions on the inputs and how to change them can be found in

Annex 2 – CBA Tool Manual.


C8 Transportation Scenario (1,2,3)

OECS CBA E-mobility Tool V1 2021
Climate Analytics
Control

1 Transportation Scenarios

Transportation Scenario (1,2,3): 3

		2021	2030
Total Transportation Benefits	MUSD	59.0	884.0
Total Lost Taxes	MUSD	0.0	-145.8
Total Charging Station Costs	MUSD	0.0	-1.8
Total Benefits Avoided Emissions	MUSD	0.4	14
Total	MUSD	59	750

2 CBA Results

Net Costs	130	MUSD
Net Benefits	819	MUSD
Net Social Benefits	689	MUSD
Benefit/Cost Ratio	6.30	

3 Costs, Benefits and Net Social Benefits per year

End

Figure 4 Control sheet as seen in the model with the results from scenario number three (3).

4. Fiscal Incentives

Fiscal incentives have historically been a major driver for encouraging adoption of EVs. In Norway, the country with the world's highest EV market share, there have been aggressive fiscal incentives to promote electric vehicles. The historical reliance on incentives can be seen as well, for example in the US State of Georgia, where a repeal of a state-level tax credit for EVs caused an 80% drop in their sales (Yang, et al. 2016).

While Norway has one advanced model for aggressive EV incentivization, the International Council on Clean Transportation (ICCT) (Yang, et al. 2016) has categorized four major incentive types for electric vehicles: income tax credit; vehicle purchase rebate; one-time vehicle tax reduction; and annual vehicle tax reduction. These are explained in greater detail in Table 1.

Table 1 General Electric Vehicle Incentive Types and Their Timing

Category	Type	Consumer value	Typical timing	Examples
Subsidy	Income tax credit	A reduction of annual consumer taxes, for example, from $2,500 - $7,500 per vehicle, that would otherwise be paid (when there is tax liability)	End of tax year	U.S.
	Vehicle purchase rebate	A check, typically $1,000-$5,000 per vehicle, provided by government to vehicle consumer within a set amount of time	Within several months of vehicle transaction	California, Québec, France

Tax reduction	One-time vehicle tax reduction	A reduction in vehicle-related taxes, ranging from 5% up to 80% of the original vehicle retail price	Around time of vehicle purchase	Norway, Washington
	Annual vehicle tax reduction	A reduction in vehicle-related taxes, generally ranging from $100-$500 per vehicle per year	Once per year	Germany

Source: (Yang, et al. 2016)

Studies have found that incentives reducing point-of-sale purchase prices of electric vehicles (such as immediate rebates or one-time vehicle tax reductions) are more effective than those that provide future benefits (i.e. mail-in rebates, income tax credits, annual vehicle tax reductions, etc.). Point-of-sale incentives reduce uncertainty, and are not affected by consumers' discounting of future benefits (Yang, et al. 2016). They also lead to lower upfront cost requirements for purchasing a new vehicle, which can be particularly valuable in an environment where interest rates are high or loan terms short.

This focus on upfront costs is borne out by the economics of EV ownership. Electric vehicles currently cost more than ICEVs. However, they tend to have lower operation and maintenance costs, partly due to having fewer moving parts. Operating costs ("fuel" costs) are typically lower, even in environments with high electricity costs. This can lead to an overall total cost of ownership that is significantly lower than that of an ICEV. Additionally, EVs come with other non-financial benefits, such as better performance and the ability to charge at home.

4.1 Fiscal Incentives for EVs in the Caribbean

Governments of OECS member countries can potentially use any of the previously identified categories of fiscal incentive for EVs. An OECS country government could provide an income tax credit to consumers on vehicles following their purchase. In this circumstance, the consumer would likely need to be able to cover the upfront cost of the vehicle, either through savings or financing, and would need to have a sufficiently high income-tax burden to allow for the use of the tax credit. The consumer would also need to have the financial security to be able to wait until the end of the tax year and the processing of their taxes to receive the tax credit, and then would need to have confidence in the stability of the incentive.

This approach may be less appropriate to many countries in the OECS. While most OECS countries have income tax rates of 25-45 percent, some member states, such as Antigua and Barbuda, and St. Kitts and Nevis, do not have any income tax (though St. Kitts applies a "social service" fee to wages) (Gomez Osorio, Waithe and Blenman 2017). In general, as can be seen in Figure 5, Caribbean countries only receive a small share of their revenue from income taxes, and receive most of their income through taxes on goods and services. Furthermore, the higher upfront investment would likely prevent the lower and middle income class from using the incentive and in consequence spend taxpayer money for the benefit of the higher income class consumers.

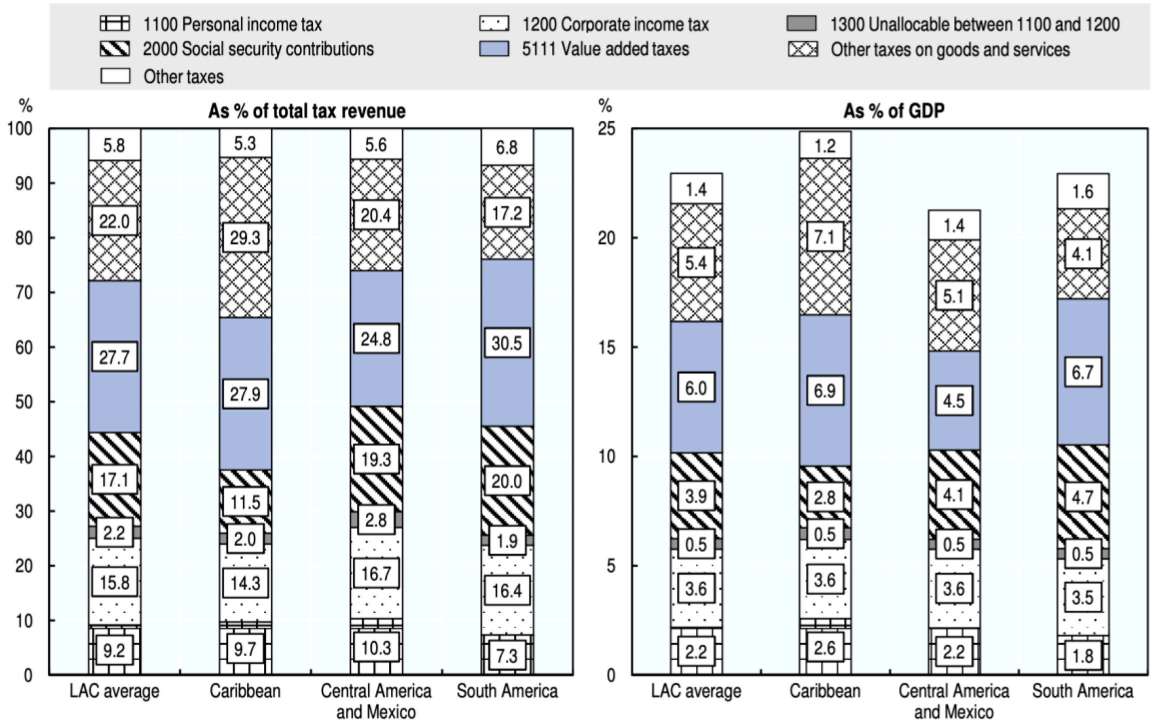


Figure 5 Average Tax Structure in the LAC region and Subregions, 2019

Source: (OECD et al. 2021)

There are two tax reduction approaches identified in Table 1: a) One-time vehicle tax reduction; and b) Annual vehicle tax reduction. While either of these can be applied, a one-time vehicle tax reduction, at the time of purchase, would appear to be the more appropriate choice based on the literature reviewed. First, as noted above, incentives that immediately reduce the upfront cost of electric vehicles are more effective. Additionally, a perception of high costs over time is not a significant barrier to the acquisition of EVs – as noted above, they have lower fuel and maintenance costs.

A vehicle purchase rebate does not necessarily require the same income tax burden, and has a shorter delay, but it still has a delay following the purchase of the vehicle, which needs to be made in full, including all applicable taxes. Such an approach may be more attractive than an income tax credit, and available to a larger share of consumers – consumers who can afford to wait for an incentive for less than a year and those who do not have a sufficiently high tax burden. Vehicle purchase rebates are preferable because they are realized by consumers closer to the time of purchase than tax deductions.

To reduce the upfront costs of vehicles through tax policy in the OECS countries likely means to adjust the import duties. No OECS country is a producer of automobiles, so all vehicles are imported. Vehicle import duties in the Caribbean can be substantial and can significantly add to the cost of a vehicle. As a result, selective reduction in import duties that favours EVs can be a powerful incentive. Governments will have to determine the balance between offering financial incentives for making the switch to EVs, potential for lost revenue both from vehicle import duties and fuel import duties, and their commitments to reduce emissions. In addition, fairness issues for all segments of the population will play a role in constructing subsidy programs.

4.1.1 Using import duties to reach upfront cost parity

A Toyota Corolla, a relatively popular vehicle in some Caribbean countries, has a Manufacturer's Suggested Retail Price (MSRP) of USD 20,025 new.[8] The latest Nissan Leaf, a relatively inexpensive electric vehicle, has an MSRP of USD 31,670. If the Corolla had a 58% import duty and the Leaf a 0% import duty, the upfront cost of the two vehicles would be comparable.

However, not all vehicles are purchased new. While this is the case for both EVs and ICEVs, the scale of the market for ICEVs is currently *much* larger than that for EVs. Consequently, in the near future every year many times more second-hand ICEVs are likely to be available relative to EVs. As a result, it is likely that new EVs will need to compete with *used* ICEVs.

Considering the same vehicle models as above, a 2017 Toyota Corolla (approximately 4 years old) can be estimated to cost USD 15,000 – 16,000. A 111% import duty on a USD 15,000 vehicle would make the total upfront cost equal to that of a new Nissan Leaf with no import duty.

Of course, reducing EV import duties to zero is not the only option to reduce the upfront cost differential between an EV and an ICEV.

Alternatively, the government may still charge import duties for EVs, but charge higher duties for ICEVs. Supposing the country is accustomed to charging a 50% import duty on a Corolla, that is a revenue of approximately USD 10,000 per vehicle. To get the same revenue from a Nissan Leaf purchase would require a duty of ~32%. This would result in a cost of USD 41,670 per vehicle. To make the upfront cost of a new Corolla equivalent would require an import duty of 108%. To make the upfront cost of a four-year-old Corolla equivalent would require an import duty of 178%. While such an approach would protect government revenue, it would also drive up the cost of purchasing a used vehicle.

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[8] Vehicles often have various types of incentives and people do not pay the full MSRP. On the other side, there are also costs associated with importation of vehicles. As a result, MSRP is unlikely to be a perfect estimate of the costs, but is the best basis for an apples-to-apples comparison.

By structuring incentives/policies appropriately, you can increase the market share of EVs. Though car sales did initially dip in 2020, it was an unprecendented year for EV sales. Even during the COVID-19 pandemic in that year, more than 10 million electric vehicles were on the world's roads with battery electric models driving the expansion.[1] EVs now account for 1% of the global vehicle stock share.[1] BEVs accounted for two-thirds of the new electric car registrations and two-thirds of the stock in 2020.[1] There is a distinction between all-electric vehicles (BEVs), PHEVs, and other "non-rechargeable" HEVs. In some countries, both EVs and HEVs receive similar or the same incentives, but the environmental and emissions impacts are different. In this report, the fiscal incentives discussed pertain to all-electric vehicles, or BEVs.

In Norway, for example, the Parliament set a goal that all new cars sold by 2025 should be zero-emission (electric or hydrogen).[1] They heavily subsidize all-electric vehicles, and in addition provide access to bus lanes and free municipal parking to EV drivers. Since 2017, municipalities have also implemented the 50% rule, meaning that counties and municipalities cannot charge more than 50% of the price for ICEVs on ferries, public parking and toll roads.[1] The market share of all electric vehicles in Norway hit 56% in March 2021, followed by PHEVs at 28.6%, and HEVs at 5.6%.[1]

Norway as a high-income country can afford to progressively subsidize electric vehicles, and the most popular EV model last year – the Tesla Model 3 – is not cheap. In vehicle markets in many countries BEV and PHEVs proved to be more resilient to COVID-19's economic downturn than the auto markets in general. Global BEVs and PHEVs deliveries increased by 43% year-on-year in 2020, while the global light vehicle market decreased by 14%.[1] Over the last decade, Figure 1 demonstrates that BEV and PHEV sales have been on the upward trend.

Box 1 An EV success story.

5. Non-fiscal Incentives

Many of the measures that we have considered thus far for encouraging adoption of new technologies are centered around financial incentives. Although standard economic theory starts from the premise that we are all rational actors seeking to maximize our economic well-being after weighing all relevant factors, it is clear that real human beings act under a variety of influences that go well beyond purely economic ones. Using Norway as an example – simply because that country has made the most progress in fostering adoption of EVs – it is not only reduced vehicle taxes and parking tolls that play a role in the strategy.

Given the novelty of EVs in the transportation fleet, the initial "range anxiety" of drivers plays an important part in hesitancy to adopt the new technology. Therefore, in parallel to incentives that reduce the cost of ownership of EVs, the importance of a dense network of charging infrastructure is crucial. In Norway, there are 16,000 charging points, 9% of the total in all of Europe, although Norway has less than 1% of Europe's population.[9] More directly relevant to the Caribbean, charging infrastructure in Barbados has been built out so that drivers are never more than a few kilometers from a charging point.[10] Considering the driving habits of most citizens and the size of most Eastern Caribbean islands, however, *home charging would nearly always be sufficient*. But the additional peace

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[9] (Wallbox 2021)

[10] (Ellsmoor 2018)

of mind that comes with knowing a charger is close by should not be underestimated, especially at early stages of adoption of EVs. Evidence suggests that "range anxiety"[11] decreases significantly as drivers become more familiar with their vehicles, and this is a psychological factor that will gradually dissipate with the phase-in of EVs at scale.

Another psychological effect that could potentially be used by governments to encourage adoption of EVs is that of the so-called "neighbor effect" in which the presence of a new technology in a given area makes it more likely that others will adopt the same technology. There have been numerous studies concerning EVs and the neighbor effect, partly because this is a new technology, but also because an EV in a driveway or in front of a house is a very visible object.[12]

Stepping back to examine the big picture, financial considerations are important, but if only payback times (as is often argued for EVs vs. ICEVs) were important, then everyone would drive only the cheapest and most fuel-efficient vehicle on the market. Consumers do *not* buy a sunroof, a fancy car stereo, or a BMW because the decision to do so will "pay off"; *many purchases are made simply because of personal preferences and the ability to pay among other reasons*. To a certain extent, one of the interventions that is necessary is to transform thinking about EVs – if they were the "coolest" cars on the market, a perception shaped by social values, advertising and other factors, then the additional economic cost would be less of an issue for many. In the end, however, even the economics do work out for EVs – over the lifetime of the vehicle the extra up-front cost does pay off, which cannot be said about any other type of extra vehicle cost.

In the case of hilly terrain, consumers fear that an electric powered vehicle may not have the same engine power as an internal combustion engine vehicle to traverse steep inclines. There is no evidence to support this belief, but it is a psychological barrier to adoption. In fact, some functionalities in EVs are superior to ICEVs, like their torque. An ICEV generates torque by burning fuel, causing combustion, then turning parts like the crankshaft. The energy is then transferred to the wheels of the vehicle via its transmission. On the other hand, EVs have fewer moving parts and have an "instant torque" since they generate the necessary force to turn the wheels of a vehicle through electric currents through a magnetic field. ICEVs are also heavier than an EV because of their larger motor, which adds resistance to the vehicle's ability to accelerate as quickly as an EV.

EVs can also regenerate electricity with their motors when driving downhill, while the potential energy in ICEVs only escapes as heat from their motors and brakes. In fact, EVs also have a regenerative braking feature that converts the kinetic energy from braking into electrical energy that recharges the battery of the vehicle. The converted electrical energy that is stored can extend the driving range by up to 10%.[13]

EVs vehicles are suitable for driving on the same inclines as ICEVs, but many consumers will not internalize this comparison until they see real-life proof. The "neighbor effect", seeing that someone in their close proximity is able to use EVs with the same functionality as ICEVs is important for wider consumer adoption of EVs. Furthermore, simple measures such as public demonstrations and "test drive and EV" days can help dispel concerns about the new technology.

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[11] (Wardlaw 2020)

[12] The same effect has been studied with respect to solar panels and how installations tend to cluster in neighborhoods (https://www.nature.com/articles/s41598-021-87714-w); an interesting combination would be that of solar panels, home chargers and EVs as technology units that could be promoted in tandem.

[13] (Chau 2014)

Especially in this early stage of EV adoption in the Eastern Caribbean, EVs may be more expensive than ICEVs even with fiscal incentives placing lower or zero taxes on them. This price disparity is especially true since EVs have not been as widespread in the market as ICEVs. Secondhand EVs are therefore a challenging find, and the upfront cost of purchasing an EV may be substantially higher for a consumer to eliminate this option. Over the long run, however, the lower electricity cost overpaying for gasoline and, and potential lower maintenance costs can result in lower total costs over the lifetime of the vehicle. For consumers that can afford this relatively higher cost vehicle and reap the long term benefits, this calculation may not be apparent without access to financial information and an estimation of the associated costs over the lifetime of the vehicle.

Some non-fiscal incentives can continue throughout the vehicle lifetime unlike one-time financial incentives for purchase. Table 2 highlights the existing non-fiscal incentives which are used by several countries in the world. The impact of these incentives differs between regions partially due to differences in traffic conditions, travel patterns, consumer preferences, and other local variations.

Table 2 Examples of non-fiscal incentives for EVs.

Non-fiscal Incentive	Examples
High occupany vehicles, bus or transit lane access	U.S., Germany, Norway
Free, discounted or preferential parking	London, Germany
Toll or road charge waivers or discounts	Norway, London
Licencing incentives – reduced or no licensing fee	China
Preferential tariffs for charging electric vehicles: lower cost of electricity when charging at off-peak hours	California

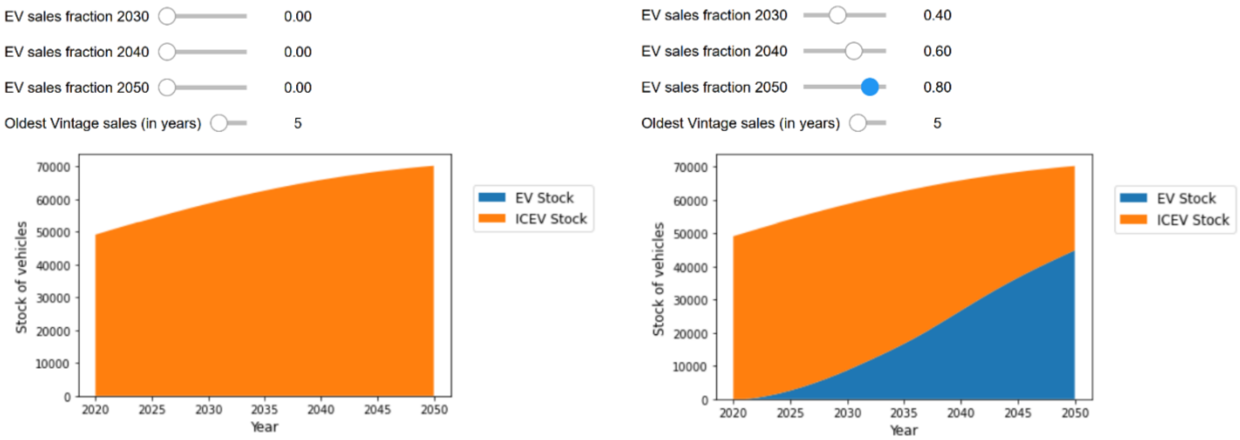
Source: (Scott 2019)

6. Electric Vehicle Visualization Tool

Climate Analytics has developed a simple interactive tool (https://share.streamlit.io/rjbrecha/oecs_e-mobility/main/Vehicle_Stock_Turnover_Gompertz.py) to help visualize the shift in sales and imports of vehicles from internal combustion engine vehicles (ICEVs) to electric vehicles (EVs) and how this shift will impact the stock of vehicles over time. This tool does not represent new research on the topic, but serves to emphasize the “inertia” of vehicle stocks due to the relatively long lifetimes of personal vehicles in the region. This tool will be hosted by Climate Analytics but available publicly. The tool development was not part of the initial Terms of Reference, but can be considered as an ancillary product that is relevant to and complements the current project.

The basic idea of the tool is explained here and static screenshots of the interactive tool are shown. The overarching goal of the tool is to relate the EV fraction of total vehicle sales or imports in a given year to the changing stock of both EVs and ICEVs in a given country. Of course, to model these dynamics a few basic sets of data are needed, including current stocks of vehicles by vintage, average lifetimes of vehicles, and historical data on the volume of vehicle sales each year. Not all of these data were available for all countries, so the initial version of the tool uses what might be considered a representative case for the OECS.

The starting point for the model is to provide as an input the current stock of vehicles, and to overlay this input with an estimate of the lifetimes of cars (how many vehicles are retired or scrapped each year). Then sales of new and imported vehicles in a given year was included, divided into EVs and ICEVs. We account for growth in the total number of vehicles according to an empirical relationship between a country's vehicle density (number per 1000 people) and the GDP per capita of the country. The interactive part of the tool allows a user to move a slider, thereby choosing the fraction of EV sales in years 2030, 2040 and 2050, and showing as an output the total stock of vehicles over time.


EV sales fraction 2030 0.00
EV sales fraction 2040 0.00
EV sales fraction 2050 0.00
Oldest Vintage sales (in years) 5

EV sales fraction 2030 0.40
EV sales fraction 2040 0.60
EV sales fraction 2050 0.80
Oldest Vintage sales (in years) 5

Figure 6 Stock of ICEVs and EVs in a representative OECS country case.

In Figure 7, two examples of the tool output are shown. On the left, no EVs are sold, so the sliders are set at 0 in all years. The total stock of vehicles increases somewhat over time, but all are ICEVs throughout the period. For the example on the right, increasing shares of EV sales are chosen, 40% in 2030, 60% in 2040 and 80% in 2050. The resulting share in the total stock of vehicles given by EVs grows more slowly, as can be seen by the blue area. Even with what might be seen to be a relatively aggressive target for EVs, the stock of EVs is less than two-thirds of the total vehicle stock by 2050. In effect, only total EV sales by 2030 leads to the result of a nearly 100% EV fleet by 2050.

Although not part of this tool, the overall greenhouse gas reduction benefits from switching to EVs will be given by a combination of the decarbonization of the power grid and the change to EVs. However, the decarbonization of the transport sector through other measures, such as combustion engine efficiency or a switch to biofuels, would be far more difficult to achieve. Thus the electrification of transport, although slow due to the inertia of the stock of ICEVs and their relatively long lifetimes, provides the most promising trajectory for reaching zero emissions in that sector.

7. Renewable Energy & Electric Vehicle Coupling

7.1 Sector coupling – EVs, electricity grid and distributed systems

In most Caribbean island countries, carbon dioxide emissions from fossil-fuel energy use are roughly evenly split between the power sector and the transportation sector. One of the keys to broad-based decarbonization over the course of the next few decades, not only in the Caribbean, will be the coupling of these two sectors through the use of electric vehicles.

Historically, most people have been passive consumers of electricity that is provided by a utility or other provider that procures supplies, builds and maintains generation and transmission infrastructure, ensures reliability and sends a bill to consumers each month. For end-users, the source of electricity has not been of primary interest, and the main contact with the electricity system is through the expectation that the lights turn on when a switch is flipped, and in turn by paying the resulting bill. This model is changing globally, to one in which traditional providers will increasingly be engaged in not only producing and transmitting electricity to passive consumers, but also managing and receiving power generated by distributed systems, *i.e.* interacting with producer-consumers or *prosumers.*

This shift in model is relevant for electric vehicle policies in the Caribbean especially because of the expectation that many more households and commercial entities, as well as governments, will be installing solar photovoltaic systems, and also be purchasing electric vehicles that will be charged on site. On the other hand, larger producers of variable renewable energy will be required to think about energy storage options such as batteries to compensate for that variability. Although the combination of solar pv, wind, conventional dispatchable power, battery storage, distributed generation and increased demand due to EVs may create a more complex system, there are also advantages that can be gained by a holistic set of planning measures that encompass both “traditional” electricity consumption sectors and transportation from the outset.

A specific example of possible linkages is that of vehicle-to-grid (V2G) interactions in which EVs at residences or from government fleets can be viewed as a variable and controllable resource for utilities to help stabilize and balance the grid.[14,15] Most personal vehicles are driven for only an hour or so a day and government vehicles or school buses are typically not used at night. Since charging times are short compared to the periods during which vehicles are parked, having a fraction of battery capacity available as a reserve for the grid could provide a valuable service. In addition, typical peak loads in the Caribbean are in the hours soon after sundown, such that battery storage of even a few hours can effectively shift electricity produced by sunlight to early evening hours, giving the rest of the night as time for charging during a period of overall lower demand.

The idea of the “smart grid” as described above is a relatively new concept in countries globally, and one that clearly will need a combination of legislative and regulatory frameworks, technological and infrastructure investments and upgrades, economic incentives and public education as to benefits (and any potential downsides) for individuals and the business community. Since many measures and policies globally are still in pilot phases, a selection of ideas that would also be relevant for countries in the OECS is presented in the following Table.

Measure	Location	Key impact or goal	Reference for further information
Managed charging	California, USA	Control timing of charging to align with RE availability and grid needs, while still satisfying customer needs.	WRI article BMW Charge Forward pilot program Southern Cal Edison, others
Charging with on-site RE	Various – also in the OECS	Solar PV parking canopies that offer charging stations	
Discount charging for peak RE times	California, USA Other locations	Encourage charging on weekdays and off-peak hours on weekends (solar maximum) and in evenings	WRI article Southern Cal Edison

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[14] (Fattori, Anglani and Muliere 2014)
[15] (Gay, Rogers and Shirley 2018)

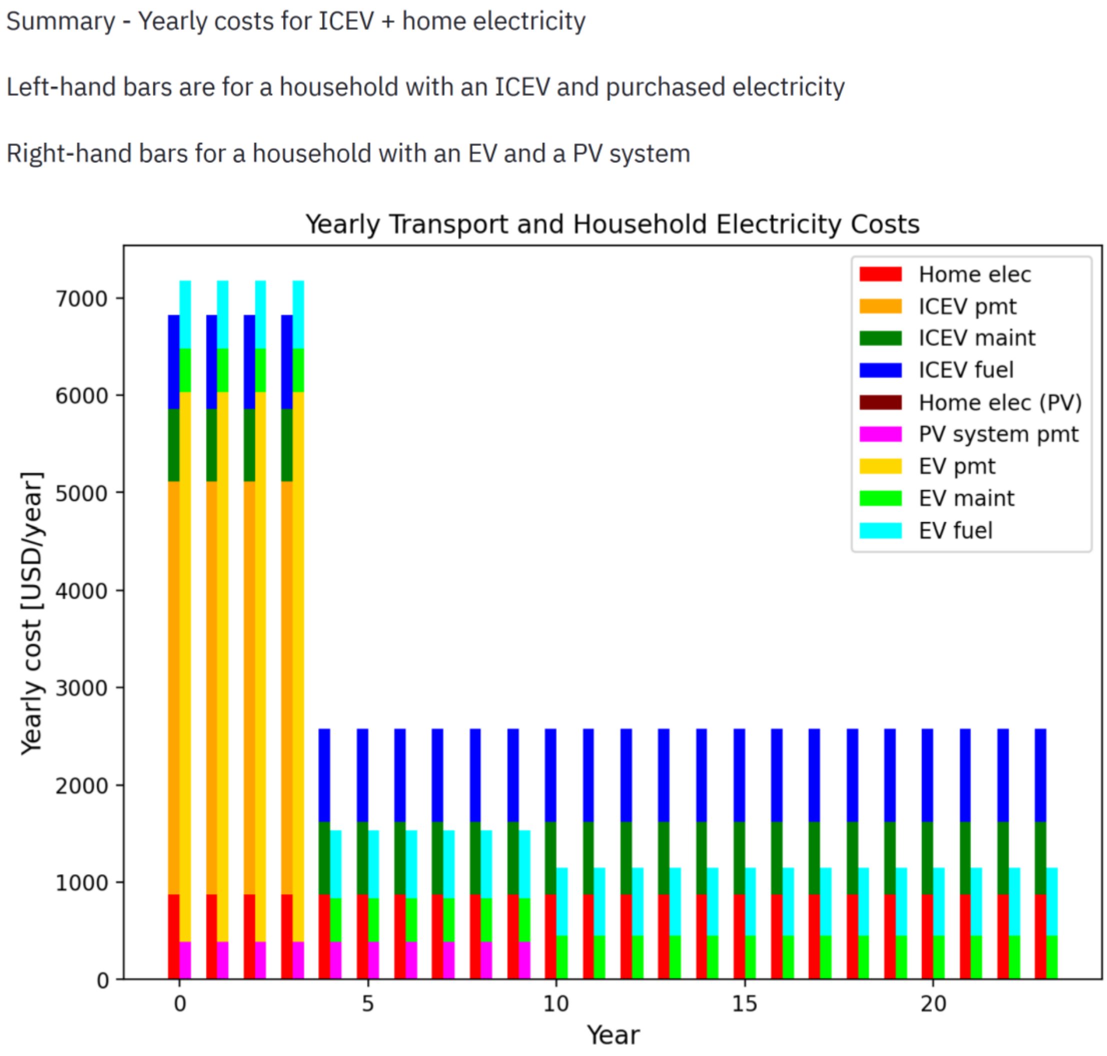
		(wind maximum); not between 4pm-9pm	
Charging networks	Various – also in the Caribbean	Companies offer broad charging networks, some that are also covered by 100% RE	WRI article EVgo (USA) Megapower, Barbados Xergy Energy (Jamaica)
Vehicle-to-Grid (V2G) for school buses	New York City, other pilots	Taking advantage of the relatively large size and low, regularly scheduled usage of (electric) school buses	New York City, Lion Electric Co. European examples
Utility focus on "customer experience"	General	If utilities want to "use" customer vehicles, focus has to be first on convenience, economic incentives	Utility Dive article
Virtual batteries	General	A version of demand management, financial incentives	JuiceNet enelX
Fleet charging to avoid demand charges	Massachusetts, USA	Taking advantage of shifting large fleet loads to reduce peak demand costs	WRI article II School bus pilot
Smart charging to avoid unnecessary distribution system upgrades	London, UK	Staggered and smart charging to avoid having demand get too high at one time	WRI article II UPS - London

7.2 Simple model of payback for solar PV + EV vs. ICEV and household electricity bills

Climate Analytics has put together another simple model to serve as a tool (https://share.streamlit.io/rjbrecha/oecs_e-mobility/main/PVplusEV.py) that can examine the potential advantages of coupling solar photovoltaic systems and electric vehicles. The starting point is a household with a typical electricity consumption and driving an ICEV a certain number of kilometers per year. Two scenarios are then contrasted. In the first, the household buys a new (or used) ICEV and the tool calculates monthly costs for the household to pay for its electricity use (unaffected by the vehicle) as well as monthly car, gasoline and repair payments. In the second choice, the household decides to purchase an electric vehicle and at the same time to install a solar photovoltaic system that is large enough to cover their yearly consumption, including the additional electricity needed by the EV.

The tool shows the total monthly or yearly expenses for a household's electricity and vehicle use, starting from the assumption that it is these total payment that will make a difference in most cases. Put simply, if policies and incentives can be found such that monthly expenses for electricity and travel costs for an EV and solar PV can be made equal to what those expenses are for grid electricity and an ICEV, the decision to make the switch will be more easily made. Parameters that can be investigated with this tool are loan terms and interest rates, direct subsidies in the form of a higher downpayment for the EV (lower loan amount). Although defaults are provided, different relative vehicle upfront costs can be entered, as well as PV system size and typical yearly electricity consumption. Once again, the tool is available publicly and hosted on an open platform. It was not part of the Terms of Reference to develop this tool, but its development was inspired by both this project and other work done by Climate Analytics in the Caribbean.

An example output is shown in Figure 7, for an EV costing $30,000 (XCD 81,000) vs. an ICEV with a cost of $20,000 (XCD 54,000),[16] each with a 4-year loan term at 5% interest rate. The difference here is that the EV owner also purchases a system large enough to cover all electricity demand on average during the year, and also receives a $5000 incentive for the EV. The results show that yearly payments during the loan period are slightly higher for the EV + PV system and significantly less for all following years, especially after the PV system loan is paid off after ten years. The tool can be used to explore the impact of different policies (subsidies or rebates, preferential interest rates or loan terms, etc.).



Summary - Yearly costs for ICEV + home electricity

Left-hand bars are for a household with an ICEV and purchased electricity

Right-hand bars for a household with an EV and a PV system

Figure 7 Total estimated yearly costs for a system with EVs + PV (right-hand stacked bars in each pair) vs. a system with ICEVs and home electricity (left-hand stacked bars for each pair), for 25years. The important first several years show that the combined EV + PV system might initially cost little more (with the subsidy assumed here) and then result in substantial savings to the consumer in future years.

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[16] Cost of ICEV and EV does not include import and excise duties levied by the country.

8. Recommendations for a Regional E-Mobility Policy

Following the identified gaps and recommendations from Deliverable 2 of this consultancy – Assessment of Transportation Policies in the Eastern Caribbean Region – and the incentives described above, this section will make recommendations for an Eastern Caribbean E-mobility Policy. As mentioned in Deliverable 2, there is a lack of policies at the country-level in the region pertaining to e-mobility. The hope for a regional policy is to have a trickle-down effect in which countries are nudged to develop EV policies.

As small island states, a coherent regional initiative to harmonize incentives and measures and the creation of a unified market can facilitate higher penetration of EVs in the region. A regional EV strategy can influence policies at the country-level especially because the Eastern Caribbean states analyzed for this review have similar characteristics. Such a collaboration can help countries reach an economy of scale to access EVs at prices that would otherwise be challenging to find. Such a regional collaboration can target the private sector and/or target cooperation between governments for regional EV projects that can gain support from multinational funding sources like the World Bank or the Global Environment Facility (GEF).

8.1 Establishment of a regional coordinating committee

A committee that has oversight of this regional e-mobility policy can conduct periodic review and updating as national and technological circumstances change. Such a committee will serve a large coordination role between the member states in advising and/or harmonizing national EV incentive policies and import rules. It will also serve as a resource bank that can brief Eastern Caribbean countries on nationally appropriate e-mobility policies and collect lessons learned. As part of its role as a resource bank, it will have knowledge materials and launch public education campaigns to improve public perception and subsequently adoption of EVs.

8.2 EV vehicle sales targets

Decarbonizing the transportation sector is an ambitious as well as urgent plan to prevent dangerous climate change. The Electric Vehicle Visualization Tool established that vehicle stock turnover is a slow process because cars are generally on the road for 10-15 years. The sales of ICEVs need to therefore be phased out by the end of this decade, around 2030, for the transport sector to decarbonize by mid-century. The policies related to e-mobility are strictly time-bound for this reason, and a target for EVs should be formulated to accelerate the transition process. Each country should set their own national EV targets, and the committee proposed above can serve as an advisory body supporting countries in setting their own targets.

Additionally, the targets set by each country can be aggregated for a regional Caribbean EV target. Antigua has a national EV target to make 100% of all vehicle sales electric by 2030 in their NDC. Saint Lucia’s NDC is also focused on the transition to e-mobility.

8.3 Creation of a regional EV market

The involved member states should identify their aggregate demand of domestic sales of EVs and make wholesale purchases of EVs as a unified market. With an aggregate demand for electric vehicles, importing EVs at a higher volume can decrease the price of EVs in the region by decreasing freight costs and logistical arrangements, and even negotiating a lower price point per vehicle. Key to this strategy is to involve the private sector to negotiate prices and form or identify a regional dealership for the transaction and logistical operations behind the imports and domestic sales of EVs.

8.4 Subsidy scheme at the country-level

As described in the Fiscal Incentives section, studies show that incentives reducing point-of-sale purchase prices of electric vehicles are more effective than those that provide future benefits. It is therefore advisable for countries in the region to adopt vehicle purchase rebates. Offering rebates is preferable in the region because more revenue is generated through sales tax than income tax, so the potential advantage for the consumer is higher through rebates than tax exemptions. Furthermore, equity considerations need to be at the forefront of any subsidy scheme, so a progressive rebate system based on the MSRP of the vehicle is preferable.

Since EVs are newer than ICEVs, they do not have a similar mature second hand market to tap into, so consumers will most likely be purchasing brand new EVs at this point. The cost of a brand new EV likely outprices low-income households in the Eastern Caribbean. If a household is purchasing a considerably high-priced EV like a Tesla Model 3, their decision to buy does not likely hinge on the rebates than they would be offered. On the other hand, a rebate offered to a household considering a Nissan Leaf might be persuaded to make the purchase.

8.5 Incentives to replace older and highly inefficient vehicles

For those car owners with older and more inefficient vehicles, switching to EVs can create a financial burden. Incentives to replace these older vehicles should be coupled with rebate offerings in the country. A handful of countries in the Eastern Caribbean already charge higher taxes on old and/or second-hand vehicles that are less fuel efficient, this can lead to inequities for lower income families with older vehicles. Similar tax policies could be implemented in all the member countries, but with an added attention to equity concerns such that the transition to EVs does not further disadvantage poorer households. For example, the country can offer a larger grant or rebate to lower income households to switch to an EV.

8.6 Infrastructure development

Though the Caribbean islands are small and home and office charging options should be sufficient for ordinary travel purposes, a sufficiently dense network of charging ports is needed to overcome psychological barriers like range anxiety, and to increase the visibility of EVs. Barbados is leading the country in EV charging stations, many of which are constructed by the leading EV company in the region Megapower.

EVs can also enable utilities to balance loads through vehicle-to-grid (V2G) technology. Especially when the transition to EVs is coupled with the scaling up of renewable energy, bidirectional chargers enable EVs to be used as storage for later reinjection fo energy into the grid, a particularly useful application for the integration of variable renewable energy, such as wind and solar.[17] When power supply from these variable renewable energy sources is low, the EV can get plugged in and re-inject power into the grid. When power supply is high, the EVs can be charged. This strategy uses EVs as a source of power capacity that supplements the grid and reduces the need for new capcity as peak demand increases over time.[18] The national grid may need to get updated in order to facilitate this strategy.

8.7 Training of mechanics

EVs are fundamentally different from ICEVs, and have fewer moving parts, many of which are electric. The advantage of the simpler operation structure means EVs need fewer reports, but mechanics will

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[17] (Viscidi, et al. 2020)

[18] (Viscidi, et al. 2020)

need to acquire a new skillset. Skills training will be needed to facilitate the e-mobility transition. In addition, many car repairs are informally conducted in the Caribbean, which could prove to be a challenge with EVs because you need more sophisticated equipment and background knowledge. This technology for maintenance and testing will need to be imported, and the demonstration of how to use them will need to be a part of the skills training for mechanics.

8.8 Training and equipment of firefighters and first responders

Fire departments need to have protocols in place to fight fires that may spark in battery-powered vehicles on the road. Firefighters and first responders need additional training for extinguishing fires on lithium-ion batteries, such as the right type of equipment to use for extrication operations, like the dimensions of a water hose, and where to impact the vehicle. These high voltage lithium-ion batteries are not a huge challenge for firefighters in terms of an electrical perspective, but they require a large volume of water to put out and can re-ignite. Firefighters can be trained to extinguish these fires and be on the looking for re-ignition signals. As one of the first in the region, the SLIM project is facilitating the transition to e-mobility in Antigua and Barbuda by training first responders.

8.9 Scrappage of vehicles

On an individual basis, no single Eastern Caribbean country has a vehicle market that makes opening a scrappage facility economically feasible. Coordination to create a regional scrappage facility on the other hands, poses its own unsurmountable challenges in the current context. Essentially, the scrappage of EVs is similar to the situations of scrapping ICEVs. There is a large extent of metals, plastic and fabric, and both types of vehicles are including more machines components and chips as vehicles get “smarter”.

When it comes to EVs, recycling their lithium batteries is a major distinction from ICEVs. Since lithium-ion batteries contain toxic chemicals that should not be placed in landfills, they need to be either recycled, which involves an intensive manufacturing process, or repurposed for other uses.[19] Fully recycling lithium-ion batteries is costly – the cost of extraction of lithium from old batteries is five times more expensive than mined lithium at the moment.[20] Caribbean countries would have to ship batteries at the end of their life to EV recycling companies, the nearest ones being in the United States and Canada.

Reusing batteries is another route for their safe disposal and productive use. Many EV batteries that are “spent” still have up to 70% of their capacity left.[21] After used EV batteries have been broken down, tested and re-packaged, they can be used for things like home energy storage. These batteries can power streetlights or be useful for storing solar energy and backing up traditional electrical grids. The opportunities for these “spent” batteries will continue to grow over time as they are matched with novel uses.

In Antigua and Barbuda, the Department of Environment is engaging with the National Solid Waste Management Authority to build local capacity for ICEV and ICE scrappage, recycling and disposal. This program will also affect the scrappage of EVs.

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[19] (IER 2019)

[20] (IER 2019)

[21] (IER 2019)

8.10 Public awareness for wider EV adoption

Lack of public awareness regarding EVs is one of the major barriers to EV adoption. Consumers have several misconceptions against EVs, such as range, performance on hilly terrain, maintenance costs, and other issues. There is a lack of awareness about the incentives related to EVs and the lifecycle cost assessment of EVs in comparison to ICEVs. Organizing EV outreach events and developing awareness campaigns to educate residents in the Eastern Caribbean on the benefits of EVs is an intervention that can erase these misconsceptions. Montserrat, for example, had an EV campaign where EV owners were asked to bring their EV vehicles for a test drive and to demonstrate that ordinary community members are also driving EVs.

Consumer awareness to increase public understanding of EV feasibility and benefits can be developed by engaging stakeholders using a wide range of methods including public meetings, focus groups, radio shows, newspapers, web forums, regional events, and targeted leaflet campaigns. Maintaining an EV website with information on EV and charging infrastructure resources, concessions, and rebates for consumers would make such essential information accessible to the public. Open source global databases on charging stations (like Plugshare) also exist, and adding public charging information on to such databases is a simple but effective way of communicating adequate infrastructure for EV adoption. Lastly, exhibits showcasing EVs in collaboration with auto dealers and other relevant stakeholders for EV demonstration – information on EV imports and maintenance, free EV test drives, display of EV fleets and charging infrastructure should be organized.

9. Conclusion

This Toolkit offers several tools to assist decision makers in facilitating the transition to e-mobility in the Eastern Caribbean region:

- Cost-benefit analysis tool
- Fiscal incentives
- Non-fiscal incentives
- Electric vehicle visualization tool
- Renewable energy and electric vehicle coupling
- Recommendations for a regional e-mobility policy

The Cost-Benefit Analysis tool will support policy-makers decide on e-mobility interventions based on quantifiable indicators that include Net Social Benefits and Benefit/Cost ratios with the possibility to compare different scenarios. This tool has the possibility to program 3 different scenarios and it calculates different types of costs and benefits in real USD and at net present value. The actual tool is in Excel format and an introductory manual is included in the Annexes.

Fiscal incentives can drive consumer behavior, in case drive up sales of EVs in comparison to that of ICEVs. A major challenge to wider EV penetration in the region is the higher upfront costs of EVs compared to ICEVs. Based on past studies, point-of-sale purchase prices for electric vehicles were more effective and therefore deserves consideration for future policy-making in this area. A suite of fiscal incentives is available for each country to tailor EV policies to their country-context, such as tax reduction and rebates, and long-term planning is necessary to compensate for the loss of revenues that governments may see from the decreased consumption of fossil fuels and the taxes imposed on them.

In addition to financial barriers, there are also psychological barriers to overcome in the electrification of the transport sector in the region. Range anxiety, performance anxiety on various terrains, and simply the hesitation over adopting a new technology are challenges that have solutions through media and educational campaigns. Non-fiscal incentives such as preferential parking for EVs and the reduction of certain fees can help consumers realize the benefits of EVs upfront, and nudge them into purchasing them.

The electric vehicle visualization tool is an interactive way for users to experiment with the penetration of EVs by using sliders to play with sales numbers in 2030, 2040 and 2050. It is an external tool that emphasizes the time lag between sales and the percentage of EVs in the vehicle fleet due to the relatively long lifetimes of vehicles on the road. Essentially, if all private vehicles are to be electric in the Eastern Caribbean by 2050, all vehicle sales must be electric by 2030.

Over the long run, the power generation and transportation sectors will be increasingly interlinked. Traditional consumers of electricity, such as households, will also be producing and transmitting electricity into the grid by plugging in their EVs to meet the electricity demand when supply is short. This idea of a “smart grid” is relatively new and still developing, but the economic payback for this coupling of sectors will benefit these consumers that will also have an electricity production role in the future.

Lastly, this Toolkit provides broad recommendations for consideration in the region. The recommendations overall aim to aggregate the target and demand for EVs to import them at a higher volume at a potentially lower price. Key to this strategy is to involve the private sector to negotiate prices and form or identify a regional dealership for the transaction and logistical operations behind the imports and domestic sales of EVs. Similarly, regional collaboration can be key to reaching a scale of vehicles to recycle at the end of their lives by developing a scrappage system. Incentives to phase out ICEVs, especially old ones, also need to be implemented while bearing in mind equity considerations since those with older vehicles are likely households that cannot afford to purchase new vehicles within a few years. With the scaling up of EVs, capacity must also increase as supporting infrastructure as well as local knowledge for auto repair and safety measures.

10. Bibliography

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11. Annexes

11.1 Annex 1 – References on the "neighbor effect"

Below are some references from academic literature on neighbor effects:

- Mau et al. "The 'neighbor effect': Simulating dynamics in consumer preferences for new vehicle technologies" Ecological Economics 68 (2008) 504 – 516
- Axsen et al. "Combining stated and revealed choice research to simulate the neighbor effect: The case of hybrid-electric vehicles" Resource and Energy Economics 31 (2009) 221–238
- Chen et al. "Where are the electric vehicles? A spatial model for vehicle-choice count data" Journal of Transport Geography 43 (2015) 181–188
- Pettifor et al. "Social influence in the global diffusion of alternative fuel vehicles – A metaanalysis" Journal of Transport Geography 62 (2017) 247–261
- Coffman et al. "Electric vehicles revisited: a review of factors that affect adoption" Transport Reviews (2017) 37 (1) 79–93
- Manca et al. "Modelling the influence of peers' attitudes on choice behaviour: Theory and empirical application on electric vehicle preferences" Transportation Research Part A 140 (2020) 278–298
- Barton-Henry et al. "Decay radius of climate decision for solar panels in the city of Fresno, USA" Scientific Reports 11 (2021) 8571

11.2 Annex 2 – CBA Tool Manual

This annex includes the model manual describing each section of the model and some exercises to familiarise the user with the model functionalities.

11.2.1 Introduction to the Tool

The cost-benefit analysis tool named *OECS_E-mobility_CBA_Tool*.xlsx is aimed at governmental officers, decision-makers or technical officers in charge of developing capacities and programmes for e-mobility. It is envisioned that this tool will help policy-makers evaluate potential e-mobility interventions aimed at increasing the share of electric vehicles in the vehicle fleet and reducing emissions from fossil fuels. The manual will elaborate further on the aspects of the excel tool. Annex 3 – CBA Toolkit Exercises includes exercises on how to use the model to change some assumptions and the scenarios.

11.2.2 Legend

In the excel model, different visual formats are used to distinguish the information more practically and conveniently. Table 3 shows the different formatting with a brief description for each one:

Name	Format	Description
Inputs	🟦	This cell contains a manually entered assumption.
Totals	⬜	This cell sums the totals for different calculations.
Scenario	🟦	This cell shows either a scenario option (in the *Control* sheet) or the scenario chosen.
Links	🟩	This cell shows that the value was brought from another cell or sheet.
Calculation	🟦	This cell contains calculations for the model and should not be changed.
Result	🟨	This cell shows the main results or values representative of the model.

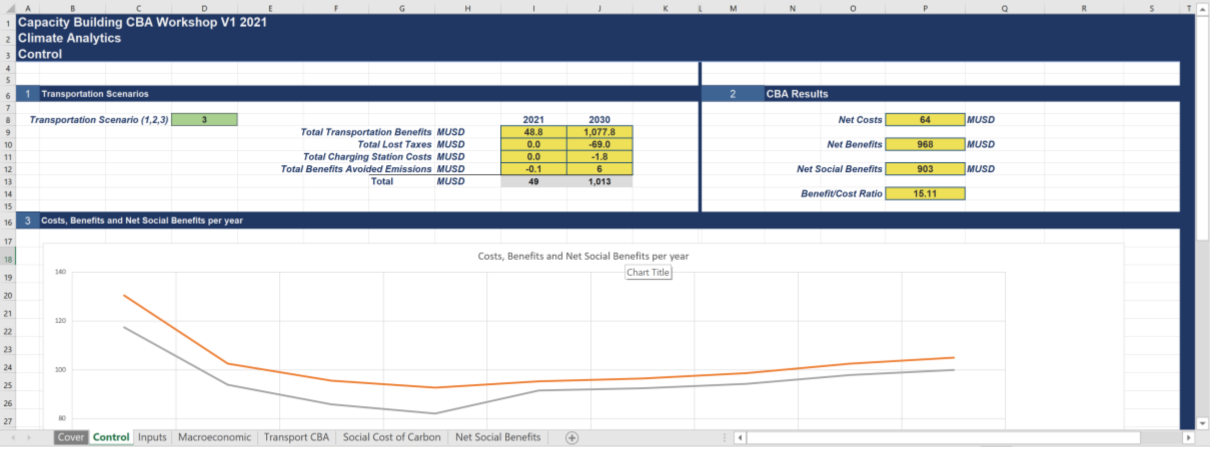
Table 3 – Legend used in the model

11.2.3 Model Sheets

11.2.3.1 Control

The *Control* sheet is where the main results from the model are shown, including a summary of costs and benefits for the scenario chosen in real 2021 USD. The main indicators for the Cost-Benefit analysis are also shown here with the Net Present Value of costs, benefits and net social benefits.

In this sheet, cell **D8**, the user can choose between scenarios 1,2,3, being scenario one the Business As Usual (BAU) scenario. Figure 8 shows the *Control* sheet as seen in the model.



Capacity Building CBA Workshop V1 2021
Climate Analytics
Control

1 Transportation Scenarios

Transportation Scenario (1,2,3) 3

		2021	2030
Total Transportation Benefits	MUSD	48.8	1,077.8
Total Lost Taxes	MUSD	0.0	-69.0
Total Charging Station Costs	MUSD	0.0	-1.8
Total Benefits Avoided Emissions	MUSD	-0.1	6
Total	MUSD	49	1,013

2 CBA Results

Net Costs	64	MUSD
Net Benefits	968	MUSD
Net Social Benefits	903	MUSD
Benefit/Cost Ratio	15.11	

3 Costs, Benefits and Net Social Benefits per year

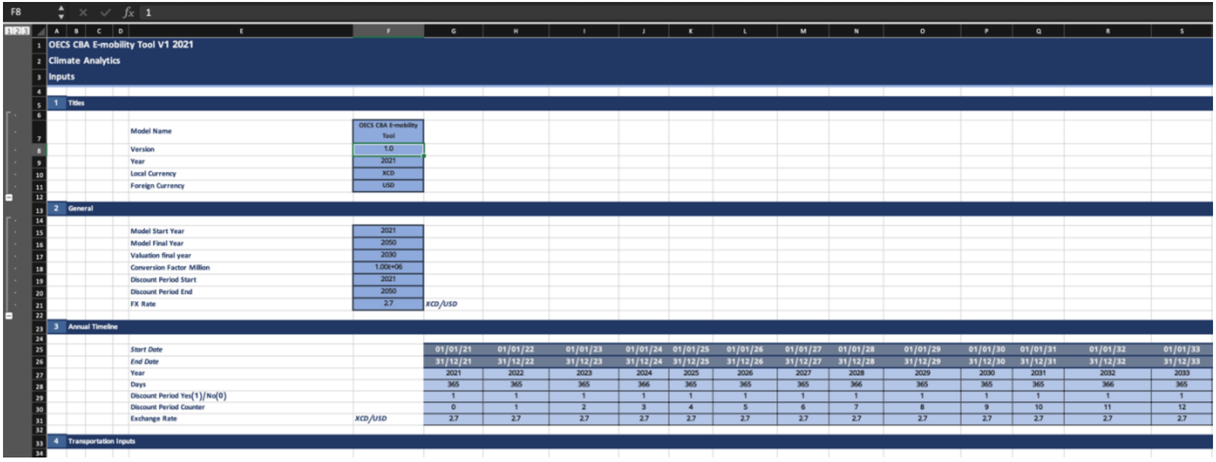
Figure 8 – Control Sheet

11.2.3.2 Inputs

In this sheet, the basic assumptions and main inputs for the model are entered. It is divided into the following sections:

1. **Titles**: This section contains the general titles at the top of each sheet (A1, A2, A3) of the model, including the model's name, the version, the year, and the currency code for the local and foreign currency used in the model. (USD and XCD)
2. **General**: This section contains the model start year, final year and final valuation year, general conversion factors, discount period start year and discount period end year, and the initial exchange rate from the local currency to the foreign currency.
3. **Annual Timeline**: This section contains the timeline used in the calculations of the model, it includes each year from the model start to final years, it also contains the number of days per year, as well as a flag, which just represent a zero (0) or one (1) and which will be further used as a TRUE or FALSE value for some calculations. This section also includes a discount period counter. The last component is the exchange rate which calculation can be found in the *Macroeconomic* sheet.

Figure 9 shows sections *1, 2,* and *3* in the inputs sheet as seen in the model.



OECS CBA E-mobility Tool V1 2021
Climate Analytics
Inputs

1 Titles

Model Name	OECS CBA E-mobility Tool
Version	1.0
Year	2021
Local Currency	XCD
Foreign Currency	USD

2 General

Model Start Year	2021	
Model Final Year	2050	
Valuation final year	2030	
Conversion Factor Million	1.00E+06	
Discount Period Start	2021	
Discount Period End	2050	
FX Rate	2.7	XCD/USD

3 Annual Timeline

Start Date		01/01/21	01/01/22	01/01/23	01/01/24	01/01/25	01/01/26	01/01/27	01/01/28	01/01/29	01/01/30	01/01/31	01/01/32	01/01/33
End Date		31/12/21	31/12/22	31/12/23	31/12/24	31/12/25	31/12/26	31/12/27	31/12/28	31/12/29	31/12/30	31/12/31	31/12/32	31/12/33
Year		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Days		365	365	365	366	365	365	365	366	365	365	365	366	365
Discount Period Yes(1)/No(0)		1	1	1	1	1	1	1	1	1	1	1	1	1
Discount Period Counter		0	1	2	3	4	5	6	7	8	9	10	11	12
Exchange Rate	XCD/USD	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7

4 Transportation Inputs

Figure 9 – Sections 1, 2, 3 in the Inputs Sheet

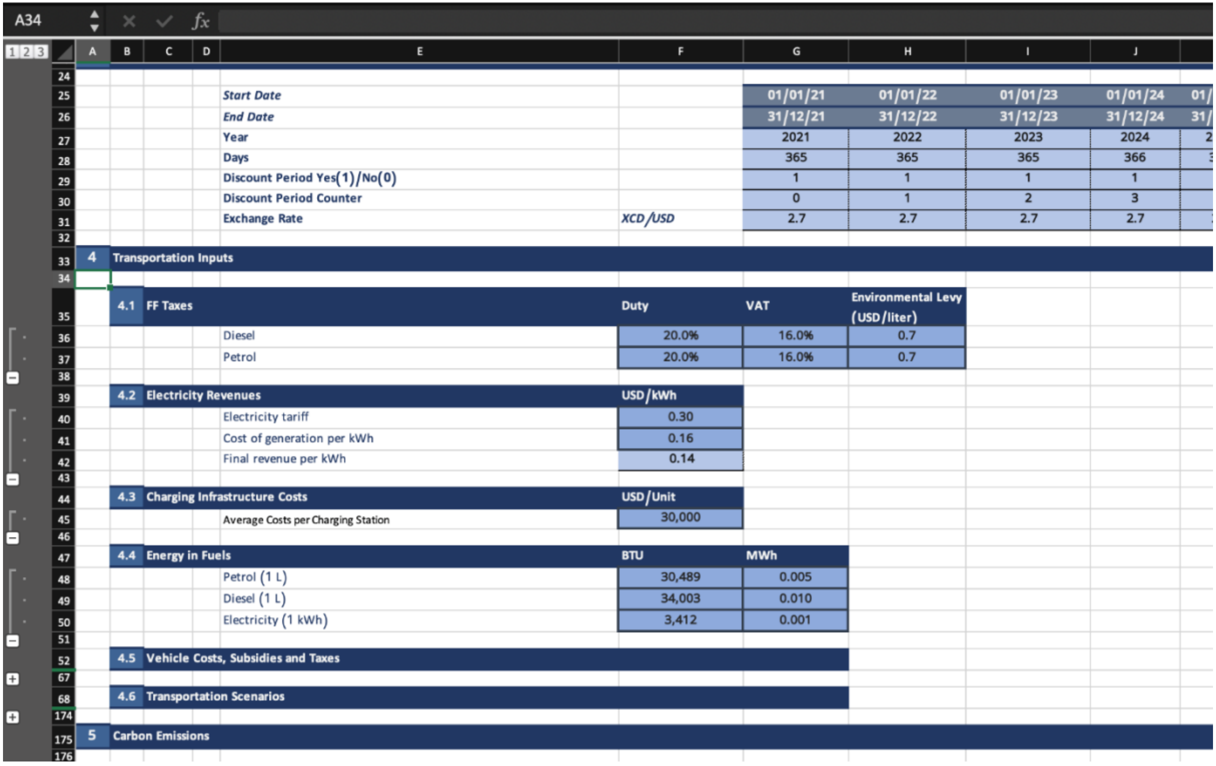
4. **Transportation Inputs**: This section is divided into further subsections:
    4.1. *Fossil Fuel Taxes:* In this section, cells **F36** and **F39** have the assumption for the duty charged on diesel and petrol, respectively, at *20%*. This number can be changed based on the duty charged for each specific country. Cells **G36** and **G39** have a 15% Value Added Tax (VAT), and finally, cells **H36** and **H39** consider an environmental levy in USD per litre of petrol and diesel.

4.2. *Electricity Revenues:* This section contains the inputs for the revenues from electricity sold in cell **F40** with an estimated electricity tariff of 0.3 USD/kWh. The electricity generation cost can be found in cell **F41** and set at 0.16 USD/kWh. Finally, the estimated revenue in USD/kWh is calculated in cell **F42** by subtracting the cost of generation from the electricity tariff.

4.3. *Charging Infrastructure Costs:* In cell **F45,** the average cost per charging station is set at 30,000 USD/Unit. This value can be changed based on the context of different countries.

4.4. *Energy in Fuels:* This section contains some factors to transform energy units base on the energy content for Petrol, Diesel and Electricity. These values should not be changed.

Figure 10 shows sections *4.1, 4.2, 4.3* and *4.4*, as seen in the model.



A34

	A	B	C	D	E	F	G	H	I	J
24										
25					*Start Date*		01/01/21	01/01/22	01/01/23	01/01/24
26					*End Date*		31/12/21	31/12/22	31/12/23	31/12/24
27					Year		2021	2022	2023	2024
28					Days		365	365	365	366
29					Discount Period Yes(1)/No(0)		1	1	1	1
30					Discount Period Counter		0	1	2	3
31					Exchange Rate	*XCD/USD*	2.7	2.7	2.7	2.7
32										
33	4	Transportation Inputs								
34										
35		4.1	FF Taxes			Duty	VAT	Environmental Levy (USD/liter)		
36					Diesel	20.0%	16.0%	0.7		
37					Petrol	20.0%	16.0%	0.7		
38										
39		4.2	Electricity Revenues			USD/kWh				
40					Electricity tariff	0.30				
41					Cost of generation per kWh	0.16				
42					Final revenue per kWh	0.14				
43										
44		4.3	Charging Infrastructure Costs			USD/Unit				
45					Average Costs per Charging Station	30,000				
46										
47		4.4	Energy in Fuels			BTU	MWh			
48					Petrol (1 L)	30,489	0.005			
49					Diesel (1 L)	34,003	0.010			
50					Electricity (1 kWh)	3,412	0.001			
51										
52		4.5	Vehicle Costs, Subsidies and Taxes							
67										
68		4.6	Transportation Scenarios							
174										
175	5	Carbon Emissions								
176										

Figure 10 – Sections 4.1, 4.2, 4.3, and 4.4 in the Inputs sheet

4.5. *Vehicle Costs, Subsidies and Taxes:* In this section, the names of the different vehicle categories can be changed in cells **E55:E59.** There are five different fossil fuel vehicle categories and their electric counterparts (which can be seen in cells **E60:E64**). The electric vehicle names should not be changed.

In this section, the price per vehicle for 2021 is entered in cells **F55:F64** and can be changed depending on the context for each country.

Cells **G55:G64** include a sensitivity option for the vehicle price as a percentage. The values in these cells can range from -100% to 100%. These values can be changed to analyse different sensitivity scenarios by increasing or decreasing the cost by a certain percentage, which will only affect the starting price for 2021. Cells **I55:I64** include another sensitivity input determining how much the price of the vehicle category will be increased or reduced per year up until the year 2030, after which the prices will remain static.

Cells **J55:M64** contain the values for the Environmental levy, Customs Service Charge (CSC), Excise tax + Duty and VAT rates charged for each vehicle. These values can be changed to determine the best taxation structure. However, the tax rate used in these cells will be fixed from 2021 to the year 2050. Please consider this.

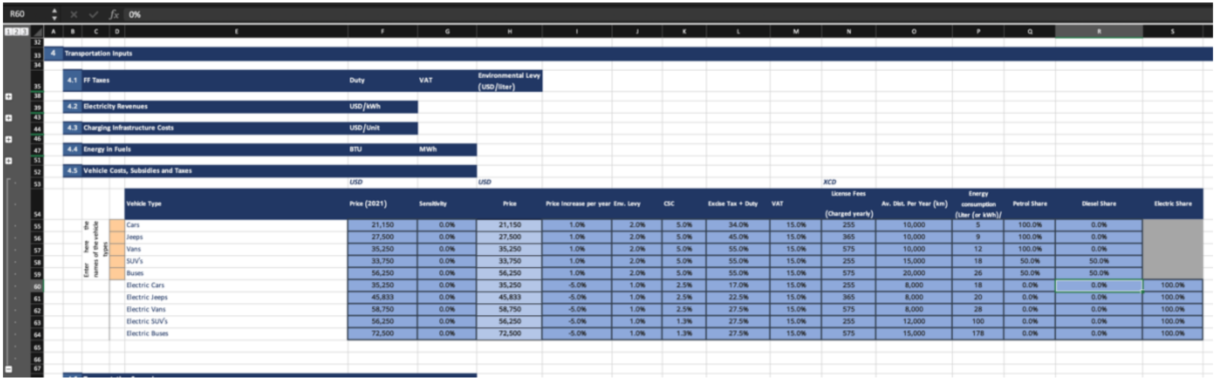
Cells **N55:N64** consider licence fees in *XCD* per vehicle and per year to calculate benefits from collecting fees from a governmental perspective.

Cells **O55:O64** use an average value of kilometres (km) travelled per vehicle per year to calculate the emissions. These values can be changed depending on the analysis.

Cells **P55:P64** assume different energy consumption as litres or Petrol or Diesel per 100 km travelled or kWh per 100 km for electric vehicles.

Finally, cells **Q55:Q54** show what share of the vehicle category uses petrol, ranging in values from 0% to 100%, and for cells **R55:R64** do the same but for the share of diesel vehicles. The share of electric vehicles is considered as 100% for all-electric vehicle categories.

Figure 11 shows a screenshot of section *4.5,* as seen in the model.



4 Transportation Inputs

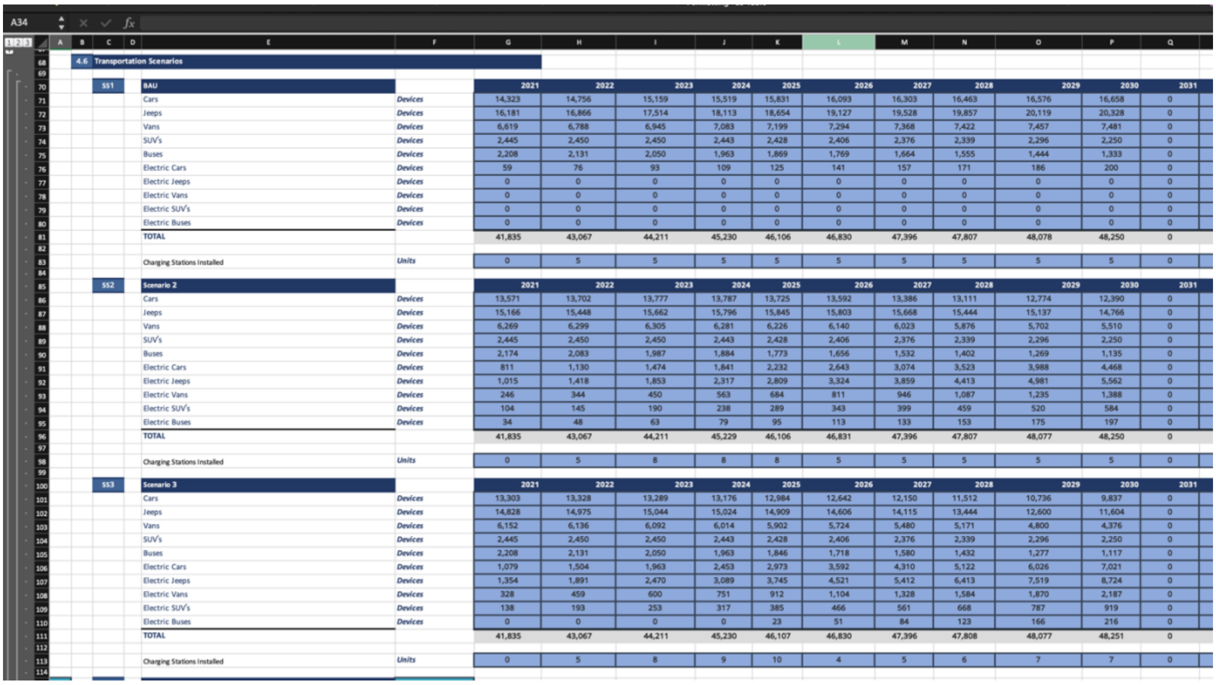
4.1 FF Taxes	Duty	VAT	Environmental Levy (USD/liter)
4.2 Electricity Revenues	USD/kWh		
4.3 Charging Infrastructure Costs	USD/Unit		
4.4 Energy in Fuels	BTU	MWh	
4.5 Vehicle Costs, Subsidies and Taxes			

Enter here the names of the vehicle types

	USD		USD						XCD					
Vehicle Type	Price (2021)	Sensitivity	Price	Price Increase per year	Env. Levy	CSC	Excise Tax + Duty	VAT	License Fees (Charged yearly)	Av. Dist. Per Year (km)	Energy consumption (Liter (or kWh)/	Petrol Share	Diesel Share	Electric Share
Cars	21,150	0.0%	21,150	1.0%	2.0%	5.0%	34.0%	15.0%	255	10,000	5	100.0%	0.0%	
Jeeps	27,500	0.0%	27,500	1.0%	2.0%	5.0%	45.0%	15.0%	365	10,000	9	100.0%	0.0%	
Vans	35,250	0.0%	35,250	1.0%	2.0%	5.0%	55.0%	15.0%	575	10,000	12	100.0%	0.0%	
SUV's	33,750	0.0%	33,750	1.0%	2.0%	5.0%	55.0%	15.0%	255	15,000	18	50.0%	50.0%	
Buses	56,250	0.0%	56,250	1.0%	2.0%	5.0%	55.0%	15.0%	575	20,000	26	50.0%	50.0%	
Electric Cars	35,250	0.0%	35,250	-5.0%	1.0%	2.5%	17.0%	15.0%	255	8,000	18	0.0%	0.0%	100.0%
Electric Jeeps	45,833	0.0%	45,833	-5.0%	1.0%	2.5%	22.5%	15.0%	365	8,000	20	0.0%	0.0%	100.0%
Electric Vans	58,750	0.0%	58,750	-5.0%	1.0%	2.5%	27.5%	15.0%	575	8,000	28	0.0%	0.0%	100.0%
Electric SUV's	56,250	0.0%	56,250	-5.0%	1.0%	1.3%	27.5%	15.0%	255	12,000	100	0.0%	0.0%	100.0%
Electric Buses	72,500	0.0%	72,500	-5.0%	1.0%	1.3%	27.5%	15.0%	575	15,000	178	0.0%	0.0%	100.0%

Figure 11 – Section 4.5 Vehicle costs, subsidies and taxes in the inputs sheet.

4.6. *Transportation Scenarios:* In this section, the assumptions for the vehicle fleet stocks and the number of charging stations are entered. Scenario 1 or BAU assumptions can be changed in cells **G71:AJ80** for the vehicle fleet and **G83:AJ83** for the number of charging stations installed. Similarly, for scenario 2, the assumptions are found in cells **G86:AJ95** and **G98:AJ98**. Scenario 3 is found in cells **G101:AJ110** and **G113:AJ113**. Figure 12 shows this section as seen in the model.



4.6 Transportation Scenarios

SS1	BAU		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Cars	Devices	14,323	14,756	15,159	15,519	15,831	16,093	16,303	16,463	16,576	16,658	0
	Jeeps	Devices	16,181	16,866	17,514	18,113	18,654	19,127	19,528	19,857	20,119	20,328	0
	Vans	Devices	6,619	6,788	6,945	7,083	7,199	7,294	7,368	7,422	7,457	7,481	0
	SUV's	Devices	2,445	2,450	2,450	2,443	2,428	2,406	2,376	2,339	2,296	2,250	0
	Buses	Devices	2,208	2,131	2,050	1,963	1,869	1,769	1,664	1,555	1,444	1,333	0
	Electric Cars	Devices	59	76	93	109	125	141	157	171	186	200	0
	Electric Jeeps	Devices	0	0	0	0	0	0	0	0	0	0	0
	Electric Vans	Devices	0	0	0	0	0	0	0	0	0	0	0
	Electric SUV's	Devices	0	0	0	0	0	0	0	0	0	0	0
	Electric Buses	Devices	0	0	0	0	0	0	0	0	0	0	0
	TOTAL		41,835	43,067	44,211	45,230	46,106	46,830	47,396	47,807	48,078	48,250	0
	Charging Stations Installed	Units	0	5	5	5	5	5	5	5	5	5	0

SS2	Scenario 2		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Cars	Devices	13,571	13,702	13,777	13,787	13,725	13,592	13,386	13,111	12,774	12,390	0
	Jeeps	Devices	15,166	15,448	15,662	15,796	15,845	15,803	15,668	15,444	15,137	14,766	0
	Vans	Devices	6,269	6,299	6,305	6,281	6,226	6,140	6,023	5,876	5,702	5,510	0
	SUV's	Devices	2,445	2,450	2,450	2,443	2,428	2,406	2,376	2,339	2,296	2,250	0
	Buses	Devices	2,174	2,083	1,987	1,884	1,773	1,656	1,532	1,402	1,269	1,135	0
	Electric Cars	Devices	811	1,130	1,474	1,841	2,232	2,643	3,074	3,523	3,988	4,468	0
	Electric Jeeps	Devices	1,015	1,418	1,853	2,317	2,809	3,324	3,859	4,413	4,981	5,562	0
	Electric Vans	Devices	246	344	450	563	684	811	946	1,087	1,235	1,388	0
	Electric SUV's	Devices	104	145	190	238	289	343	399	459	520	584	0
	Electric Buses	Devices	34	48	63	79	95	113	133	153	175	197	0
	TOTAL		41,835	43,067	44,211	45,229	46,106	46,831	47,396	47,807	48,077	48,250	0
	Charging Stations Installed	Units	0	5	8	8	8	5	5	5	5	5	0

SS3	Scenario 3		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
	Cars	Devices	13,303	13,328	13,289	13,176	12,984	12,642	12,150	11,512	10,736	9,837	0
	Jeeps	Devices	14,828	14,975	15,044	15,024	14,909	14,606	14,115	13,444	12,600	11,604	0
	Vans	Devices	6,152	6,136	6,092	6,014	5,902	5,724	5,480	5,171	4,800	4,376	0
	SUV's	Devices	2,445	2,450	2,450	2,443	2,428	2,406	2,376	2,339	2,296	2,250	0
	Buses	Devices	2,208	2,131	2,050	1,963	1,846	1,718	1,580	1,432	1,277	1,117	0
	Electric Cars	Devices	1,079	1,504	1,963	2,453	2,973	3,592	4,310	5,122	6,026	7,021	0
	Electric Jeeps	Devices	1,354	1,891	2,470	3,089	3,745	4,521	5,412	6,413	7,519	8,724	0
	Electric Vans	Devices	328	459	600	751	912	1,104	1,328	1,584	1,870	2,187	0
	Electric SUV's	Devices	138	193	253	317	385	466	561	668	787	919	0
	Electric Buses	Devices	0	0	0	0	23	51	84	123	166	216	0
	TOTAL		41,835	43,067	44,211	45,230	46,107	46,830	47,396	47,808	48,077	48,251	0
	Charging Stations Installed	Units	0	5	8	9	10	4	5	6	7	7	0

Figure 12 - Transportation scenarios in the Inputs sheet

Rows **115** through **173** have calculations on the chosen scenario and the baseline case or scenario. The calculations should not be modified. The values for each scenario can be entered from the year 2021 until the year 2050.

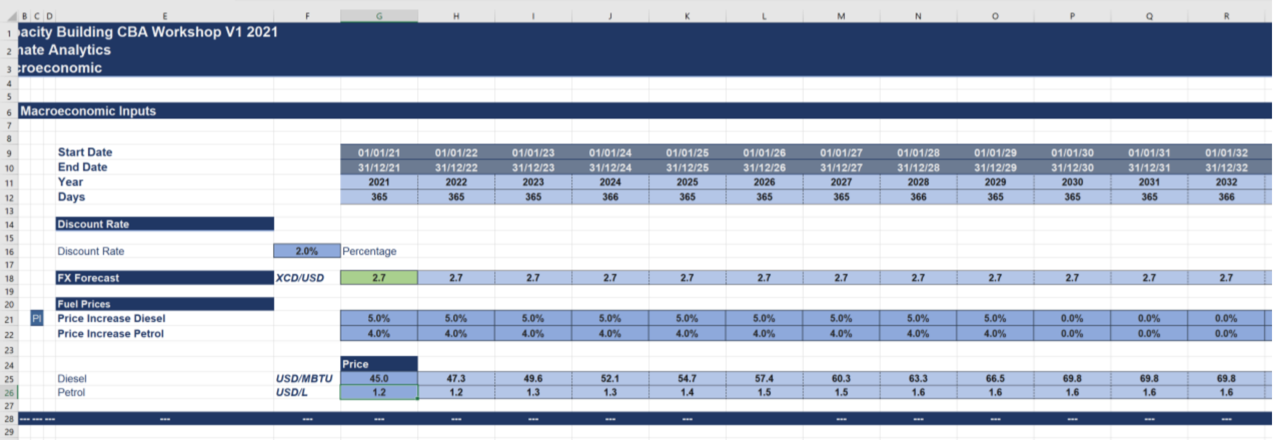
5. **Carbon Emissions**: This section is divided into the following subsections:
   5.1. **Social Cost of Carbon (SCC):** Cell **G179** is where the initial cost of carbon is entered for 2021, cells H189:J189 is where the increase for the social cost of carbon is entered as a percentage ranging between 0% to 100%. The increase will happen every year by that same percentage in periods between 2025, 2030, 2050.
   5.2. **Carbon Emission Scenarios**:
      5.2.1. *Emission Factors:* Cells **G186** and **G187** are where the emission factor for diesel and petrol is entered in kg CO_2eq/litre. Cell G188 also considers an emission factor for electricity produced at tonne CO_2eq per MWh produced. These values can be changed depending on the emission factor used for greenhouse gas inventories or with the specific emission factor for electricity generation depending on each country.
      5.2.2. *Transport emissions:* In this section, the emissions for the BAU and the chosen scenario (1, 2 or 3) are calculated. The calculations should not be modified.

11.2.3.3 Macroeconomic Inputs

In this sheet, the macroeconomic assumptions are found.

- **Discount Rate:** Cell **F16** is where the discount rate is entered. The discount rate is used to calculate the net present value of costs and benefits in the *Net Social Benefits* sheet.
- **FX Forecast:** This section uses the value found in the *Inputs* sheet cell **F21** and calculates the exchange rate per year. The model assumes a pegged exchange rate of ***2.7 XCD/USD***.
- **Fuel Prices:** In cells **G21:AJ21** and **G22:AJ22,** the increase in petrol and diesel prices per year is entered as a percentage. These values can be changed, ranging from 0% to 100%. In cell **G25,** the initial 2021 price for diesel is entered on a ***USD/million BTU*** and then forecasted using the price increase for diesel. Cell **G26** is where the initial 2021 price for petrol is entered on a ***USD/litre*** basis and then forecasted using the petrol price increase percentages.

Figure 13 shows the *Macroeconomic Inputs* tab as seen in the model.



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Macroeconomic Inputs

Start Date		01/01/21	01/01/22	01/01/23	01/01/24	01/01/25	01/01/26	01/01/27	01/01/28	01/01/29	01/01/30	01/01/31	01/01/32
End Date		31/12/21	31/12/22	31/12/23	31/12/24	31/12/25	31/12/26	31/12/27	31/12/28	31/12/29	31/12/30	31/12/31	31/12/32
Year		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Days		365	365	365	366	365	365	365	366	365	365	365	366
Discount Rate													
Discount Rate	2.0%	Percentage											
FX Forecast	XCD/USD	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
Fuel Prices													
PI Price Increase Diesel		5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	0.0%	0.0%	0.0%
Price Increase Petrol		4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	0.0%	0.0%	0.0%
		Price											
Diesel	USD/MBTU	45.0	47.3	49.6	52.1	54.7	57.4	60.3	63.3	66.5	69.8	69.8	69.8
Petrol	USD/L	1.2	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.6
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Figure 13 - Macroeconomic Inputs sheet

11.2.3.4 Transport CBA

1. **Annual Timeline**: This section contains the timeline as shown in the *Inputs* sheet, including the number of days, flags and exchange rate.
2. **Transport sector inputs**: This section brings the main assumptions as entered in the *Inputs* tab. It includes the fossil taxes, electricity revenues inputs, charging infrastructure costs and fuel energy conversion factors, and the transportation fleet scenario inputs. This section should not be modified in the model.
3. **Transport Sector CBA** (in Real 2021 USD): This section contains the calculation of costs and benefits for the transportation sector. The values are presented as 2021 real USD. The calculations in this tab should not be modified. The subsections included in this sheet are as follows:
    - 3.1. ***Price per year per vehicle:*** This section calculates the price for the different vehicle categories per year based on the price increase or decrease as entered in the *Inputs* sheet. The prices increase or decrease based on the fixed percentages but only until the year 2030. After the year 2030, the vehicle price is assumed to be the same every subsequent year.
    - 3.2. ***Taxes per vehicles sold:*** This section calculates the taxes per vehicle sold every year and for the different categories.
    - 3.3. ***License fees:*** This section calculates the license fees collected based on the license fees per vehicle category.
    - 3.4. ***Taxes from sales per year:*** This section calculates the total taxes collected from vehicles sold by multiplying the taxes collected per vehicle from section *3.2* times the number of vehicles sold.
    - 3.5. ***Lost Taxes EV:*** The lost taxes for Electric Vehicles (EVs) are the indirect costs from having a reduced taxes for EVs compared to their Internal Combustion Engine (ICE) counterparts. This situation could arise from implementing different taxation schemes to incentivise electric vehicles' demand with lower tax rates and increase their share in the vehicle fleet. The lost taxes are calculated only for electric vehicles in section *3.2.* These calculations should not be modified.
    - 3.6. ***Charging Stations Costs***: This section calculates the total costs for the installed charging stations based on the average station cost per unit and the number of charging stations installed as entered in the *4.6 Transportation Scenarios* section from the *Inputs* tab.

11.2.3.5 Social cost of carbon

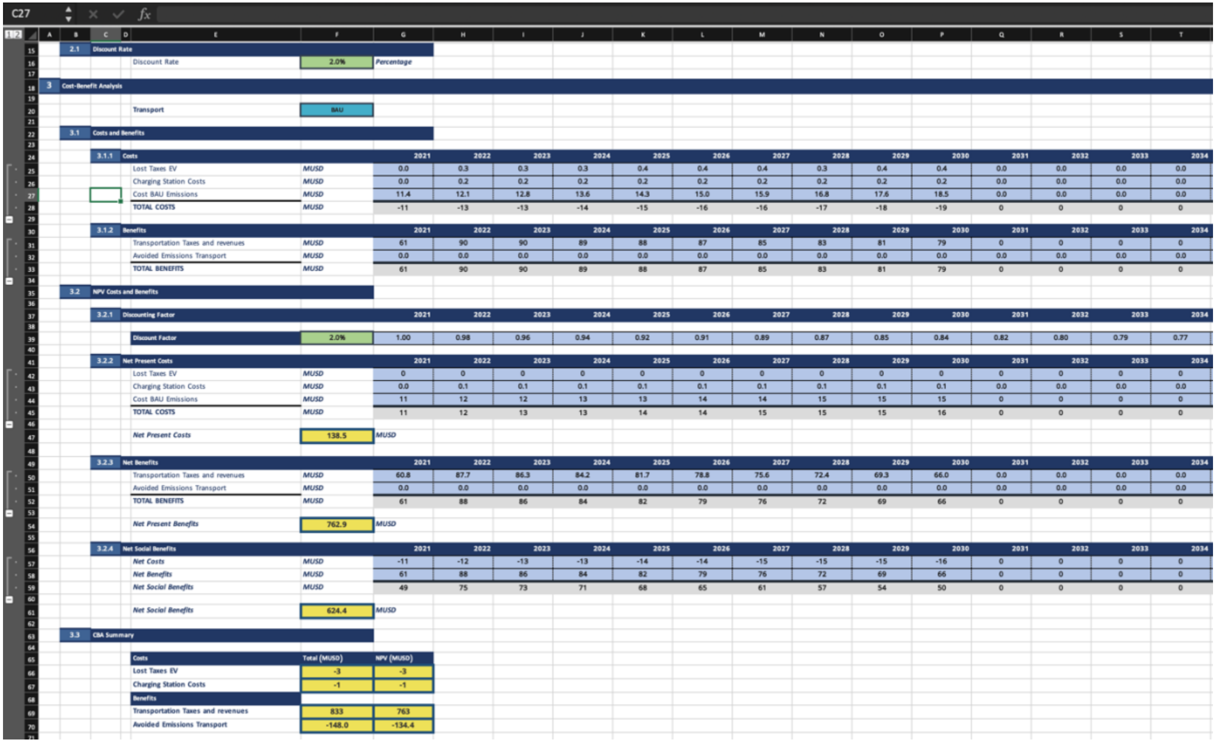
1. **Annual Timeline**: This section contains the timeline as shown in the *Inputs* sheet, including the number of days, flags and exchange rate.
2. **Social cost of carbon inputs**: This section brings all of the relevant assumptions used to calculate the benefits or costs from avoided emissions.
3. **Social cost of carbon Calculation (2021 Real USD)**: This section calculates the social cost of carbon per year based on the previously entered assumptions. It also calculates the benefits from avoided emissions when comparing scenario 2 or 3 vs the BAU scenario.

11.2.3.6 Net Social Benefits

The *Net Social Benefits* sheet is where all the costs and benefits are calculated on a Net Present Value (NPV) basis. The calculations in this sheet should not be modified.

1. **Annual Timeline**: This section contains the timeline as shown in the *Inputs* sheet, including the number of days, flags and exchange rate.
2. **CBA Inputs**: This section brings the discount rate as entered in the *Macroeconomic Inputs* tab.
3. **Cost-Benefit Analysis**:
   - 3.1. Costs and Benefits: This section gathers the different costs and benefits in real 2021 USD
   - 3.2. **NPV Costs and Benefits**: This section is where the costs and benefits are calculated on a Net Present Value basis by calculating a discount factor per year.
   - 3.3. **CBA Summary**: This section gathers the main results from the CBA for the different costs and benefits in real 2021 USD and in Net Present Value.

Figure 14 shows the Net Social benefits sheet as seen in the model.



C27

2.1 Discount Rate

Discount Rate	2.0%	Percentage

3 Cost-Benefit Analysis

Transport	BAU

3.1 Costs and Benefits

3.1.1 Costs		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Lost Taxes EV	MUSD	0.0	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.4	0.4	0.0	0.0	0.0	0.0
Charging Station Costs	MUSD	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0
Cost BAU Emissions	MUSD	11.4	12.1	12.8	13.6	14.3	15.0	15.9	16.8	17.6	18.5	0.0	0.0	0.0	0.0
TOTAL COSTS	MUSD	-11	-13	-13	-14	-15	-16	-16	-17	-18	-19	0	0	0	0

3.1.2 Benefits		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Transportation Taxes and revenues	MUSD	61	90	90	89	88	87	85	83	81	79	0	0	0	0
Avoided Emissions Transport	MUSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL BENEFITS	MUSD	61	90	90	89	88	87	85	83	81	79	0	0	0	0

3.2 NPV Costs and Benefits

3.2.1 Discounting Factor		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Discount Factor	2.0%	1.00	0.98	0.96	0.94	0.92	0.91	0.89	0.87	0.85	0.84	0.82	0.80	0.79	0.77

3.2.2 Net Present Costs		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Lost Taxes EV	MUSD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charging Station Costs	MUSD	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0
Cost BAU Emissions	MUSD	11	12	12	13	13	14	14	15	15	15	0	0	0	0
TOTAL COSTS	MUSD	11	12	13	13	14	14	15	15	15	16	0	0	0	0

Net Present Costs	138.5	*MUSD*

3.2.3 Net Benefits		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Transportation Taxes and revenues	MUSD	60.8	87.7	86.3	84.2	81.7	78.8	75.6	72.4	69.3	66.0	0.0	0.0	0.0	0.0
Avoided Emissions Transport	MUSD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL BENEFITS	MUSD	61	88	86	84	82	79	76	72	69	66	0	0	0	0

Net Present Benefits	762.9	*MUSD*

3.2.4 Net Social Benefits		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Net Costs	MUSD	-11	-12	-13	-13	-14	-14	-15	-15	-15	-16	0	0	0	0
Net Benefits	MUSD	61	88	86	84	82	79	76	72	69	66	0	0	0	0
Net Social Benefits	MUSD	49	75	73	71	68	65	61	57	54	50	0	0	0	0

Net Social Benefits	624.4	*MUSD*

3.3 CBA Summary

Costs	Total (MUSD)	NPV (MUSD)
Lost Taxes EV	-3	-3
Charging Station Costs	-1	-1
Benefits		
Transportation Taxes and revenues	833	763
Avoided Emissions Transport	-148.0	-134.4

Figure 14 – Net Social Benefits Sheet

Annex 3 – CBA Toolkit Exercises includes exercises to familiarise with the model and learn how to change some assumptions to analyse different scenarios.

11.3 Annex 3 – CBA Toolkit Exercises

11.3.1 Exercise 1 - Changing the assumptions

In this exercise, the vehicle stocks from scenario 3 will be replaced with the values from Table 4.

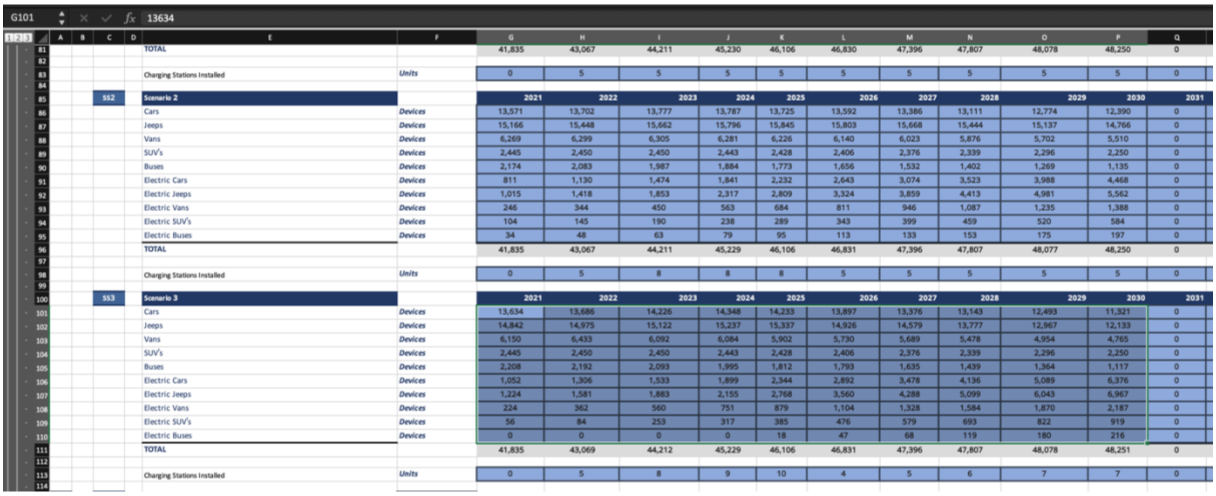
Table 4 – Vehicle stocks for scenario 3

Vehicles (Devices)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cars	13,634	13,686	14,226	14,348	14,233	13,897	13,376	13,143	12,493	11,321
Jeeps	14,842	14,975	15,122	15,237	15,337	14,926	14,579	13,777	12,967	12,133
Vans	6,150	6,433	6,092	6,084	5,902	5,730	5,689	5,478	4,954	4,765

SUV's	2,445	2,450	2,450	2,443	2,428	2,406	2,376	2,339	2,296	2,250
Buses	2,208	2,192	2,093	1,995	1,812	1,793	1,635	1,439	1,364	1,117
Electric Cars	1,052	1,306	1,533	1,899	2,344	2,892	3,478	4,136	5,089	6,376
Electric Jeeps	1,224	1,581	1,883	2,155	2,768	3,560	4,288	5,099	6,043	6,967
Electric Vans	224	362	560	751	879	1,104	1,328	1,584	1,870	2,187
Electric SUV's	56	84	253	317	385	476	579	693	822	919
Electric Buses	0	0	0	0	18	47	68	119	180	216

The steps to do this are as follows:

1. Go to the *Inputs* sheet to section *4.6 Transportation Scenarios*.
2. Click on the *"+"* sign to open the different levels or the number three (3) on top of the sheet.
3. Enter the values from Table 4 in cells **G101:P110,** as seen in Figure 17.



G101 13634

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
81					TOTAL		41,835	43,067	44,211	45,230	46,106	46,830	47,396	47,807	48,078	48,250	0
82																	
83					Charging Stations Installed	Units	0	5	5	5	5	5	5	5	5	5	0
84																	
85			SS2		Scenario 2		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
86					Cars	Devices	13,571	13,702	13,777	13,787	13,725	13,592	13,386	13,111	12,774	12,390	0
87					Jeeps	Devices	15,166	15,448	15,662	15,796	15,845	15,803	15,668	15,444	15,137	14,766	0
88					Vans	Devices	6,269	6,299	6,305	6,281	6,226	6,140	6,023	5,876	5,702	5,510	0
89					SUV's	Devices	2,445	2,450	2,450	2,443	2,428	2,406	2,376	2,339	2,296	2,250	0
90					Buses	Devices	2,174	2,083	1,987	1,884	1,773	1,656	1,532	1,402	1,269	1,135	0
91					Electric Cars	Devices	811	1,130	1,474	1,841	2,232	2,643	3,074	3,523	3,988	4,468	0
92					Electric Jeeps	Devices	1,015	1,418	1,853	2,317	2,809	3,324	3,859	4,413	4,981	5,562	0
93					Electric Vans	Devices	246	344	450	563	684	811	946	1,087	1,235	1,388	0
94					Electric SUV's	Devices	104	145	190	238	289	343	399	459	520	584	0
95					Electric Buses	Devices	34	48	63	79	95	113	133	153	175	197	0
96					TOTAL		41,835	43,067	44,211	45,229	46,106	46,831	47,396	47,807	48,077	48,250	0
97																	
98					Charging Stations Installed	Units	0	5	8	8	8	5	5	5	5	5	0
99																	
100			SS3		Scenario 3		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
101					Cars	Devices	13,634	13,686	14,226	14,348	14,233	13,897	13,376	13,143	12,493	11,321	0
102					Jeeps	Devices	14,842	14,975	15,122	15,237	15,337	14,926	14,579	13,777	12,967	12,133	0
103					Vans	Devices	6,150	6,433	6,092	6,084	5,902	5,730	5,689	5,478	4,954	4,765	0
104					SUV's	Devices	2,445	2,450	2,450	2,443	2,428	2,406	2,376	2,339	2,296	2,250	0
105					Buses	Devices	2,208	2,192	2,093	1,995	1,812	1,793	1,635	1,439	1,364	1,117	0
106					Electric Cars	Devices	1,052	1,306	1,533	1,899	2,344	2,892	3,478	4,136	5,089	6,376	0
107					Electric Jeeps	Devices	1,224	1,581	1,883	2,155	2,768	3,560	4,288	5,099	6,043	6,967	0
108					Electric Vans	Devices	224	362	560	751	879	1,104	1,328	1,584	1,870	2,187	0
109					Electric SUV's	Devices	56	84	253	317	385	476	579	693	822	919	0
110					Electric Buses	Devices	0	0	0	0	18	47	68	119	180	216	0
111					TOTAL		41,835	43,069	44,212	45,229	46,106	46,831	47,396	47,807	48,078	48,251	0
112																	
113					Charging Stations Installed	Units	0	5	8	9	10	4	5	6	7	7	0
114																	

Figure 15 Scenario 3 Inputs using Table 2 values

Scenarios 1 and 2 can also be modified following these exact instructions, but the values must be entered in the corresponding cells.

11.3.2 Exercise 2 – Changing vehicles prices using sensitivity assumptions

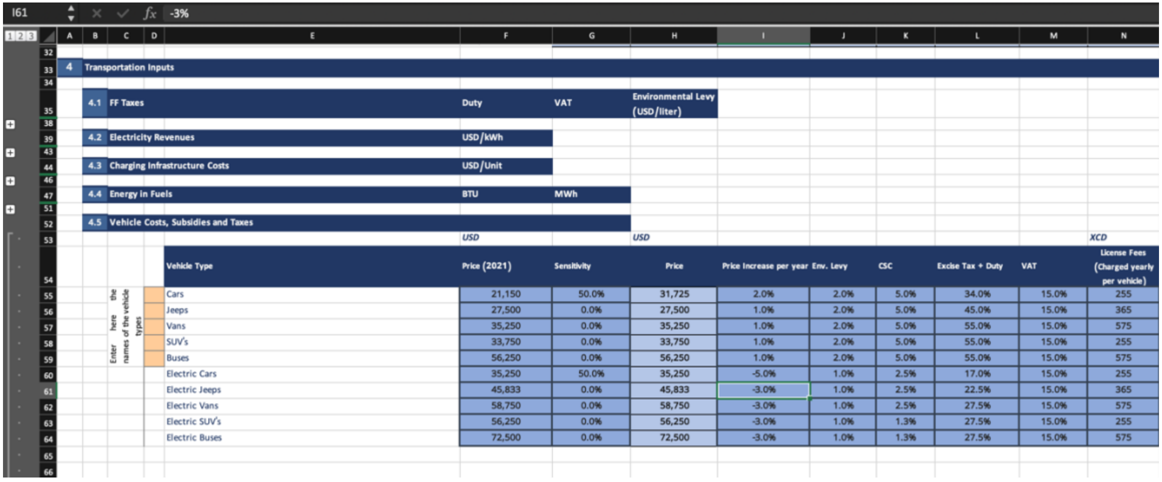
This exercise will change the sensitivity to vehicle prices for 2021 and the increase or decrease per year.

1. Go to the *Inputs* sheet to section *4.5 Vehicle Costs, Subsidies and Taxes*.

2. Click on the "+" sign to open the different levels or the number three (3) on top of the sheet.
3. Change the value in cell **G55** to *50%* and the value in cell **G60** to *50%*. This will increase the base price for Cars and Electric Cars by 50% for 2021, and the result can be seen in cells **H55** and **H60,** respectively.
4. Now change the value in cell **I55** and **I60** to *2%* and *-5%*, respectively. This will increase the price per year for the cars by 2% and decrease the electric vehicles price by 5% every year.

Figure 16 shows how it should look in the model after doing exercise 2. As described in section

Inputs*,* the different inputs can be changed in a similar way as to how it was done in this exercise. Some of these inputs include the tax rates for the different vehicle categories.



4 Transportation Inputs

4.1 FF Taxes — Duty — VAT — Environmental Levy (USD/liter)

4.2 Electricity Revenues — USD/kWh

4.3 Charging Infrastructure Costs — USD/Unit

4.4 Energy in Fuels — BTU — MWh

4.5 Vehicle Costs, Subsidies and Taxes

Enter here the names of the vehicle types

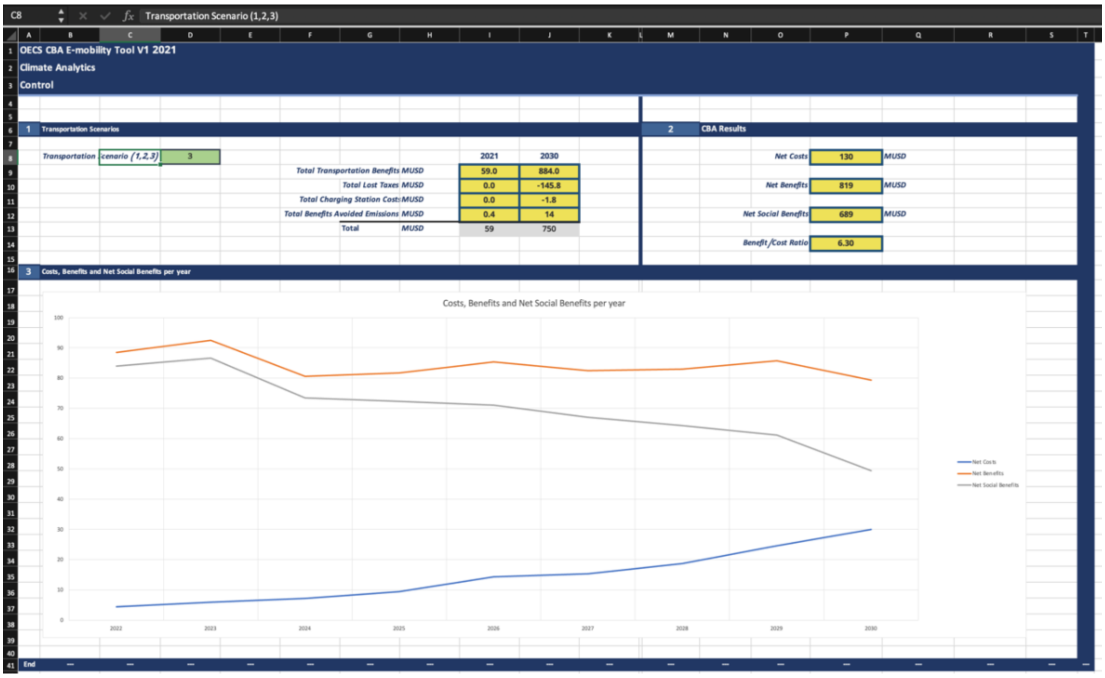
Vehicle Type	Price (2021)	Sensitivity	Price	Price Increase per year	Env. Levy	CSC	Excise Tax + Duty	VAT	License Fees (Charged yearly per vehicle)
	USD		USD						XCD
Cars	21,150	50.0%	31,725	2.0%	2.0%	5.0%	34.0%	15.0%	255
Jeeps	27,500	0.0%	27,500	1.0%	2.0%	5.0%	45.0%	15.0%	365
Vans	35,250	0.0%	35,250	1.0%	2.0%	5.0%	55.0%	15.0%	575
SUV's	33,750	0.0%	33,750	1.0%	2.0%	5.0%	55.0%	15.0%	255
Buses	56,250	0.0%	56,250	1.0%	2.0%	5.0%	55.0%	15.0%	575
Electric Cars	35,250	50.0%	35,250	-5.0%	1.0%	2.5%	17.0%	15.0%	255
Electric Jeeps	45,833	0.0%	45,833	-3.0%	1.0%	2.5%	22.5%	15.0%	365
Electric Vans	58,750	0.0%	58,750	-3.0%	1.0%	2.5%	27.5%	15.0%	575
Electric SUV's	56,250	0.0%	56,250	-3.0%	1.0%	1.3%	27.5%	15.0%	255
Electric Buses	72,500	0.0%	72,500	-3.0%	1.0%	1.3%	27.5%	15.0%	575

Figure 16 – Sensitivity Changes Exercise

11.3.3 Exercise 3 – Changing between scenarios

This exercise will exemplify how to change between different scenarios and show different results depending on each scenario assumptions.

1. Go to the *Control* sheet.
2. Cell D8 controls the scenario chosen and can be changed between values one, two or three, representing each scenario 1 or BAU, Scenario 2 and 3. If we change the value, the results will automatically be shown in this same tab, including the Net Social Benefits and Benefit/Cost ratio for the chosen scenario.



Transportation Scenario (1,2,3)

OECS CBA E-mobility Tool V1 2021

Climate Analytics

Control

1 Transportation Scenarios

Transportation Scenario (1,2,3) 3

		2021	2030
Total Transportation Benefits	MUSD	59.0	884.0
Total Lost Taxes	MUSD	0.0	-145.8
Total Charging Station Costs	MUSD	0.0	-1.8
Total Benefits Avoided Emissions	MUSD	0.4	14
Total	MUSD	59	750

2 CBA Results

Net Costs	130	MUSD
Net Benefits	819	MUSD
Net Social Benefits	689	MUSD
Benefit/Cost Ratio	6.30	

3 Costs, Benefits and Net Social Benefits per year

Costs, Benefits and Net Social Benefits per year

*Figure 17 – Control sheet with scenario 3 chosen in cell **D8***

Figure 17 shows the control tab with scenario 3 chosen and the results after doing all the exercises in this annex.