Economic Impact of E-Mobility Transition in St. Vincent and the Grenadines

Final Report

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Acronyms and abbreviations

BAU	Business-as-usual
BOP	Balance of payments
CO_2	Carbon dioxide
EV	Electric vehicles
GDP	Gross domestic product
GHG	Greenhouse gas emission
GNI	Gross national income
ICE	Internal combustion engine
INDC	Intended Nationally Determined Contribution
k	Kilo (=1,000)
NPV	Net present value
RE	Renewable energy
RES	Renewable energy source
RES-E	Electricity produced from renewable energy source
SVG	Saint Vincent and the Grenadines
t	tonne
TCO	Total cost of ownership
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
VINLEC	St. Vincent Electricity Services Ltd.

Executive Summary

Can the early adoption of electric vehicles in St. Vincent and the Grenadines (SVG) have positive economic impacts for the economy? Are there synergies to be exploited with the renewable energy market? What enabling conditions would be needed to foster a transition to electric mobility? These are some of the questions that this study seeks to assist in answering.

Like many countries in the Caribbean, SVG relies primarily on imported fossil fuel for its energy needs; fossil fuels represent over 90% of the country's primary energy supply. The impacts on the wider economy of such heavy dependency include: vulnerability to global oil price fluctuations and oil supply availability; and significant expenditure on imported energy, which represents roughly 20% of all import expenditure. The transportation sector accounts for the largest share of the country's imported energy, but diversification in this sector has traditionally been hampered by a lack of economically viable substitutes for conventional fossil fuel-based technology. Electric vehicle technology is however approaching cost competitiveness, and possesses characteristics suited to transportation needs in many small island states; if coupled with renewable energy as the source of electricity, it offers the potential to significantly reduce fossil fuel dependence and the associated negative impacts.

This study investigates the economic impact of an accelerated transition to electric vehicles, particularly in conjunction with an electricity sector based on significant shares of renewable sources of energy. The study also looks at feasible pathways for the government to pursue such a transition. The accelerated transition involves a push towards 100% share of electric vehicles in private motor car purchases by 2020, sustained through to 2040, compared to the expected situation, for the same time period, in the absence of a push for electric vehicles.

Results suggest that fossil fuel savings from early adoption of electric vehicles in the private motor car fleet alone, achieve 6.5 million USD cumulative foreign exchange savings for SVG between now and 2040. When EV adoption is coupled with renewable-based electricity, cumulative foreign exchange savings from early EV adoption increase from 6.5 to 10 million USD. EV adoption will also result in a lower total cost of ownership[1] (TCO) for car owners. Cumulative net savings in the economy from early EV adoption amount to 20 million USD; these savings will improve the spending power of households in SVG and results in an equivalent benefit of 20 million USD to the SVG society. Furthermore, EV adoption could facilitate a more efficient and stable grid network operation, leading to savings in utility costs and, by extension, lower electricity prices for all consumers. Avoided greenhouse gas emissions from early EV adoption are estimated to be 190-210,000 tons CO_2/y.

Achieving the transition towards electric vehicles would require raising awareness amongst the general population, as well as incentives to overcome the barrier posed by the higher upfront purchase price

[1] Total cost of ownership is the lifetime cost of owning a vehicle, including the cost of purchase, cost of fuel/energy to operate the vehicle, and the costs of maintenance

of EVs in the market, likely through excise tax reductions. **The cost of such an incentive is estimated to be 16 million USD. This cost is largely outweighed by the 20 million USD benefit to society from early EV adoption.** Should the government nonetheless seek to raise funds for the incentive programme, this could be achieved through the introduction of a visitor tax of 9 USD per visitor entry (or exit) to St. Vincent and the Grenadines. Further investigation into time-of-use electricity rates for the incentivisation of EV adoption, and towards more efficient grid operation, is recommended. Finally, policy measures would be needed to clarify the taxation framework as it relates to road tax for EVs, as the current framework currently does not cover the case of EVs.

1 Introduction

Like many islands in the Caribbean, St. Vincent and the Grenadines (SVG) rely primarily on imported fossil fuel for its energy needs. Fossil fuels represent over 90% of the country's primary energy supply. The implications for the wider economy of this heavy dependency include: vulnerability to global oil price fluctuations and oil supply availability; and high cost to society, with fossil fuel expenditure representing roughly 20% of all import expenditure.

As a consequence of this heavy dependence, SVG, like many Caribbean islands, has started to explore the use of renewable sources of energy. Total installed capacity in SVG is approximately 59 MW, of which roughly 6 MW is renewable energy capacity. Renewable energy penetration in the electricity sector, primarily from hydro-electric power stations, stands at roughly 12%. Solar power accounted for about 0.8 MW (1%) of installed capacity in mid-2015 and exploration into geothermal energy reserves is currently underway, with a view to starting first production in 2018. Fossil fuel substitution in the electricity sector is on its way.

However, energy diversification in the transportation sector, starting with road transportation, will also be key to achieving greater energy independence. Saint Vincent and the Grenadines has a population of 109,460, and a gross national income (GNI) per capita of USD 6,670 in 2015 (World Bank, 2015). In 2014, a total of 28,368 motor vehicles were recorded for the country, of which 20,308 (72%) were cars and 4-wheeled light-duty vehicles (World Health Organization, 2015), or roughly 1 for every 5 persons in the country. Between 2008 and 2015, registration of new vehicles rose 93%, despite GDP growth showing a contraction during this period.

Energy diversification in transportation is hampered by a lack of economically viable substitutes for fossil fuels, or a need to retool the transport sector to accommodate alternative fuel or non-fuel based vehicle technology. Alternatives for road transport generally fall into two categories: alternative liquid fuels, such as biofuels that can perform well with existing internal combustion engine (ICE) vehicle technology; and new energy vectors, such as hydrogen and electricity, which require a new motor technology such as an electric one. Biofuels for transportation are liquid fuels which are derived from plant matter. They are closer to market readiness than hydrogen, however, their widespread use for transportation poses other challenges, including land competition for other uses such as food-based agriculture. Hydrogen-based transport technology still has significant advances to make to reach competitiveness, and is not expected to reach market readiness for another 10-20 years; moreover, hydrogen-based technology requires massive changes in transport infrastructure, not just at the level of vehicles but for fuel (hydrogen) delivery as well. Electric vehicles (EVs) are currently the most likely alternative to fossil fuel-based (gasoline, diesel) vehicles in the near term. EVs do not require the extent of infrastructure overhaul that hydrogen-based vehicles do, are readily available on the market, and are expected to be fully competitive with ICE vehicles in less than 10 years. Given the progression of SVG's electricity mix towards greater renewable energy integration, EVs are well positioned to be a low fossil-fuel alternative. EVs are already in application in several Caribbean countries: there are over

100 electric vehicles and a charging network in Barbados, as well as smaller initiatives in Grenada and St. Vincent, and more recently Jamaica, involving a few electric vehicle units each.

Transitioning away from fossil fuels also has positive implications for greenhouse gas emissions. Whilst SVG is not a large emitter of greenhouse gases, it has committed to an economy-wide reduction of 22% in greenhouse gas (GHG) compared to its business as usual (BAU) scenario for 2025. SVG had total greenhouse gas emissions of 407,199 metric tonnes of CO_2-equivament in 2010. An electricity-based transportation sector, grounded in a high renewable energy penetration grid, will also contribute to achieving this emission reduction objective.

The total land area of SVG is 389 sq km, the majority (344 sq km) on the island of St Vincent, where there are approximately 829 km of roads. Typical travel distances on the islands are relatively small. For instance, on the main island of St. Vincent, the distance from Kingstown, the capital, to New Sandy Bay Village on the North East tip of the island, is only 44km; and from the capital Kingstown to the furthest accessible point by road in the North West area of Wallibou, it is only 40 km. With such short distances, EVs can be successfully introduced without a significant charging infrastructure.

The objective of this study is to determine the economic impact of an accelerated transition to electric vehicles, in particular as regards the cost of fossil fuel imports, but also with respect to efficiencies that may be achieved elsewhere in the economy. The study also seeks to determine feasible pathways for effecting an accelerated transition to electric vehicles, by identifying government interventions that can foster a transition and interventions to maintain fiscal neutrality in fostering such as transition. The aim is to support the government of St. Vincent and the Grenadines in its decision-making regarding a transition to electric mobility solutions.

The report is structured as follows: the next section of the report, section 2, outlines the methodological approach of the study; section 3 provides the results from survey and economic modelling; and section 4 provides conclusions and recommendations ensuing from the findings.

2 Approach

The study evaluates macroeconomic impact due to accelerated adoption of electric vehicles compared to what is expected would be the natural rate of adoption, the so-called "business-as-usual" (BAU) scenario. Accelerated adoption refers to an adoption rate (or demand for electric vehicles) beyond the normal (BAU) pace of adoption; this accelerated or early adoption is achieved through the introduction of an external stimulus, such as a government intervention or incentive (as described in section 2.3) – generally to reduce the relative cost of the EV compared to the conventional fossil fuel alternative – which acts in the market to change the supply-demand dynamics in favour of EV adoption, or increased EV demand, earlier. These adoption scenarios are described in further detail in section 2.3. The macroeconomic impact is evaluated primarily from the perspective of savings in fossil fuel expenditure, and by extension on SVG's balance of payments. The balance of payments is the accounting ledger of all payments made into and out of a country over a given period. As fossil fuel savings is a key indicator in the macroeconomic impact assessment, the extent of renewable energy

(RE) penetration in the electricity grid, and by extension in an EV car market, is of central importance, and will be examined through various scenarios of RE penetration, as explained in section 2.4.

Macroeconomic impact is also evaluated from the perspective of savings elsewhere in the economy, in particular at the level of the consumer, who stands to benefit from lower running costs (and potentially lower overall costs), from energy expenditure, due to owning an electric vehicle compared to a fossil fuel (gasoline, diesel) vehicle. Finally, savings in greenhouse gas emissions, are also evaluated, in the context of SVG's international climate change commitments.

The extent of the macroeconomic impact of EV adoption, naturally depends directly on the scale of adoption; and the timing of the macroeconomic impact depends directly on the pace of the adoption, or demand. The study requires a two-part approach:

1. Estimation of the demand, under BAU and under early adoption
2. Estimation of the economic impact associated with the demand levels

With demand established for the BAU situation, and the accelerated adoption scenario, the macroeconomic impact resulting from each level of adoption can then be evaluated and compared.

The analyses and results for all monetary values is expressed in Unites States Dollars to facilitate ease of reference and accessibility of the results of the study beyond SVG, in particular to other Caribbean and small island states who can use this case as a reference. Given the existence of a fixed exchange rate between Eastern Caribbean Dollars (ECD) and Unites States Dollars (USD) the results are easily translated into local currency. In addition, all values are expressed in constant 2015 dollars[2].

2.1 Scope of the market

The particular market segment which is studied is that of road transportation, and in particular the passenger car market as, in the short to medium term, EV is primarily an alternative in this market (versus larger vehicle markets e.g. SUV, vans, trucks etc.). In order to be able compare the demand dynamics for an electric vehicle versus a fossil fuel based vehicle in this market, reference products, or reference vehicles in this case, are used. Reference products are used to be able to draw a comparison between two broad classes of products, each of which subsume a number of differentiated products, by assuming that on average the dynamics between the two reference products will be representative of the dynamics between the two product classes as a whole. The reference vehicles were decided based on consultations with key stakeholders in SVG[3]. The sedan car was deemed to be most representative of the passenger car market, and the reference vehicles selected for each vehicle type were:

- Fossil fuel/ICE car: gasoline Toyota Corolla

[2] Purchasing power of the dollar changes over time, due to inflation; the use of constant dollar values corrects for inflation, allowing comparison of dollar values between different years

[3] An electric mobility workshop was held by the Energy Unit of St. Vincent and the Grenadines in June 2016, to sensitize stakeholders, in energy and transportation sectors, on electric vehicles and obtain feedback on parameters for this study. During the course of the workshop, the reference technologies for the study were discussed and identified in consultation with the stakeholders

- Electric vehicle: Nissan Leaf

The main techno-economic characteristics of the reference vehicles are outlined in Table 9 of the Appendices.

The total number of vehicles registered in SVG was estimated at 28,368 in 2014 (WHO, 2015). According to data from the Inland Revenue Service, roughly 39% of all vehicle imports are classified as cars[4]; by extension. The transition towards electric mobility is therefore studied for this segment of the market.

The total number of cars on the market is projected to evolve with time according to the relationship:

$$\text{No. cars}_{t} = (1-d) * \text{No. cars}_{t-1} + \text{No. imported cars}_{t} \qquad \text{Equation 1}$$

Where d represents the depreciation rate, or the rate at which cars reach the end of their economic lifetime and are retired from the market. The depreciation rate is taken to be 3.8%, based on data on car stocks in 2008, 2011, and 2015 (WHO, 2009; WHO, 2013; WHO, 2015), and on data regarding vehicle importations over the period from the Inland Revenue Department. With the stock of cars known for 2008, it was possible to determine the rate at which cars would have left the road in order for the calculated evolution in car stock from 2008 to 2011, and from 2011 to 2015, to be consistent with the data, given year-on-year car importations. The number of imported cars, on average, in a given year is greater than the number coming to their end of life and leaving the road. Thus the total number of cars increases with time; this trend is projected to continue over the medium term, and thus for the period of analysis.

2.2 Characterizing the demand

The demand is expressed in terms of the relative demand for electric vehicles (Nissan Leaf) in the entire car purchase market (the total number of cars demanded each year, all technology types combined). The car purchase market is approximated by the number of cars imported for sale on the local market (as no vehicles are manufactured in SVG, the demand equation speaks to the vehicle import market). The (relative) demand for electric vehicles is therefore expressed as the proportion of car imports which are expected to be EVs. That is to say, it is assumed that the demand for electric vehicles will result from individuals who are looking to purchase a vehicle in the first place, and who are therefore making a choice only to buy an electric vehicle over a conventional gasoline one. The factors influencing the choice of, or demand for, EV vs gasoline car are outlined below.

The literature identifies the demand for electric vehicles as being influenced by a number of factors, including: upfront cost, energy (electricity) costs, driving range, availability of charging infrastructure (see for example Hidrue et al 2011 and Sheperda et al 2012). This is corroborated by the results of a consultation[5] conducted with stakeholders in SVG, which indicated the following key decision factors when purchasing a (any) vehicle:

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[4] This is based on figures for the period 2011 to 2015

[5] Conducted during the electric mobility workshop referred to in footnote 3

- Cost-related factors such as upfront purchase cost, fuel/energy costs, maintenance costs
- Non-cost related factors such as reliability (proven time on the market), safety acceleration, range, aesthetics, ease of servicing/parts, and user features.

The factors identified during the consultation, as having the greatest weight in decision making were however narrowed down to up-front cost, running cost (fuel and/or maintenance) and reliability.

A survey was conducted amongst a broader group of stakeholders to support the demand premise from the literature and from preliminary consultations. This survey was developed online and administered via email through the Energy Unit of St. Vincent and the Grenadines to their network of contacts, which included public service employees, employees of the national utility St. Vincent Electricity Services Ltd. (VINLEC), as well as academia and technical persons. In addition to questions related directly to demand dynamics, the survey sought information to establish the context in which responses were made (level of awareness of respondent; respondents' concerns regarding electric vehicles), as this could have an indirect influence on the demand expressed. Forty-one responses were received from the survey. Questions focused on: characterizing the type of respondent e.g. according to income, level of awareness regarding EVs; identifying concerns regarding electric vehicles; establishing willingness to pay, and thus demand, for EV.

Once the EV demand relationship was established – describing determinants of EV demand and their relative weight in the demand – it was possible to identify the determinants which can be influenced through government intervention, and which are likely to have the most significant impact in accelerating EV adoption beyond the BAU rate. The demand equation was therefore used as the basis for identifying possible government interventions.

2.3 EV adoption scenarios

Two main scenarios are considered for the analysis. The first is the business as usual (BAU) scenario, which reflects the evolution of the demand for EVs in the absence of any government intervention or incentive towards EVs. The second is the accelerated adoption scenario, in which a specified government intervention is used to stimulate EV demand, namely through reducing the relative cost to the consumer of the EV compared to the ICE alternative. The approach of cost reduction for accelerating demand was based on the results of the stakeholder consultation exercise. Government interventions can therefore be of the following types:

1. An intervention which acts so as to reduce the cost of EVs compared to the status quo
2. An intervention which acts so as to increase the cost of ICE cars compared to the status quo
3. An intervention which combines both of the above

Based on feedback from stakeholders at an electric mobility workshop held during the course of this study, option 2 above, which would likely raise the cost of gasoline cars compared to the status quo, would not be expected to be socially acceptable. Option 1, which is effectively a subsidy on the EV cost to the consumer, is the primary method investigated. Option 3, which would still raise the cost of gasoline cars but perhaps to a lesser extent than option 2, is studied as part of a solution for achieving fiscal neutrality in the application of the subsidy (refer to section 2.5)

The primary method investigated for the government intervention is a reduction in import taxes on EVs. The advantage of effecting the subsidy through import taxes is the simplicity of implementation, compared to other subsidy mechanisms such as ICE buy-back programmes, differentiated electricity rates for EV owners. Moreover, the level of the subsidy which can be provided is relatively significant, compared to other means such as licensing fees and road taxes, which if reduced could feasibly reduce overhead costs for EVs but by themselves would not be sufficient to close the cost gap between EVs and gasoline cars in a manner substantial enough to significantly affect demand.

It should be noted that the study does not consider investment in public charging infrastructure, which may foster the transition towards electric mobility, as it is not possible to quantify the relationship between such investment and the demand with any confidence. It is therefore assumed that the absence of such a charging infrastructure does not negatively or significantly impact the demand.

The scenarios are conducted for the period 2016 to 2040. However, government subsidies are only taken to apply up to 2025. This is because electric vehicles are expected to become competitive on a total cost of ownership basis by 2025 (McKinsey 2010), and according to some projections, perhaps even solely on the basis of upfront cost by 2025 (see for example IEA 2013; Seba 2014). The period of accelerated adoption, through the application of subsidies, is therefore the period leading up to 2025; after this point in time, subsidies are removed and the rate of adoption reverts to that which would exist at prevailing (unsubsidised) market prices for EV and gasoline cars.

2.4 Renewable energy penetration

The ability to integrate increasing amounts of indigenous sustainable energy sources into SVG's transportation sector, through a transition to electric mobility, will be critical if the country is to realise significant fossil fuel savings and greater energy independence. Current installed capacity is 59MW, of which 6MW is from renewable energy sources (RES). However, renewable energy (RE) potential in SVG far exceed these. RE potentials are estimated at 10 MW for hydroelectric power, 8MW for wind, 100-890 MW for geothermal and 23 MW for solar, and the country has set RE targets of 30% by 2015, and 60% by 2020 (Ochs et al, 2015), based primarily on the anticipated implementation of geothermal.

The macroeconomic impact of accelerated EV adoption, in terms of fossil fuel savings, will change significantly if renewable energy, in particular geothermal, is implemented. Moreover, the question of *when* additional RE capacity is installed has a significant impact on the macroeconomic case: if significant RE penetration occurs during the period of the envisaged EV push (to 2025), it enhances the macroeconomic case for an accelerated transition; however, if RE penetration occurs mainly after 2025, the macroeconomic case for transitioning earlier is lowered.

The projected electricity demand will also impact fossil fuel consumption, and the level of RE penetration.

The average annual growth rate in electricity demand between 2002 and 2012 was roughly 3%, with year-on-year growth values ranging between -2% and 11%. Growth in 2002 was roughly 5%, followed by much higher growth rates of 11% and 9% in 2004 and 2005 respectively, however, since 2006, growth has been much lower, averaging 1.1% between 2006 and 2012, with 2008, 2010 and 2011 showing negative growth rates. Given the wide range of growth rates observed over the period, with apparent outliers in 2004 and 2005, it was decided to use the median growth rate for the period 2002-2012, which was 2.3%. Overall electricity demand is therefore assumed to increase by 2.3% per year from 2015 to 2040 – this applies for the electricity demand that would exist in the absence of electric vehicles, hereafter referred to as the "zero-EV" demand level. The introduction of electric vehicles on the market would increase the zero-EV demand for electricity, by an amount roughly equal to the annual consumption of the EV, times the number of EVs in the market[6]. For both BAU and accelerated EV adoption scenarios, therefore, the zero-EV electricity demand is adjusted in each year by the amount required to accommodate the calculated electricity needs of the EVs in the market, for the given scenario of EV adoption. Figure 1 shows the projected electricity demand in the case of EV adoption under the accelerated adoption scenario, compared to the zero-EV demand level.

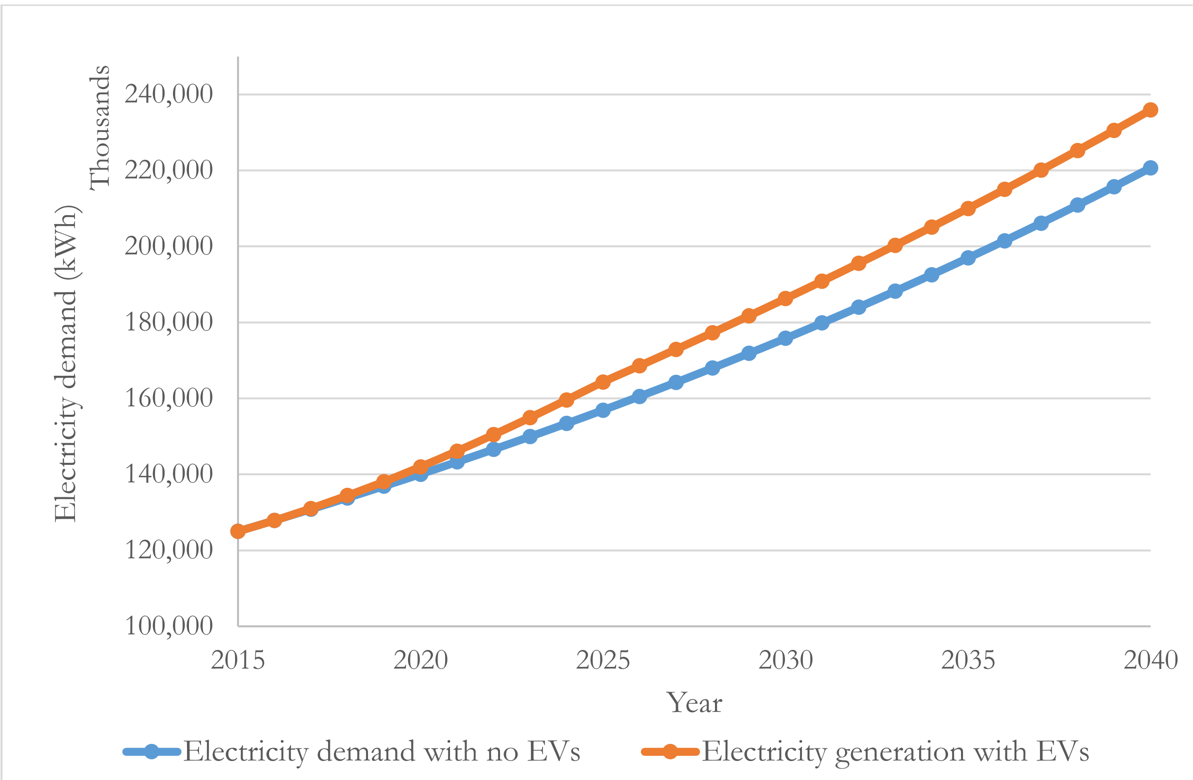


Figure 1: Projected electricity demand with and without EV

The analysis is conducted for two possible outcomes for RE penetration:

1. Geothermal energy does not come on stream in the considered time horizon, and the only sources of RES in grid-based electricity are hydro and solar. Hydro capacity remains at 2015 levels, and solar PV capacity increases to 2.5 MW in 2020 and 7.5 MW in 2040, with

[6] An allowance is also made for grid losses when determining the additional electricity demand that would be required to accommodate EVs. Grid losses are assumed to be 8.7%, as stated in the document Sustainable Energy for SVG: The Government's National Energy Policy. Mar. 2009

corresponding RES-E penetration increasing from its current level of 12.2% to 13.8%[7] in 2020, and subsequently decreasing to 12% in 2040 with increasing electricity demand

2. In addition to solar PV capacity additions from the ouctome above, 15 MW of geothermal capacity is added to the grid by 2020, subsequently upgraded to 20MW in 2030, with a corresponding increase in RES-E penetration from 12.2% currently to 78% in 2020, subsequently decreasing to 64% by 2040, as overall electricity consumption rises

Underlying the analyses regarding RE penetration in electricity used for transportation, is the assumption that the primary means of EV charging will be through the grid infrastructure, rather than through stand-alone charging stations e.g. solar carports.

2.5 Fiscal neutrality

The study also seeks to establish potentially fiscally neutral means of enacting government incentives/subsidies to achieve accelerated EV adoption. Achieving fiscal neutrality means that public finances that would be used to fund a subsidy scheme for EV adoption, would have to be raised elsewhere in the budget. The following financing options are investigated as sources of revenue to fund an EV subsidy scheme:

- Taxation of gasoline sales
- Levy on imported gasoline cars
- A tax on a good not related to the transportation market

3 Results

3.1 Demand factors

The results of the survey highlights a number of concerns by consumers, which indicate that they do not yet readily embrace electric vehicles as a transportation alternative (refer to Table 1). Generally, the participants displayed a relatively a high level of reserve regarding EVs. The primary concerns highlighted are: the upfront purchase price; the availability of parts and servicing; and the availability of a charging infrastructure. To a lesser extent consumers indicated concern about electricity cost, and range. The electricity cost is somewhat unexpected, as EV are more energy efficient than gasoline cars on a tank-to-wheel basis and have lower annual energy costs than gasoline cars; this signals a lack of awareness regarding EV energy costs. The relatively high levels of concern regarding range and charging infrastructure also signals a lack of knowledge regarding EV adequacy given stated travel distances. Indeed 100% of respondents indicated that their average daily return commute (weekday or weekend) was less than 80 miles or 140 km (refer to Table 2), which is well within the range limits of the EV, even at existing levels of the technology. At the same time there appeared to be little concern regarding reliability and safety of EVs.

[7] Given that the additional RE penetration from solar PV generated electricity is only around 2%, there is not expected to be a significant impact on the grid in terms of grid stability and reserve requirements, nor on associated grid costs, as may be expected with higher penetrations of intermittent RES-E in the gird

Table 1: Primary concerns regarding EVs

Level of concern	Purchase price	Electricity cost	Range	Reliability/ Safety	Servicing/ parts	Charging infrastructure
1 (not at all concerned)	4.9%	2.4%	2.4%	4.9%	2.4%	4.9%
2	7.3%	4.9%	12.2%	19.5%	4.9%	7.3%
3	14.6%	14.6%	22.0%	39.0%	14.6%	12.2%
4	19.5%	34.1%	24.4%	17.1%	17.1%	24.4%
5 (extremely concerned)	53.7%	43.9%	39.0%	19.5%	61.0%	51.2%

Table 2: Typical distances travelled by respondents

Mileage	Weekday	Weekend
0-20	44%	59%
20-40	37%	29%
40-80	12%	10%
80-200	7%	2%
>200	0%	0%

As can be expected, willingness to pay is influenced by a number of factors. Willingness to pay was surveyed amongst participants of varying incomes, levels of awareness and levels of importance accorded to environmental factors. However, none of these factors was observed to have a significant impact on the decision to choose an EV. Willingness to pay was found to be most significantly influenced by the upfront purchase price and the range of the car, reflecting previously cited concerns about price, range and charging infrastructure. The majority of respondents surveyed indicated a willingness to pay level, for a new EV, which was lower than its current purchase price, and also lower than the current purchase price of a new gasoline car (most respondents indicated a willingness to pay for an EV of USD 35,000, compared to the current cost of USD 65,000 for an EV and USD 40,000 for a gasoline care) (refer to Figure 2). However, survey respondents' willingness to pay was observed to increase as the range of the EV increased, with the number of respondents willing to pay the same or more for an EV increasing from 13 (out of 41 respondents) at a range of 100-150 miles, to 16 at a range of 200 miles, to 21 (just over 50% of respondents) at a range of 300 miles.

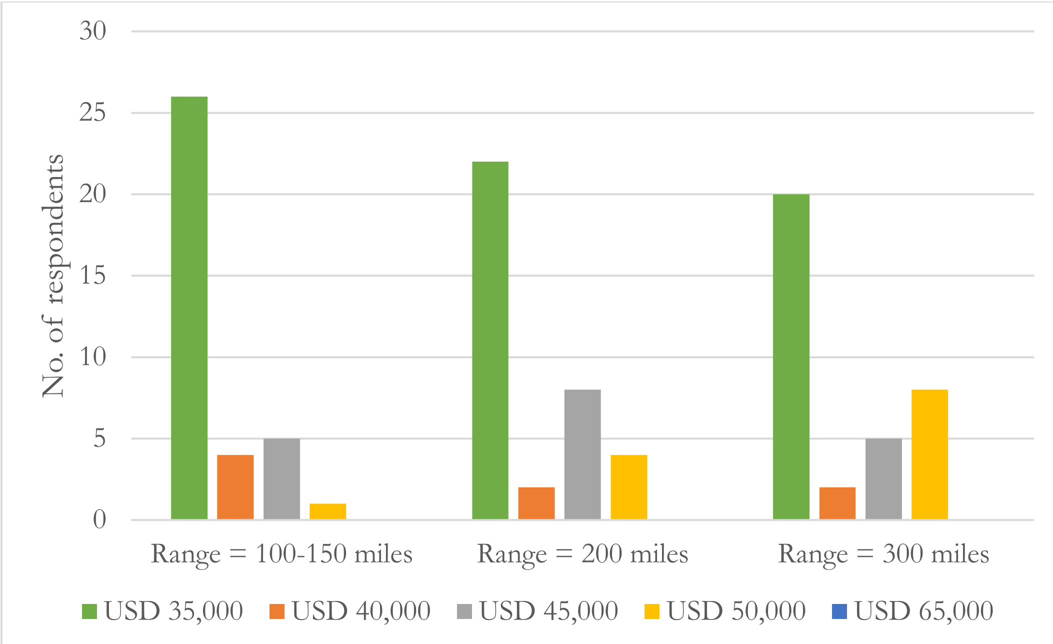


Figure 2: Willingess to pay for an EV at various ranges

Given the above, the demand for electric vehicles was assessed based on relative cost, and range. The range is in this case representative of technological progress with time; while the range of the EV for the current technology of reference is fixed, it is anticipated that this will improve with time as the technology improves. In this way, the demand equation also captures the impact of technological advances with time, not just through cost reduction, but also through the main performance criterion which is of concern to potential adopters, namely the range.

3.2 Assessing the demand

The potential demand for EV was assessed using the stated preference method to estimate willingness to pay. The method is usually used in areas of marketing management like pricing decision, or new product development, and tests price-response functions (demand)[8]. Respondents (potential consumers) were asked to state their choice of EV or gasoline car, each characterized by a particular set of attributes. In this case, the characterization focused on purchase price, range, maintenance and fuel/electricity costs; other attributes such as reliability, safety, availability of servicing/parts, and charging/fuel infrastructure were assumed to be similar for both car types. The choice of EV or gasoline car was tested for various purchase prices and ranges of EV; the attributes of the gasoline car were not varied.

Table 3 Attributes of both EV and gasoline cars used for the survey

Attribute	Gasoline vehicle	Electric Vehicle	Electric Vehicle	Electric Vehicle
Purchase price (landed vehicle)	40,000 USD (2016 price for reference car)	Various prices tested: 65,000 USD (2016 price for reference car), 50,000 USD, 45,000 USD, 40,000 USD, 35, 000 USD		

[8] See (Breidert et al, 2006) for a review of methods for measuring willingness to pay

Maintenance and fuel[9] costs	1,600 USD/yr	800 USD/yr	800 USD/yr	800 USD/yr
Range	480 km	200 km	320 km	480km
Representative year* (assumed from the year)	2016	2016	2020	2025

* The assumed year was not stated in the survey; various theoretical EV ranges, assumed to be representative of technological development for the stated years, were tested to determine the impact on consumer choice

The various EV purchase prices used in the survey are representative of hypothetical EV prices, which can be attained through the application of subsidies, or through cost reductions with time, or both. Given expected future cost reductions it is expected that the level of subsidy required to reach the EV purchase price that would be needed to encourage wide scale EV adoption will naturally fall over the passage of time.

Respondents were asked to indicate the highest price (amongst the purchase price options outlined in Table 3) they were willing to pay for an EV, over a gasoline vehicle, or at all, given the stated attributes of both cars. Based on the data collected on respondents' stated preference for EV at a particular price, it was possible to model , using simple regression, the demand (preference) for EV as a function of the difference in price between the EV and the gasoline car (referred to as the EV price delta) and the range of the car. The demand relationship can be taken to be applicable not just to the current situation, but also in the future as the EV performance improves, as reflected in its increasing range.

Regressions of demand as a function of awareness, income, and level of importance accorded to environmental issues, did not reveal a relationship, as indicated in section 3.1.

The relationship for EV demand was determined as follows:

Y = alpha + beta * (price delta) + zeta * (mileage)

Where Y = relative EV demand (% consumers choosing EV over gasoline (vehicle)

And, alpha, beta, zeta = constants (coefficients) determined from the regression, found to be 0.40526, $-5.301*10^{-5}$ and $5.232*10^{-4}$ respectively.

It should be noted that even when the price delta is zero or positive (meaning EV are equal in price or more expensive than gasoline) the demand for EV is positive.

As explained earlier, the demand relationship is expressed as the relative demand for EV or the proportion of imported passenger cars, from 2016, onwards which will be EV. Application of a subsidy acts to decrease the relative cost of EV to gasoline cars i.e. to decrease the "price delta" variable; as the coefficient of the price delta variable is negative, the lower the price delta, all else being equal the demand for EV will increase, and vice versa if the price delta increases.

The government incentive is applied through the excise tax; for our simulation, EVs are considered to be exempt from usual excise tax on vehicles. The current excise tax level on vehicle imports is 45%.

[9] Based on 10,000 km/year assumed travel

The effective subsidy accorded per imported EV for each year of the analysis period, with the excise tax exemption, is show in Figure 3.

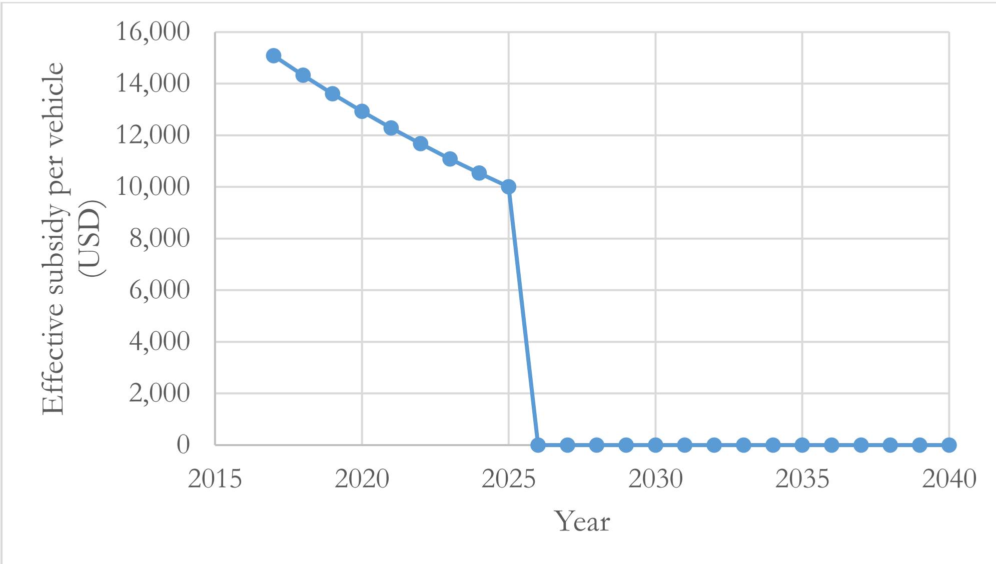


Figure 3: Effective annual EV subsidy, with excise tax exemption

As can be seen, the effective subsidy decreases in time as the EV price at import decreases with time as the EV approaches full market maturity. As stated earlier, the subsidy measure is only applied through to 2025, after which the EV is expected be competitive on the basis of upfront purchase price, the main decision criterion for consumers.

The impact of applying the excise tax exemption on the demand for EV in the import market for passenger cars is shown in Figure 4. With no incentive, EV adoption does not start until 2021, when the relative purchase price difference between EV and gasoline cars is low enough[10] to incite EV demand. Even with no subsidies the impact of decreasing EV costs with time, manifests itself in the demand, as the demand for EV increases as costs decrease. Applying the excise tax exemption accelerates the adoption of EV by SVG consumers, as it closes the price gap between EV and gasoline cars faster than can be achieved through technology cost reductions alone. With the application of the tax incentive, the demand for EV in the imported car market increases from 0% in 2016 to 25% in 2017, reaching 100% in 2024. On the contrary, without the incentive, demand for EV in the car import market remains at 0% until 2021 when it reaches almost 12%, getting up to only 66% by 2025. In both cases, the demand remains steady at a level of 66% after 2025, when the subsidy has been stopped.

[10] Based on the demand curve

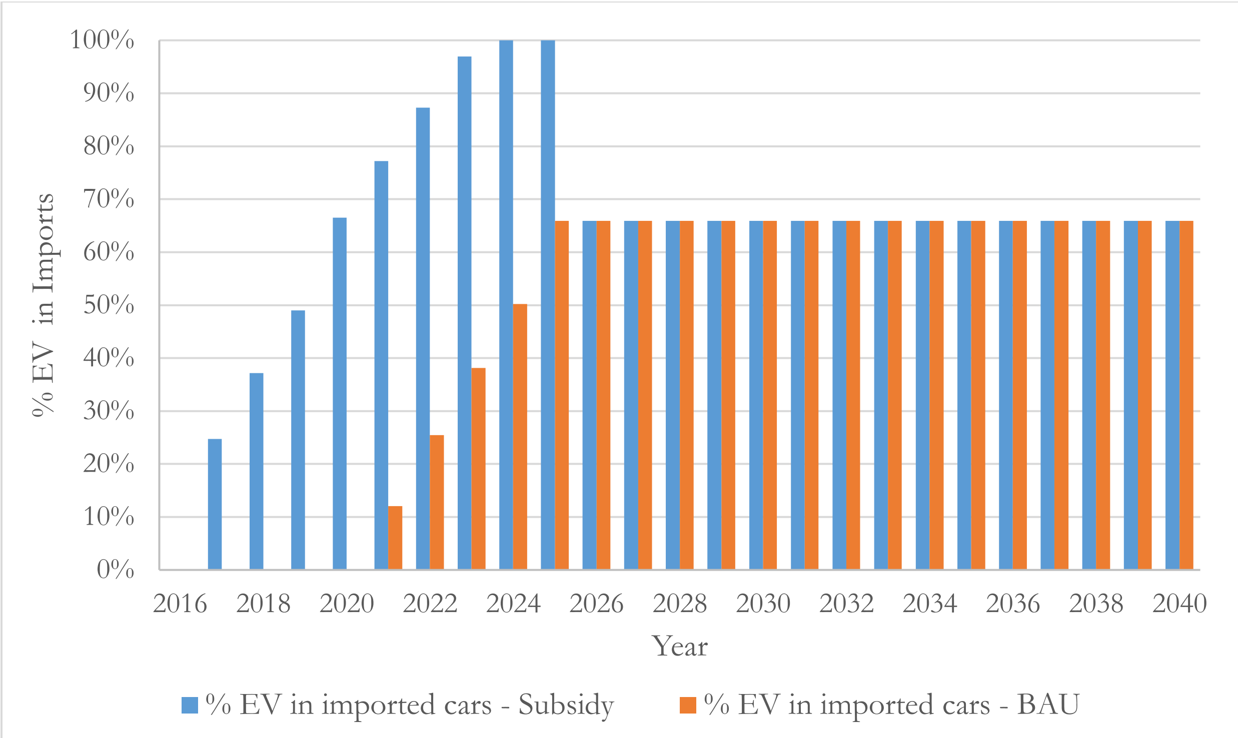


Figure 4: Proportion of EV in the passenger car import market with and without incentives

It should be noted that the figure shows the theoretical demand, under conditions of perfect information; this explains why the demand for EV in imports jumps instantaneously from 0% to 12%, in the case of no subsidy, and from 0% to 25% in the case of the subsidy. Real markets have a lag time for information to reach the market, however, for the purpose of the analysis we assume perfect information[11]. As the lag time would apply to both the BAU and the subsidised situations, the conclusions from the results, which reflect a comparison between the two scenarios (both affected by a lag situation), would still be valid[12].

In terms of the impact that EV uptake in new car purchases has on the conversion of the overall fleet from gasoline (ICE) to electric mobility, the penetration of EVs in the fleet as a whole, as distinct from the share of the imports, is necessarily more gradual, as shown in the Figure 5 below. This is expected as a car has an economic lifetime of about 15 years, and users would not be expected to dispense with (and potentially replace) a car – EV or ICE – before that lifetime has been reached. This creates a certain inertia in the car market, as a significant part of new car purchases results from replacement of vehicles at their end-of-life[13]. This essentially limits the rapidity and extent to which the fleet of gasoline (ICE) cars can be replaced with electric vehicles – as can be seen from the figure,

[11] There is not sufficient information to determine the lag time that might apply; this lies outside the scope of the present study

[12] The result could be expected to shift in time but not in the magnitude of the difference between the two scenarios

[13] The remainder of new car purchases would result from first-time buyers and, to a lesser extent, persons buying a second or third vehicle to add to their existing vehicle fleet.

by 2040, the penetration of EVs in the overall car fleet is only 40% despite EV constituting the majority of imports for several years prior.

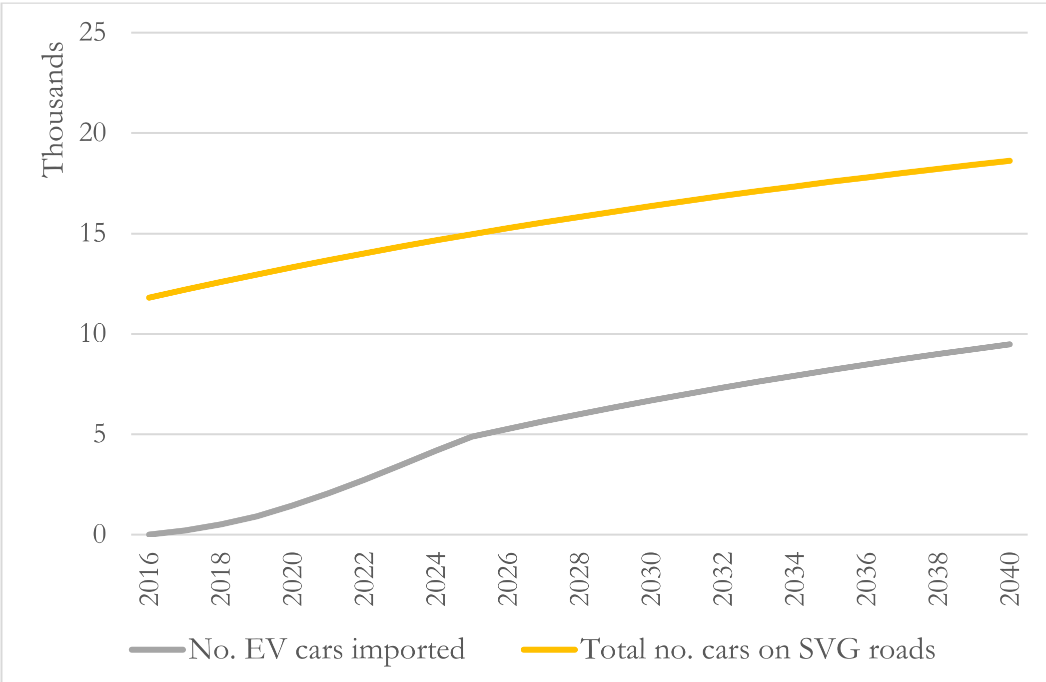


Figure 5: EV penetration in the overall SVG car fleet

3.3 Economic Impact

As outlined earlier, the impact on the country's economy is analysed using the following indicators:

- Fossil fuel expenditure
- Balance of payments
- Efficiencies in the energy economy, namely total cost of ownership for car owners
- Greenhouse gas emissions

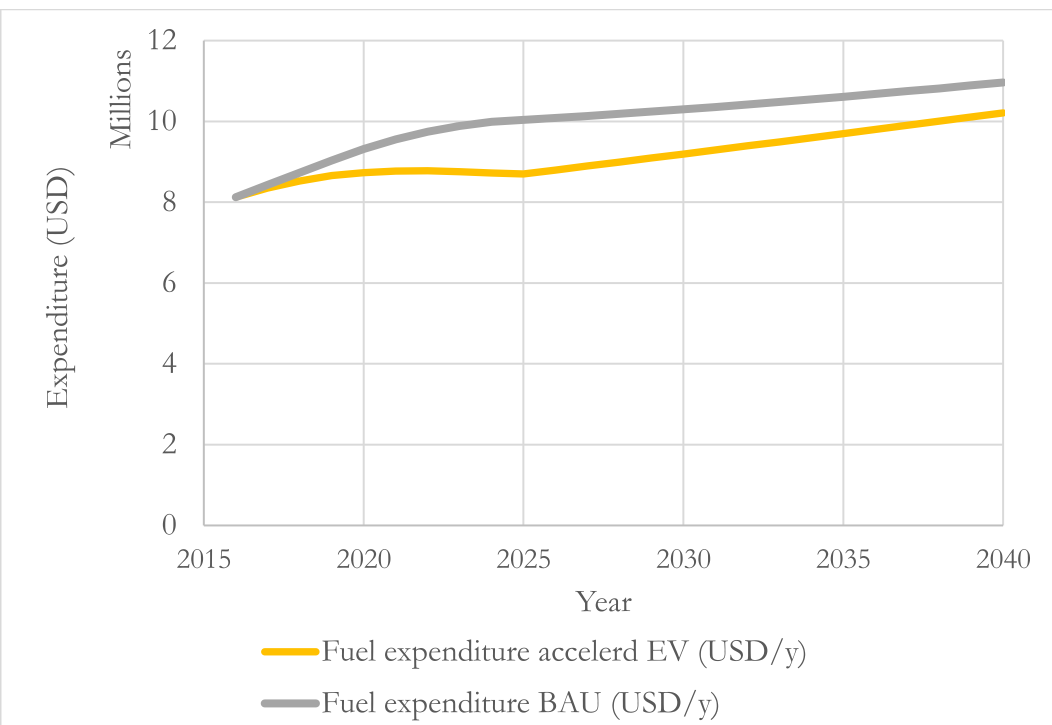
The impact is estimated for two possible outcomes for the penetration of electricity from renewable energy sources (RES-E) in the electricity market, as described earlier:

1. RES-low outcome: No geothermal electricity generation; new RE capacity additions come from solar PV capacity which increases to 2.5 MW in 2020 and 7.5 MW in 2040, with corresponding RES-E penetration increasing from 12.2% in 2016, to 13.8% in 2020, then falling 12% in 2040
2. RES-high outcome: Geothermal electricity generation is realized with 15MW of capacity added to the grid in 2020, upgraded to 20MW in 2030, and solar PV capacity additions follow the same trend as outcome 1. Overall, RES-E penetration increases from 12.2% in 2016, to 78% in 2020, and falling to 64% by 2040.

3.3.1 Fossil fuel expenditure

Assessment of fossil fuel expenditure includes purchases of gasoline for the evolving stock of gasoline cars, under both BAU and accelerated EV scenarios, as well as that of diesel for the production of electricity to the grid, from which EV are assumed to be charged. Diesel and gasoline prices are assumed to evolve in line with projections from the Energy Information Administration's fuel price projections for 2015 onwards.

Under the low RES-E outcome, expenditure on imported fossil fuels reaches 11 million USD/yr by 2040 under the BAU, and 10.2 million USD/yr under the accelerated EV adoptions scenario, as shown in Figure 6. Fossil fuel expenditure increases over time due to the projected increase in total number of cars on the road (gasoline and EV) as explained in section 2.1 – under the low RES-E outcome the energy source for electricity for EVs is primarily diesel, so the greater number of EVs and gasoline cars with time will result in increased diesel and gasoline consumption respectively. Due to the projected trend in gasoline and diesel prices this results in increased expenditure over time. However, fossil fuel consumption, and thus expenditure, under the accelerated EV scenario is at all times lower than that under the BAU. This is because EVs have greater fuel efficiency compared to the incumbent ICE technology – the higher proportion of EVs in the accelerated EV scenario therefore results in less overall fossil fuel consumption, and expenditure, compared to the BAU. For the reference cars assessed within this study, average annual diesel consumption of an EV is calculated to be roughly 320 litre/y[14] compared to roughly 780 litre/y for a gasoline car.



[14] For an assumed annual distance of 10,000km, and with 13% RES-E penetration in the grid (as estimated for 2016)

Figure 6: Expenditure on fossil fuel imports under low RES-E outcome

Increased displacement of fossil fuels in the electricity generation mix with renewable sources of energy will enhance the fossil fuel savings to be achieved through EV adoption, as shown in Figure 7.

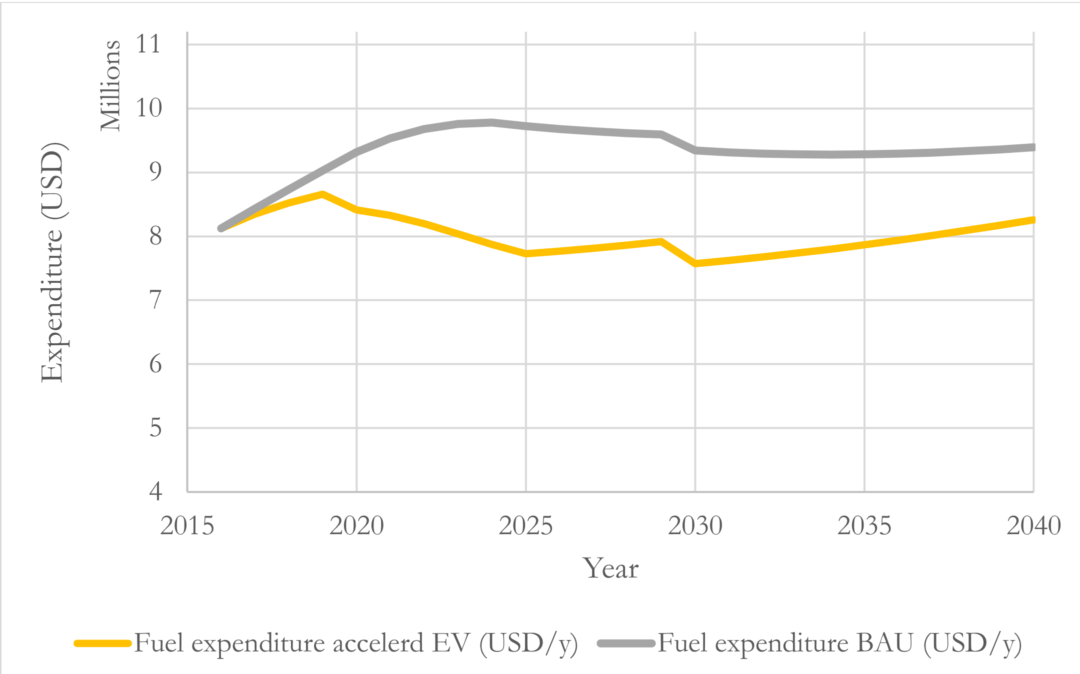


Figure 7: Expenditure on fossil fuel imports under high RES-E outcome

Under the high RES-E outcome, the fuel import bill for passenger cars stands at 9.4 million USD/yr in 2040 under BAU, compared to 11 million USD/yr under the low RES-E outcome. Under the accelerated EV adoption scenario the fuel expenditure is 8.3 million USD/yr, compared to 10.2 million USD/yr under the low RES-E outcome.

The main conclusions from the above are therefore: 1) accelerated EV adoption can produce annual savings of 0.8-1.1 million USD/yr in fossil fuel expenditure by 2040, compared to the BAU 2) the high RES-E outcome has the potential to reduce fossil fuel expenditure by almost 2 million USD/yr by 2040, regardless of the EV adoption scenario.

The equivalent net present value (NPV) of fossil fuel expenditure over the period is computed for BAU and accelerated EV adoption rates, for the period 2016-2025, the period in which the excise tax exemption is granted, and for 2016-2040, the full analysis period. Table 4 shows the expenditure in both scenarios and the resulting savings achieved under the accelerated EV adoption case, compared to the BAU level of adoption. The net impact of fossil fuel savings in the accelerated EV adoption scenario is 9.6 million USD over the period 2016-2040, for the high RES-E outcome; this is equivalent to just over 1 years' worth of fossil fuel expenditure for the passenger car market. For the low RES-E outcome, the impact of fossil fuel savings is lower at 6.5 million USD over 2016-2040; the high RES-E outcome therefore produces a gain of 3.1 million USD in savings over the low RES-E outcome.

Table 4: NPV of fossil fuel expenditure

	2016-2025		**2016-2040**	
EV adoption rate	RES-low	RES-high	RES-low	RES-high
BAU adoption	56 mill USD	55.7 mill USD	86.5 mill USD	83.4 mill USD
Accelerated EV adoption	52.6 mill USD	50.8 mill USD	80 mill USD	73.8 mill USD
Net saving on fossil fuel imports from accelerated EV adoption	**3.4 mill USD**	**4.9 mill USD**	**6.5 mill USD**	**9.6 mill USD**

3.3.2 Balance of payments

The impact on the balance of payments (BOP) is the net effect of external payments made in relation to the passenger car market, and incorporates not just external payments made for fossil fuel imports, but also for the vehicles themselves. The BOP analysis also considers external payments made for electricity with the implementation of geothermal energy as a source of grid-electricity. The analysis assumes that because of the capital investments involved, geothermal energy will be involve at least partial exploitation by foreign-owned companies, who then sell electricity to the utility VINLEC. Based on information received at the time of this study, it is assumed that geothermal exploitation will be done under a 30% state-owned and a 70% foreign-owned public-private partnership[15]. The geothermal-based electricity generated is assumed to be sold to VINLEC at a rate of 16 USc/kWh, based on prevailing estimates[16], and is imputed as a cost to VINLEC, at that rate, for the kWh of grid electricity which is calculated to be generated from geothermal energy in each of the RES-E outcomes. The cost to the government (as full owners of VINLEC and 30% owners of the geothermal energy) of acquiring these units of electricity are accounted for according to the payments that would effectively go to the foreign holding. Thus, 70% of all geothermal-generated electricity is assumed to be bought from foreign-owned entities using government funds, and is accounted for, in the balance of payments, as an external payment.

Table 5 shows the results of the net present value of the balance of payments situation under accelerated EV adoption compared to BAU adoption; negative values in the table represent net inflows (savings) on the BOP, whereas positive values represent net outflows on the BOP.

As the table shows, the net savings in fossil fuel expenditure of the accelerated EV case to the BAU case, is outweighed by net additional payments for EVs[17], due to the higher rate of purchase of EVs, along with its higher capital costs, during the period before market maturity (i.e. prior to 2025). However, the higher fossil fuel saving under the high RES outcome compared to the low RES outcome outweighs the external expenditure incurred for geothermal generated electricity under the

[15] Personal communications with the Energy Unit of St. Vincent and the Grenadines
[16] Based on (Jacobs,2016)
[17] The BAU case includes the cost of import of an equivalent number of ICE gasoline cars

high RES outcome. The high RES outcome results in an additional 1.49 million USD in fossil fuel savings compared to the low RES outcome over 2016-2025, whilst external electricity payments for the period are only 0.73 million USD. Similarly additional fossil fuel savings for the period 2016-2040 are 3.11 million USD for the high RES outcome vs low RES outcome, which outweighs the 1.48 million USD in external electricity payments. This serves to justify the shift to RES-E from geothermal in general, as well as for bolstering the EV market.

Table 5: NPV of BOP under accelerated EV adoption compared to BAU

	2016-2025		**2016-2040**	
	RES-low	RES-high	RES-low	RES-high
Fossil fuel	-3.37 mill USD	-4.86 mill USD	-6.50 mill USD	-9.61 mill USD
Vehicles	9.16 mill USD	9.16 mill USD	9.28 mill USD	9.28 mill USD
Electricity	0	0.73 mill USD	0	1.48 mill
Net difference in BOP (BOP accelerated EV – BOP BAU)	**5.79 mill USD**	**5.03 mill USD**	**2.78 mill USD**	**1.15 mill USD**

3.3.3 Efficiencies in the energy economy

The main efficiency in the economy considered is that of savings in total costs of ownership resulting from ownership of an EV rather than a gasoline vehicle. The total cost of ownership (TCO) is the total of investment and running costs incurred in connection with ownership of a durable good, in this case either EV or gasoline car, over the economic lifetime of the vehicle. The economic lifetime of both EV and gasoline car is assumed to be 15 years[18]. The total cost of ownership is determined based on: cost of purchase, fuel/energy cost, maintenance cost[19]. Fuel/energy costs take into account the projected evolution of prices of diesel (for the production of electricity for the EV) and gasoline, over the vehicles' economic lifetime. Fuel/energy and maintenance costs are calculated based on an assumed level of travel of 10,000 km/year. If the acquisition of an EV incurs a lower TCO than the acquisition of a gasoline car, the vehicle owner experiences savings throughout the lifetime of the vehicle, and thus a greater disposable income which is likely to benefit the wider economy through increased expenditure on the part of the vehicle owner.

Electric vehicles are likely to have a lower TCO than gasoline cars in the long run, when purchase prices decrease, due to EVs greater energy efficiency. In fact, on the basis of TCO, the EV is expected to become competitive with the gasoline vehicle well before it becomes competitive on the basis of upfront purchase price only. Figure 8 shows the TCO of the EV, both with and in the absence of a subsidy, as well as that of the gasoline car. As shown in the figure, the estimated TCO of EV falls from around 70,000 USD for a car purchased in 2016 to around 50,000 USD for a car purchased in

[18] In terms of the EV, the economic lifetime of 15 years includes1 battery replacement at 8 years; this replacement cost is included in the TCO calculation

[19] Other costs, such as those associated with vehicle fitness certification, plates, fees are assumed to be similar for both vehicles. Licence fees are not taken into account as currently the fee is based on CC rating; thus no regime exists for determining licence fees. Other costs, such as insurance, are also not taken into account due to non-availability of local data.

2017, when the subsidy starts to apply, and to around 45,000 USD by 2020. In the case of no subsidy, the TCO gradually decreases from 2016 to reach 45,000 USD for a car purchased in 2026. In comparison, the gasoline car has a relatively constant TCO of 52,000 USD over the period. After 2025, the EV is considered to reach market maturity and does not experience significant change in upfront purchase price. The TCO of both EV and gasoline cars would therefore only vary with projected energy prices; this can be seen by a slight upward trend in the TCO of the gasoline car due to moderately increasing gasoline prices over the period, and a slight downward trend in the TCO of the EV due to expected decreases in electricity prices. The result is shown for the high RES-E outcome, however, they hold similarly true for the low RES-E outcome as electricity prices between the two outcomes do not vary significantly[20].

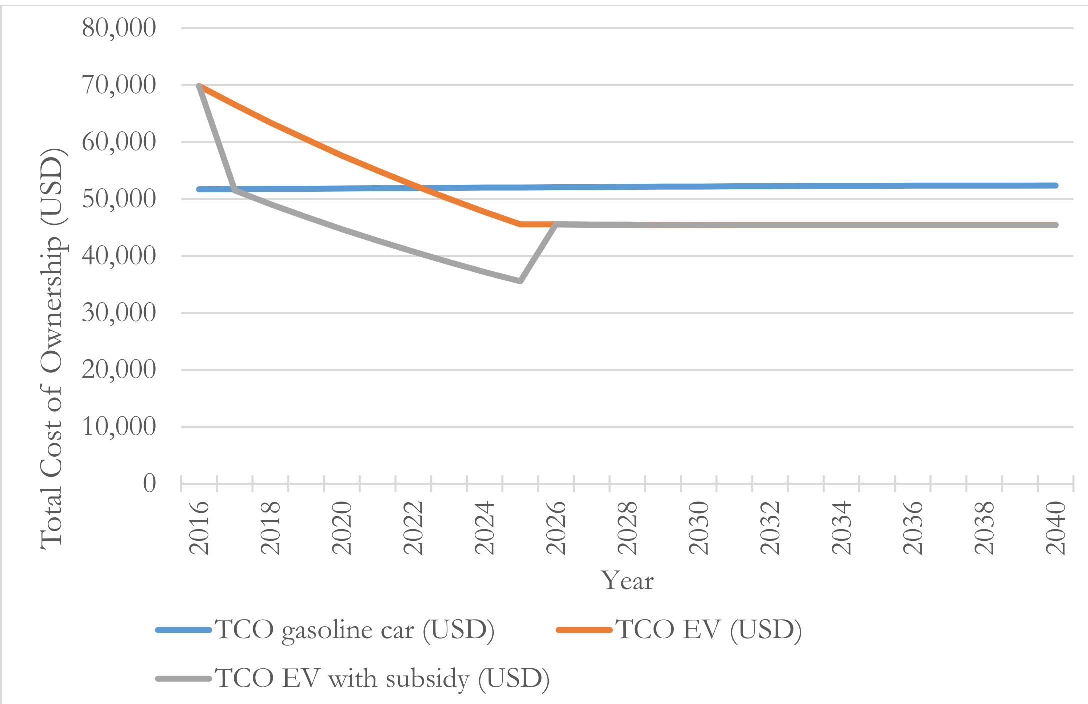


Figure 8: Evolution of total cost of ownership of EV compared to gasoline car

In the absence of subsidies, the TCO of the EV breaks even with that of the gasoline car in 2022. Recall that purchase price parity (in the absence of subsidies) between EV and gasoline car does not occur until 2025, so the achievement of equal TCO prior to 2025 is due to the lower energy and maintenance costs of the EV. In fact, energy and maintenance costs of the EV are calculated to be

[20] Electricity price in the low RES-E scenario is estimated at 37 USc/kWh in 2016, and remain constant up to 2022, after which the price falls marginally to 36 USc/kWh for the remainder of the period. For the high RES-E scenario, electricity price is estimated at 37 USc/kWh in 2016, falling to 36 USc/kWh in 2020, then to 33 USc/kWh from 2030 onwards. Electricity prices in each year are calculated based on the weighted average electricity price, based on the relative proportions (in each scenario) of diesel/hydro (current mix) electricity, solar PV electricity, and geothermal in the electricity mix. The current electricity mix is estimated to have a current sales price of 37 USc/kWh (http://www.vinlec.com/contents/electricity-rate-structure), solar PV electricity estimated to have a sale value of 26 USc/kWh, and geothermal electricity estimated to have a sale price of 35 USc/kWh). Sale prices include cost of generation, cost of transmission and distribution and sales margin.

roughly half that of a gasoline car, over the period of analysis. With subsidies, the EV breaks even with the gasoline car, on a TCO basis, from as early as 2017.

The resulting difference in disposable income in the economy, attributable to differences in TCO of purchasers of EV versus a gasoline car is analysed for the case of the subsidised EV, and is shown in Figure 9, for the high RES-E outcome. As the figure shows, the EV purchaser have greater disposable income in the economy as a group, compared to the BAU scenario. Under the BAU scenario, there is no EV adoption until 2023, so the impact in the economy from savings of EV purchasers is very low before 2025; however, under the accelerated EV scenario, there is EV adoption as early as 2017, and with TCO of the EV being lower than that of the gasoline car, the impact is lower expenditure on car acquisition and operation by EV purchasers, resulting in an overall saving of almost 25 million USD for the period 2016-2025.. For the period 2016-2040, EV consumer savings are as much as 31 million USD in the accelerated EV adoption scenario, compared to 10.5 million USD in the BAU scenario.

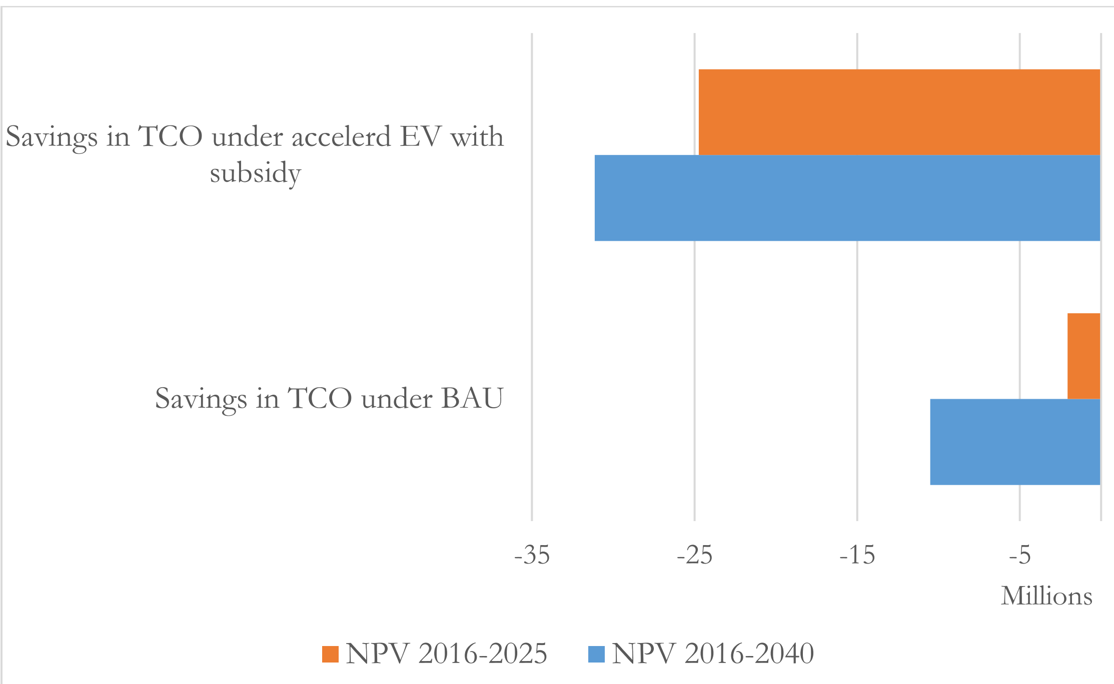


Figure 9: Savings in TCO from EV adoption, under BAU and accelerated EV adoption

The result of these savings in net present value are presented in Table 6 for the period 2016-2040, the full analysis period.

Table 6: NPV of BOP under accelerated EV adoption compared to BAU

	2016-2040	
TCO Savings	RES-low	RES-high
BAU	9.9 mill USD	**10.5** mill USD
Accelerated EV	30.3 mill USD	**31.1** mill USD
Net TCO savings attributed to early EV adoption	**20.4** mill USD	**20.6** mill USD

Savings to consumers from early EV adoption range between 20 and 21 million USD (low and high RES-E adoption respectively) for the period; that means 20-21 million USD potentially available to be spent in the economy, producing a benefit to society by the same amount. This largely outweighs the (negative) impact of an increased BOP of between 1.15 to 2.78 million USD (high- and low RES-E penetration respectively; refer to Table 5) from accelerated EV adoption. As will be shown in section 3.4, this gain also outweighs the cost of the subsidy, strengthening the case for accelerated EV adoption. The overall positive impact is higher for the case of high RES-E, strengthening the case for coupling EV adoption with an accelerated RES-E transition.

3.3.4 Greenhouse gas emissions

SVG has committed to achieving a 22% reduction in its greenhouse gas emissions compared to its business as usual scenario (hereafter referred to as the "default path") by 2025, through its intended nationally determined contribution (INDC) submission to the United Nations Framework Convention on Climate Change (UNFCCC) in Nov. 2015 (GoSVG 2015a). This is anticipated to be achieved primarily through: the reduction of GHG emissions from the electricity sector, through the development of geothermal energy and renovation of hydro power facilities; reduction in electricity consumption through street lighting, new building code and energy efficient appliances; and through the promotion of adoption of low emission vehicles through duty reductions. Neither the default path nor the mitigation scenario of the INDC indicate the adoption of EVs as part of the strategy. The adoption of EVs therefore have the potential to facilitate the achievement of SVG's emissions reduction target.

According to SVG's Second National Communication (NC) on Climate Change (GoSVG 2015b), baseline (default path) GHG emissions in the domestic transport sector are expected to rise by 88% from 137,034 tons CO_2-equivalent in 2010 to 257,029 tons CO_2-equivalent in 2025. If, we assume that the proportion of passenger cars in the transport fleet remains at the current 39%, and that by extension, passenger cars would contribute 39% of total emissions, then roughly 100,200 tCO_2/yr would result from passenger cars under SVG's default path emissions. The average annual increase in GHG emissions from the transport sector is 4% between 2010 and 2025; this is assumed to apply uniformly across all types of vehicles and to continue to 2040. The resulting annual emissions of passenger cars would therefore be 188,000 tCO_2/yr in 2040. Total emissions for the period 2016-2025 would be roughly 497 $ktCO_2$/yr, and for the period 2016-2040, roughly 886 tCO_2/yr.

The adoption of EVs would result in GHG emission savings compared to the default path emissions of the 2nd national communication (NC).

Table 7: Greenhouse gas emission savings from EV adoption

	2016-2025		2016-2040	
GHG Emissions	RES-low	RES-high	RES-low	RES-high
BAU EV adoption	147 kt CO_2	146 kt CO_2	225 kt CO_2	216 kt CO_2
Accelerated EV (a)	139 kt CO_2	134 kt CO_2	211 kt CO_2	192 kt CO_2
GHG savings attributed to early EV adoption	7,340 tCO_2	12,000 tCO_2	14,100 tCO_2	23,500 tCO_2
Car emissions projected in accordance to SVG 2nd NC (b)	497 $ktCO_2$		886 $ktCO_2$	
GHG emissions under accelerated EV vs default emissions of 2nd NC = (a)/(b)	28.0%	27.0%	23.8%	21.7%

The results of the assessment show that the early adoption of EV would result in GHG emissions from on-road passenger which are a fraction of the default path emissions projection under the second NC. For the period 2016-2025, emissions would be around 27% of the default path emissions, and for the period 2016-2040 GHG emissions would be 22-24% of default emissions.

In addition, it can be seen that, once again, the accelerated EV adoption scenario is preferable to the BAU EV adoption scenario, with GHG savings from accelerated reduction amounting to 7-12,000 tCO_2 for the period 2016-2025, and 14-24,000 tCO_2 for the period 2016-2040. The higher RES-E scenario also, once again, proves more advantageous than the low RES-E outcome.

3.4 Fiscal neutrality

The fiscal impact of EV adoption is measured through its impact on the following government revenues, which are directly impacted as a result of the adoption of EV over gasoline cars:

- **Excise taxes**: the exemption of EV from excise rate will decrease government revenues from taxation of car imports
- **VAT on gasoline sales**: the accelerated adoption of EV, substituting the purchase of gasoline cars, means fewer gasoline cars in the fleet, and less consumption of gasoline, which will reduce the tax base for collection of VAT on gasoline sales
- **VAT on electricity sales**: the accelerated adoption of EV will result in higher electricity sales for EV operation, which will increase the tax base for collection of VAT on electricity sales
- **Profit from electricity sales**: electricity sales from meeting the energy needs associated with EV users will increase with accelerated EV adoption; as the government owns the electric

utility, VINLEC, the profit from these additional electricity sales will contribute to government revenue.

Table 8 below shows how accelerated EV adoption impacts the government's revenues. The analysis is conducted for the high RES-E outcome only.

Table 8: Effect of accelerated EV adoption on government revenues

	2016-2025	2016-2040
Excise taxes		
BAU EV adoption	109 mill USD	166 mill USD
Accelerated EV	93.3 mill USD	150 mill USD
Difference in revenues (accelerated vs BAU EV adoption)	*-16.1*	*-16.1*
VAT from gasoline and electricity sales		
BAU EV adoption	9.3 mill USD	13.5 mill USD
Accelerated EV	8.3 mill USD	11.6 mill USD
Difference in revenues (accelerated vs BAU EV adoption)	*-1*	*-1.9*
Profit from electricity sales		
BAU EV adoption	138 k USD	1.2 mill USD
Accelerated EV	865 k USD	2.6 mill USD
Difference in revenues (accelerated vs BAU EV adoption)	*740 k USD*	*1.4 mill USD*
Net impact on government revenues	**-16.3 mill USD**	**-16.6 mill USD**

The provision of a government subsidy through exemption of excise duty for EVs therefore costs the government around 16.1 million USD in lost revenues. The loss of revenue from the excise tax exemption is the same for the period 2016-2025 and 2016-2040 because the entirety of the subsidy is effected in the period 2016-2025, no subsidies are applied from 2026 onwards; the NPV of the subsidy scheme is therefore the same for the 2040 period as it is for the period to 2025.

The lost revenue in excise duty is not recuperated through other sources of revenue which arise through the adoption of EV. In terms of VAT on energy sales, the loss in VAT on gasoline sales from a reduced gasoline fleet is greater than the gains in VAT on electricity sales from an increased EV fleet. In addition, the profit generated to the government-owned utility are barely sufficient to close the loss gap from VAT on energy sales, much less that from excise duty exemption.

The resulting **net deficit in government revenues from the EV subsidy scheme** is 16.3 million USD for the period 2016-2025, and **16.6 million** for the period 2016-2040**. This is noticeably less than the savings resulting to consumers from early EV adoption.** Recall from section 3.3.3 that **early EV adoption results in a net benefit to society if of 20-21 million USD. This largely outweighs the cost of the subsidy.**

Nonetheless, an analysis is presented here for the case of funding the EV subsidy scheme through: a tax on gasoline sales and/or an environmental levy on imported gasoline cars (refer to section 2.5). A number of combinations of the two can be used to fund the revenue gap. Applying an environmental levy on imported gasoline cars would require a levy of 26%, in addition to existing import and excise duties, which is likely to be socially unacceptable. Funding the scheme through the application of an additional tax on gasoline, on the other hand, would require an additional tax of over 20%. A combination of the two mechanisms could be envisaged, for greater social acceptability. For instance, the 16.3-16.6 million USD gap could be funded through the application of a 15% additional sales tax on gasoline and an 8% environmental levy on imported gasoline cars.

It should be noted, however, that the introduction of either of these measures will also impact the demand dynamics in the car purchase market in favour of EV, which would alter the profile of revenues and losses from EV adoption. Modelling of this type of dynamic is beyond the scope of this study. The feedback effect of introducing these measures should however be borne in mind in the decision to apply such tax/levy measures.

An alternative means of funding the EV subsidy programme would be to tax an unrelated good; this would have the advantage of not interfering with the demand dynamics of the EV-gasoline car market, beyond the subsidy itself. This was investigated by investigating the imposition of a tax on each visitor entering (or leaving) the island. According to the SVG Tourist Authority, there were roughly 205,000 visitor entries into the island in 2014, and 206,000 entries in 2015. If visitor entries are, on average, 205,000 each year for the period 2016 to 2040, **a visitor tax of 9 USD per visitor per entry** (or departure) **would generate** revenues of 16.7 million USD – **sufficient funds to finance the EV subsidy scheme**.

4 Conclusions

An accelerated transition towards electric mobility in the passenger car sector, and by extension, the transport sector as a whole, would generate 3-5 million USD savings in fossil fuel expenditure for the period 2016-2025 and 7-10 million USD in savings for 2016-2040, compared to a BAU scenario. On the flip side, balance of payments will increase by 5-5.8 million USD compared to the BAU for the period 2016-2025, and by 1.1-2.8 million USD for the period 2016-2040, compared to the BAU. However, this is countered by the 20 million USD in additional disposable income generated for EV adopters under accelerated EV adoption compared to the BAU case; disposable income which will benefit the wider economy through increased expenditure by the EV owner. Furthermore, early EV adoption will make a significant contribution to St. Vincent and the Grenadines' efforts to reduce its GHG emissions in line with its Intended Nationally Determined Contribution (INDC). Other advantages of EV adoption include possible economies of scale for the utility, through greater use of the electric grid infrastructure for charging, in particular at off-peak periods when EV charging is likely to take place. These economies of scale can result in greater viability of the utility and translate into lower electricity prices for all consumers.

In terms of funding the EV subsidy scheme, the **gains in the economy from savings to EV adopters largely outweighs the expense of the subsidy scheme**. Additional taxes on gasoline sales and an environmental levy could be used to fund the scheme, however the level of additional taxes may not be socially acceptable. On the other hand, a visitor tax of 9 USD per visitor would be sufficient to fund the scheme.

In terms of factors to ensure a meaningful transition to electric mobility, there is a need to raise awareness amongst consumers regarding the cost advantages of EVs over gasoline vehicles, in particular with respect to energy costs, as well as TCO, which will be competitive with gasoline vehicles in 5 years. Equally awareness-raising is needed to address concerns over lack of charging infrastructure, given that typical distances travelled within the country can be easily satisfied through home charging, obviating the need for a significant charging infrastructure throughout the island. At the same time, there may be a need for the government to subsidize some initial public charging infrastructure to allow the technology to take off, while the market develops. Finally, there is currently no framework for licence taxation of EVs, as the current licence tax system is based on CC-rating, which is not applicable to EVs; this would need to be addressed in order to facilitate the entry and registration of EVs in the country.

5 Appendices

5.1 Reference vehicles of the study

Table 9: Reference cars and their techno-economic characteristics, year 2016

	Conventional car	Electric car
	Toyota Corolla L-sedan	Nissan Leaf S-hatchback (30 kW battery)
Car life	15 years	15 years (with 1 battery replacement)
Purchase price (landed)	42,000 USD	65,000 USD
Assumed cost reduction in real terms (%/year 2016-2025)	0%	5%
Maintenance cost	444 USD/yr	250 USD/yr
Energy efficiency	7.8 litre/100 km	15 kWh per 100km
Range	480 km	200 km
Fuel cost (based on 10,000 km/yr)	1149 USD/yr	553 USD/yr
Salvage value	Negligible	Negligible

5.2 Key Equations used in Determination of Macroeconomic Impact

5.2.1 Fossil fuel expenditure

$$M_t^{fuel} = \sum_{fuel}\left(Q_t^{fuel} * p_t^{fuel}\right) \; ; fuel = diesel, gas$$

Where :

$$Q_t^{gas} = Car_t^{gas} * Fuel^{gas}$$

$$Q_t^{diesel} = Car_t^{EV} * Fuel^{diesel}$$

$$Fuel^{diesel} = x_t^{diesel} * elec^{EV}$$

M_t^{fuel} = total cost of fuel importation needed to meet car energy demand in year *t*

Q_t^{fuel}, p_t^{fuel} = quantity and price respectively of a fuel in year *t*

Car_t^{EV}, Car_t^{gas} = total no. of EV, gasoline cars respectively in the fleet in year *t*

$Fuel^{diesel}, Fuel^{gas}$ = annual fuel consumption of EV, gasoline car respectively

$x_t^{diesel}, elec^{EV}$ = fraction of diesel in grid electricity mix in year *t*, annual electricity consumption of EV

5.2.2 Balance of payments

$BOP_t = M_t^{fuel} + CarImport_t^{EV} * Y_t^{EV} + CarImport_t^{gas} * Y_t^{gas} + Geoth_t^{EV} * \ p_t^{geoth}$

Where:

BOP_t = balance of payments in year *t*

$CarImport_t^{EV}, CarImport_t^{gas}$ = no. EV and gasoline cars, respectively, imported in year *t*

Y_t^{EV}, Y_t^{gas} = CIF (carriage, insurance, freight) cost of EV, gasoline car respectively, in year *t*

p_t^{geoth} = cost of purchase of geothermal-based electricity sold to VINLEC in year *t*

$Geoth_t^{EV}$ = quantity of geothermal-based electricity consumed by EV in year *t*

And Where:

$Geoth_t^{EV} = x_t^{geoth} * elec^{EV}$

x_t^{geoth} = fraction of geothermal-based electricity in grid electricity mix

$Q_t^{gas} = Car_t^{gas} * Fuel^{gas}$

5.2.3 Total cost of ownership

$TCO_t^{tech} = \sum_{t=1}^{t=15}\left(InvCost_t^{tech} + Fuel^{tech} * p_t^{fueltech} + \ Mtce_t^{tech}\right)$

Where:

TCO_t^{tech} = Total cost of ownership of vehicle of given technology (EV, ICE/gasoline)

$InvCost_t^{tech}$ = Purchase cost of vehicle of given technology (EV, ICE/gasoline)

$Fuel^{tech}$ = Annual fuel/energy consumption of given technology (EV, ICE/gasoline)

$p_t^{fueltech}$ = Fuel/energy price of fuel associated with given technology (EV, ICE/gasoline)

$Mtce_t^{tech}$ = Annual maintenance cost of given technology (EV, ICE/gasoline)

5.2.4 Greenhouse gas emissions

$CO2_t = \ CO2^{gas} * Car_t^{gas}$Where:

$CO2_t$ = annual CO2 emissions for a given scenario

$CO2^{gas}$ = average annual CO_2 emissions of gasoline vehicle

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