PROJECT DOCUMENTS

Enhancing energy efficiency in national transportation systems

A readiness analysis for Saint Lucia

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This document has been prepared by Adrián Flores Aguilar, Marcos Hidalgo Arellano and Leda Peralta Quesada for the Sustainable Development and Disasters Unit, Economic Commission for Latin America and the Caribbean (ECLAC), in the framework of the activities of the project ECLAC/GIZ: "Sustainable Energy in the Caribbean: Reducing the Carbon Footprint in the Caribbean through the Promotion of Energy Efficiency and the use of Renewable Energy Technologies".

LC/CAR/TS.2017/2

Printed at United Nations, Santiago

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Acronyms

AC	Alternating current
AMI	Automated Metering Infrastructure
BEV	Battery Electric Vehicle
BNTF	Basic Needs Trust Fund
CARICOM	Caribbean Community
CARILEC	Caribbean Electric Utility Services Corporation
CARTAC	Caribbean Regional Technical Assistance Centre
CDB	Caribbean Development Bank
CDE	Carbon Dioxide Equivalent
CEV	Combustion engine vehicle
CFL	Compact Fluorescent Lamp
CHAdeMO	Charge de Move
CO2	Carbon Dioxide
COTED	Council For Trade And Economic Development
CREDP	The Caribbean Renewable Energy Development Programme
CWR	Carbon War Room
DC	Direct current
EC	Energy Coalition
EE	EE
EPA	Environmental Protection Agency
E-REV	Extended-Range Electric Vehicles
ESA	Electricity Supply Act
ESCO	Energy Service Company
EV	Electric vehicle
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse gases
GIZ	German Development Cooperation
GPP	Global Petrol Prices
HEV	Hybrid vehicle
HP	Horse-power
IADB	Inter-American Development Bank
ICE	Internal Combustion Engine
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
Kg	Kilogram
KPG	Kilometers per gallon
kW	Kilowatt
kWh	Kilowatt-Hour
kWp	Kilowatt-peak
kW_{th}	Kilowatt-thermal
LCOE	Levelized cost of energy
LDC	least developed countries
LED	Light-emitting diode
LUCELEC	Saint Lucia Electricity Services Limited

Mi	Miles
MPY	Miles per year
MSRP	Manufacturer's Suggested Retail Price
MW	Megawatt
NEP	National Energy Policy
NREL	National Renewable Energy Laboratory
NURC	National Utilities Regulatory Commission
NVP	National Vision Plan
OECS	Organization of Eastern Caribbean States
OFID	OPEC Fund for International Development
OPEC	Organization of the Petroleum Exporting Countries
PCF	Photovoltaic Charging Facilities
PHEV	Plug-In Hybrid Vehicle
PV	Photovoltaic
RE	Renewable Energies
SIDS	Small Island Developing States
SLBS	Saint Lucia Bureau of Standards
SUV	Sport Utility Vehicle
UKAID	United Kingdom’s Department for International Development
UNFCCC	United Nations Framework Convention on Climate Change
UNOPS	United Nations Office for Project Services
VMP	Vehicle Management Policy
WB	World Bank

Executive Summary

Most Caribbean countries rely almost completely on imported fossil fuels to meet their energy needs. This dependency leaves the various sectors feeding from the energy system vulnerable to international market fluctuations. With a view towards seeking alternatives to diversify the energy matrix, incorporating new practices that enhance local energy efficiency and achieving the targets specified within the UNFCCC, governments have developed a series of policies, regulations and actions in many sectors involved. In this regard, transportation in the Caribbean is key since the share of total energy consumption in the region significantly exceeds the global average. In Saint Lucia it accounts for over 50 per cent of total fuel imports (ECLAC, 2014). In this sense, an initiative to transition government vehicle fleets to more efficient and renewable sources of energy has been proposed within the GIZ/ECLAC project titled "Sustainable Energy in the Caribbean: Reducing the Carbon Footprint in the Caribbean through the Promotion of Energy Efficiently and the use of Renewable Energy Technologies". This study explores international best practices in relation to fleet electrification, suggests the most suitable comprehensive approach for a transition, assesses Saint Lucia's current efforts and suggests the most immediate actions to deploy. Using limited preliminary data and applying available transition filters in Saint Lucia, the study proposes that only 43 per cent of the existing government fleet (206 vehicles) could be subject for a transition to Electric vehicles (EV) and in some cases Plug-in Hybrid Electric Vehicles (PHEV). As regards the charging facility, the determination of its characteristics and specifications will depend on the transition technology selected and the sites availability. Hence, if the Government of Saint Lucia decides to transition to Hybrid Electric (HEV) no charging facility is required. Lastly, if suitable sites for a solar carport are not available, it is suggested that a solar farm to nourish the fleet be deployed and that charging docks be strategically placed according to the vehicles' routing and allocation.

Three main phases that could comprise the Fleet Transition Plan have been identified as part of the international best practices: readiness, implementation, and follow-up. Within the readiness phase six sub-phases were proposed: (i) definition of objectives and goals, (ii) establishment of vehicle eligibility criteria, (iii) fleet assessment, (iv) technology assessment, (v) infrastructure assessment, and (vi) governance assessment. The implementation phase consists of two sub-phases, these being: technology substitution and operation and maintenance, while the follow-up phase consists of monitoring and verification, respectively. In the case of Saint Lucia, the study concludes that the country's efforts towards a fleet transition can be located in the first phase of readiness. Therefore, this report focuses on the readiness phase and outlines the most relevant components and accomplishments required to carry out the preparatory phase for an energy-efficient fleet transition.

Introduction

Most Caribbean countries are net energy importers and utilize mainly fossil energy sources to drive their economies and meet social needs. Fossil energy is used primarily for power generation and domestic transportation. In light of the global challenges from climate change, many countries have initiated strategies and projects for deploying renewable energy technologies, as well as enhancing energy efficiency (EE) for electricity use. To date however, efforts to transition to renewable energy (RE) and to enhance EE in domestic transportation remain very limited. This study is part of the GIZ/ECLAC project titled "Sustainable Energy in the Caribbean: Reducing the Carbon Footprint in the Caribbean through the Promotion of Energy Efficiency and the use of RE Technologies". It shows the results of the elaboration of a roadmap for enhancing EE in national transportation systems through the transition to electric and/or hybrid vehicles and the development of an appropriate vehicle charging facility. The roadmap has been analyzed for the specific case of Saint Lucia in an attempt to exemplify the most relevant components of the transition process. Therefore, the study aims at identifying the technical, governance, infrastructure, and financial challenges that governments should overcome in order to transition vehicle fleets to more efficient and RE sources. To this end, the study identifies the phases and sub-phases required for a fleet transition, and assesses the performance and situation of the Government of Saint Lucia in attaining this goal. The main product of this study is a roadmap for vehicle transition, including a multi-dimensional assessment (i.e., governance, infrastructure, and technology), issues to be considered in a fleet assessment, the vehicle eligibility criteria and the description of potential funding alternatives. Considering that most efforts towards a fleet transition in the region are incipient, the roadmap presented in this report emphasizes the importance of the readiness phase as a fundamental requirement to achieving an energy-efficient and sustainable transition.

A. Background

The first pre-requisite for an efficient fleet transition is to understand the country's energy sector as a means of identifying opportunities and challenges for the transition. This is relevant for determining the composition of the energy matrix and for identifying ongoing and future projects to be implemented in the promotion of EE and RE. The relevance of this stage lies in understanding the sector so as to propose a comprehensive fleet transition that goes beyond simple fleet electrification, by also considering issues of grid stability, matrix diversification and efficient use of scarce public resources. By outlining critical steps in a roadmap it is possible to organize and structure the transition process, and to foresee potential opportunities and challenges; thus allowing for a transition that promotes improvements in the energy sector as a whole. As most Caribbean island states, Saint Lucia is almost 100 per cent reliant on imported fossil fuels in order to meet its energy needs. It is estimated that the island imports 3,000 oil barrels per day, mainly from Brazil and Trinidad and Tobago, from which two thirds is used to generate electricity (IDB, 2015). The costs of oil imports in Saint Lucia have historically remained in line with the rest of the Eastern Caribbean countries. As of 2014, crude and refined petroleum imports (US$ 1.35 billion and US$ 170 million, respectively) represented more than 75 per cent of total imports (OECS, 2015). This dependency leaves the country vulnerable to global oil price fluctuations, which directly influence electricity rates (NREL, 2015). As fuel costs are passed on directly to customers, price fluctuations affect access of low-income households to reliable electricity. In response to this oil-dependency situation in the Caribbean sub-region, and in order to transform its energy base and make greater use of renewable resources, the Government of Saint Lucia has established targets for improvements in EE and deployment of renewable energies (RE). The first target aims at lowering public energy consumption by 20 per cent by 2020, whilst the second seeks to generate 35 per cent of the country's energy from renewable sources by 2025 (Government of Saint Lucia, 2015c). Even if the country has a supporting National Energy Policy, the development of RE is still in its embryonic stage, and the presence of inflexible regulatory conditions, as well as technology and financing challenges related to the development of RE projects persist (Table 1).

Table 1
Potential for implementation of renewable energy in Saint Lucia

Technology	Potential	Installed Capacity	State of development
Wind	*40MW*	0	Despite recent plans for wind energy development (dating back to 2005), no grid-connected wind energy resources have been developed on Saint Lucia. CREDP-GIZ provided technical assistance in the development of a prospective wind farm project at Sugar Mill, The Government of Saint Lucia in collaboration with the Saint Electricity Services and Wind Tex Energy is in the development stages of a 12MW Wind Farm on the East Coast of the island. A wind test tower was installed in March 2015, to ensure that sufficient data and is collect for the establishment of the wind farm.
Hydropower	*150kW*	0	Saint Lucia has some economic mini-hydro potential amounting to less than 500 kW. This includes an estimated 150 kW at the existing Roseau Dam, which is owned and operated by the national water utility, and an estimated 240 kW at the Troumassée River. No implementation of any related projects is currently in place.
Geothermal	170 MW	0	Geothermal energy has long been considered one of Saint Lucia's major potential RE sources. Clear manifestations of extensive geothermal resources are readily visible in the South of the island and, over the past decades, various entities have been involved in the effort to determine the parameters of the resource.
Solar	36 MW	0.1	A handful of privately owned residential PV installations, one utility-owned system and several institutional projects of size 3 – 25 kWp comprise the approximately 61 kWp-installed base of grid-connected photovoltaic systems in Saint Lucia. Data provided by the Government of Saint Lucia indicates that the country currently has over 500 kW of grid-connected PV systems and more are being installed. By contrast, the market for solar water heating has developed significantly over the past few years and Saint Lucia's penetration of SWH is estimated at 111.4 kWth per 1,000 inhabitants, the second highest in CARICOM. In addition, a 3 MW farm is being developed.
Ocean	Unknown	0	No further details
Biomass	N/A	0	No further details

Source: NREL, "Energy Snapshot Saint Lucia," February, 2015.

The accomplishment of these targets presupposes a profound commitment from all sectors involved. In this sense, as Saint Lucia Energy Snapshot points out (NREL, 2015):

> "[...] there is little evidence that the country's regulatory and policy environment has adapted to new technologies. A 2006 review of the NSEP indicated that energy efficiency and renewable energy projects existed, but that none was grid-tied. Most projects since then have stalled in the proposal phase".

The report concludes:

> "Transitioning to clean energy sources can help protect Saint Lucia's natural resources and preserve water and air quality. With abundant geothermal, wind, and solar resources to more than meet Saint Lucia's peak demand, even partial development of these resources could result in high penetration of renewable onto the grid. Continued policy and program support could drive more extensive development of renewable energy on Saint Lucia. An investment in the existing grid, however, may be required to support safe and reliable high penetrations of renewable energy".

Even though further efforts are required to allow widespread use of EE and RE in Saint Lucia, it should be noted that the country has undertaken important actions to modernize its energy sector. In an attempt to increase the use of RE and promote investments in EE and RE, the country recently created the National Utilities Regulatory Commission. In addition to the enactment of the Vehicle Management Policy, these initiatives combined with vehicle efficiency standards, fiscal incentives, and national EE and RE targets should favor an enabling environment, which is expected to accelerate the country's energy transition and modernization process in the short term, as well as increase investment in the energy sector as a whole.

According to available data on all energy-related sectors, the transportation sector consumes accounts for over 50 per cent of total fuel imports (ECLAC, 2014). This level of energy demand from the sector, as in most Caribbean countries, is consistent with the growing penetration of motor vehicles since the 1990s as a result of the liberalization of the vehicle import policy and the growing air transportation share associated with the tourism industry (IDB, 2015). Although there has been a net increase in the number of registered vehicles, exact numbers are not available, since Saint Lucia does not maintain accurate official databases tracking the number of vehicles on its roads. It is estimated that the number of registered vehicles grew 7.9 per cent annually between 1997 and 2000. The most precise number is from 2013 and accounts for a total 62 145 registered vehicles (IDB, 2015). Through its National Energy Policy, the Government of Saint Lucia has proposed the following mitigation actions (Government of Saint Lucia, 2010):

- Maintain a level of adequate taxation on motor vehicles as well as take measures to ensure improved vehicle maintenance in order to promote EE in the transportation sector;
- Introduce beneficial tax systems to promote the purchase of more energy-economical vehicles, including the new generation of hybrid vehicles;
- Ensure obligatory vehicle inspection and regular maintenance which will promote safety, reduce the level of harmful emissions and promote EE;
- Facilitate the improved training of automotive mechanics and driving instructors with respect to EE and conservation;
- Better integrate energy and environmental strategies into urban planning;
- Improve traffic management by utilizing all feasible measures, such as computer-controlled traffic lights, which will make it possible to smooth the flow of traffic through Castries and the northern corridor

As part of the effort to promote EE technologies and RE deployment, the Government of Saint Lucia is currently seeking to enhance EE in the transport sector through the transition of its fleet to electric/hybrid vehicles and the construction of a carport for charging purposes. This study establishes a set of strategic actions to be followed in that direction.

B. Scope, objectives and methodological approach

The overall objective of this report is to develop a roadmap for enhancing vehicle fleet EE through the transition to electric/hybrid/plug-in hybrid (EV/HEV/PHEV) vehicles and the development of an appropriate vehicle charging facility. This effort presupposed identifying the main transition phases and suggesting specific actions to overcome the main infrastructural, governance and technical challenges. In order to achieve the main objective, this study undertook the following four activities:

(i) Meet with relevant stakeholders of the Government of Saint Lucia to gather data and information for elaborating the proposal.

(ii) Elaborate the specific project problem, and outline the solutions to be achieved by implementing the proposal.

(iii) Conduct a technical feasibility analysis with respect to appropriate technologies and systems to be applied.

(iv) Identify potential financing partners and conditionalities

The methodological approach of this study involved the following seven steps:

(i) Conduct a field visit to gather relevant information and meet stakeholders (August 2016).

(ii) Review of documentary materials from fleet transition/electrification best practices to identify the phases involved.

(iii) Elaborate a phased approach for Saint Lucia's a fleet transition.

(iv) Review documentary materials from Saint Lucia's ministries (i.e., Sustainable Development; Energy; Infrastructure; Physical Planning; Public Administration; Transportation), regional and international entities (i.e., CARICOM, OECS, CARIBANK, CARILEC, CARTAC, IADB, GIZ, UKAID, etc.) and LUCELEC in order to assess the local governance conditions.

(v) Review documentary materials from manufacturers and specialized technical sources to conduct a technology assessment.

(vi) Identify the vehicle eligibility criteria and fleet assessment aspects through the review of international best practices and local normative.

(vii) Undertake a preliminary Fleet Assessment in order to outline future actions.

I. Fleet transition phases

Transitioning to electric, hybrid electric and plug-in hybrid vehicles (EV, HEV and PHEV respectively) in the context of enhancing EE and deploying RE, presumes a challenge for decision makers, implementers and users, which goes beyond the mere actions of acquiring the available technologies and replacing vehicles on a one-to-one basis. International practices and experiences show how this effort also implies making different kinds of arrangements, mainly in dimensions such as governance (e.g., normative and regulative frameworks), behavior (e.g., driving patterns and routing) and infrastructure (e.g., charging infrastructure, grid stability). Fostering only technological change will not ensure the attainment of specific EE and RE targets. In this sense, it is imperative for decision makers to consider all the transition dimensions outlined throughout this roadmap.

Vehicle fleet transition does not exclusively mean electrification. Best practices related to diverse fleet transition strategies suggest that a comprehensive phased-approach is highly recommended (Bibona, 2003). The purpose of this section is to explain the transition phases towards fleet electrification based on a review of best practices, and to assess the current state of the Government of Saint Lucia in this process. Best practice emphasizes the importance of an enabling environment that considers governance arrangements,, adjusted consumption patterns and behaviors, and detailed understanding of the fleet to be transitioned before undertaking the technological transition. These practices also suggest the need to compile sound baseline information to profile the fleet and understand its uses and components before choosing the transition path and replacement technology.

A. Best practices on fleet transitioning

International experiences show that fleet transitioning (e.g., public transportation, government, private users) to more efficient, environmentally friendly, and cost-effective energy sources is an increasing trend. Some examples (Table 2) consider fleet electrification as part of these initiatives, nevertheless, most cases incorporate a more comprehensive approach in which, among other aspects, the fleet's proper design, utilization and disposal are considered (Bibona, 2003).These examples also show that having full awareness of the fleet's performance, users' needs and behavioral trends, are sine qua non requirements when managing a fleet transition.

Table 2
International best practices for a fleet transition

Name (Implementer)	Main objective	Goals	Best-practices
Clean Fleet (New York City government)[a]	To transition to a less carbon-intensive transportation system	• Add 2,000 electric vehicles to its municipal vehicle fleet by 2025 • Achieve a 50 per cent reduction in GHG emissions from fleet operations compared to 2005 levels by 2025 and an 80 per cent reduction by 2035	(a) Fleet inventory including the following vehicle criteria: • Number of units • Duty weight • Type • Fuel type • GHG emissions (b) Monitoring driving patterns (c) Monitoring fuel consumption (d) Technology assessment for different vehicle uses and performances (e) Phased-approach transition to less emitting vehicle technologies (f) Charging facilities assessment
Green Fleet Transition Plan (City of Toronto, Corporate Services Department)[b]	To reduce negative environmental impacts such as equivalent carbon dioxide	• Reducing the equivalent carbon dioxide output of the city's inventory by 10 – 15 million kilograms • Significantly reduce other forms of pollutants over the four years of the Plan and future years	(a) Technology Testing Report (technology assessment) (b) Corporate fleet right-sizing (fleet assessment) considering: • Engine sizes • Duty weight • Use • Fuel type (c) Financial assessment (d) Implementation schedule (a) Funding considerations
Clean Fleet Policy and Action Plan (Hermosa Beach City Council)[c]	To reach carbon neutrality for municipal facilities and operations	• Alternative fuel used for 100 per cent of contracted city service vehicles • Locally convenient infrastructure to support a range of alternative fuel vehicles	(a) Fleet demand assessment (use and performance) (b) Fleet performance optimization assessment (c) Charging facilities demand assessment (d) Guidelines and criteria for vehicle purchase and replacement
A Clean and Green Fleet (Department of Finance y Administrative Services, Fleet Management Division, Government of the City of Seattle)[d]	To reduce GHG emissions by 42 per cent by 2020	• Reduction of petroleum fuel use by one million gallons annually • Convert 50 per cent of all new vehicle purchases from petroleum-based to EE vehicles • Install charging infrastructure for 300+ EV in fleet facilities by 2020	(a) GHG emissions inventory (b) Definition of selection standards for green vehicles (c) Electric vehicle infrastructure (charging) procurement assessment (d) Exploration of external funding sources (e) Vehicle technology assessment (f) Improvement of operational efficiency (g) Championing of fuel reduction initiatives
Alternative Fuel Vehicle Transition and Fleet Management Plan (Government of the City of Moore)[e]	To maximize fuel efficiency and conservation in order to decrease operational and maintenance costs over the lifetime of the vehicle	• Reduce annual fuel expenditures Reduce the use of petroleum-based products and dependence on foreign oil • Positively impact air quality by reducing emissions • Achieve fleet transition while maintaining efficiency of fleet maintenance operations	(a) General vehicle inventory including: • Fuel • Duty weight • Number of vehicles (b) Estimation of operation costs (fuel and maintenance) (c) Assessment of available technology

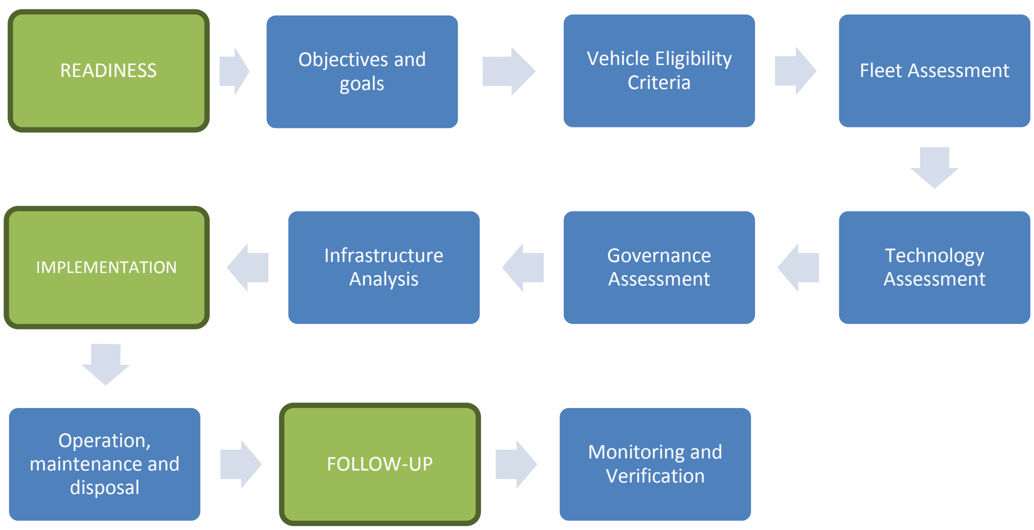
Sources: a NYCG, "NYC Clean Fleet", 2015.
bTFS, "Green Fleet Transition Plan", 2013.
cHBCC, "Clean Fleet Policy and Action Plan", 2013.
d GSC, "A clean and green fleet", 2014.
eCMG, "City of Moore Alternative Fuel Vehicle Transition and Fleet Management Plan", 2011.

B. Fleet Transition Plan

The elaboration of a Fleet Transition Plan comprises the analysis and definition of international best practices and local conditions (i.e., governance, infrastructure, financial) and capabilities. This plan consists of a guide for decision makers, implementers and vehicle users that identifies strategic actions to be undertaken in order to transition a particular fleet in the context of achieving EE targets. It also considers the country's strengths and weaknesses throughout the process in order to incorporate the necessary adjustments. In this sense, it is important to emphasize that the plan's phases and related actions should be framed and undertaken in accordance with the country's governance framework.

On the basis of all of the above, a phased Fleet Transition Plan consists of three components, namely readiness, implementation and follow-up (Figure 1).

Figure 1
Critical components of a Fleet Transition Plan



Source: elaborated by the authors.

(a) Readiness

During the *readiness* phase the country fulfills initial requirements and prepares for the implementation of the plan. In this phase, the plan is provided with general goals and objectives. Additionally, all the technical, governance, and financial aspects of the plan are considered in order to make the necessary changes and adjustments. Even more, stakeholders are engaged and informed of their duties and responsibilities throughout the transition process. The elaboration of a comprehensive transition plan should be grounded on sound baseline information on the fleet's size, performance and functionality. Understanding the composition and performance of the fleet will help to determine the optimal technology alternative for each type of vehicle and use, identify behavioral patterns and changes needed, create simplified routes and make the necessary changes for a sustainable fleet transition, rather than just vehicle electrification.

The readiness phase consists of the following six sub-phases:

(i) *Definition of goals and objectives*. During this stage particular goals and objectives are established according to local conditions and capabilities (e.g., financial and infrastructural, governance). The goals and objectives have to be supported by a work plan and/or action plan, and realistic and detailed timeframes. The main purpose of the goals and objectives is to measure fleet improvements in terms of their EE and, in general, of its environmental soundness and cost-effectiveness.

(ii) *Vehicle eligibility criteria*. Vehicle eligibility criteria should be defined to determine which vehicles are candidates for replacement. These criteria respond to usage, performance, suitability, reliability and other aspects that should be considered for the fleet transition to be EE, environmentally sound and cost-effective.

(iii) *Fleet assessment*. The fleet assessment provides baseline information regarding the fleet's current size, usage, performance, suitability, reliability and cost-effectiveness. The inputs obtained from this inventory must be later confronted with the eligibility criteria and analyzed in light of the available technology options in order to determine the convenience of replacing particular fleet units.

(iv) *Technology assessment*. During this stage the available technological replacement options are presented. This assessment should consider the suitability, availability and financial benefit of incorporating a given type of technology (e.g., EV, HEV or PHEV). Some aspects to consider when assessing potential transition technologies are: vehicle type, fuel type, vehicle range, fuelling (charging) facilities required. It should be noted that, based on the use assessment, alternative vehicle options ─such as scooters─ could arise to satisfy the fleet's needs.

(v) *Infrastructure analysis*. The adoption of new vehicle technologies could require changes and/or adaptations in the current infrastructure (e.g., grid stabilization, charging facilities). The existing infrastructure should be analyzed in function of the proposed new technology requirements.

(vi) *Governance assessment*. Sound governance arrangements represent the groundwork for proper management, help reduce costs, and minimize the environmental impacts of operating a fleet. Like the infrastructure assessment, the governance framework should be assessed to determine the feasibility of the proposed technological changes and to identify potential barriers and opportunities for the transition. New governance arrangements could be required (e.g., fiscal incentives and regulations).

During the readiness phase, the foundations are established for a comprehensive transition that considers all the characteristics of the existing fleet. Fleet assessment is a critical component of a fleet transition plan, as it allows implementers to profile existing vehicles based on their use and performance, and to determine transition criteria and goals; this assessment could also allow restructuring of the fleet to optimize its use even before transitioning. This is especially relevant when considering that transitions are costly and that the process could take multiple years to be completed. A transition, therefore, should be accompanied by other strategies to improve overall efficiency in the fleet.

An analysis of baseline fleet information could result in processes of fleet downsizing, re-routing and identifying harmful driving behaviors. Issues such as these are not necessarily solved through fleet electrification, but must be addressed as a precondition to achieving an EE transition. This also highlights the importance of preparatory steps before the actual technological transition, and evidences the multiplicity of factors intervening in a fleet transition.

(b) Implementation

Once the readiness phase is completed, the proposed changes/adaptations take place in the implementation phase. This phase is divided in two sub-phases:

(i) *Technology substitution*. After determining the eligibility criteria, selecting a new technology and profiling the vehicles to be substituted, the transition to improved technologies takes place. The purpose of the technology adoption is to improve the fleet's performance and reduce environmental and financial impacts.

(ii) *Operation, maintenance and disposal*. In order to increase the sustainability of the transition, it is important to identify future operation and maintenance requirements and costs, and to ensure that national technical and regulatory conditions are in place to allow normal operation of the new fleet. Fleet management considers not only purchasing and operating the vehicles, but making sure that obsolete vehicles are disposed in a cost effective and environmentally sound way. It should be noted that, even if disposal is considered in the implementation phase, disposal criteria, standards and other precautions should be established at the beginning of a transition plan. Inadequate disposal of vehicles and batteries could have negative environmental impacts. Disposal requirements should therefore be clearly defined in advance in order to avoid long term detrimental effects, as well as unforeseen impacts.

(c) Follow-up

The main sub-phase during this stage is monitoring and verification. The new fleet's performance should be monitored and verified in order to evaluate the transition's impacts in terms of its EE and environmental soundness. The main purpose of this stage is to provide inputs for future transitions. The aspects and features used during the baseline inventory (i.e., Fleet Assessment) should be consistently used to measure the fleets overall performance.

Some of the best practices in this phase are:

- Encouraging driver-training programs, particularly those with a speeding and idling component, to minimize practices and habits that increase fuel consumption and vehicle emissions.
- Awareness programs are also recommended to improve driving habits and behaviors by providing information on the effects that idling and use of air conditioning have on an EE vehicles; promoting change within public institutions by using vehicles for the purpose they are intended; planning staff activities based on common routes, thus reducing vehicle use, among other actions.
- Conducting regular preventative maintenance, including oil changes, to ensure that vehicles are operating at their optimum.
- Conducting periodic vehicle emission testing. The condition of a vehicle's engine emission controls and electronics is an important variable that affects its fuel efficiency and emissions.
- Monitoring vehicle use through regular review of logbooks and sign-out sheets to ensure that all fleet vehicles are being properly used and utilized to their maximum capacity.
- Monitoring vehicle expenditures and fuel purchases to ensure alternative energy sources are being purchased to the maximum extent possible.
- Ensuring that fleet management information is being updated and properly tracked.
- Conducting annual assessments of fleet information for ongoing fleet planning and vehicle acquisition.

II. Readiness

A. Fleet Transition Plan: objectives and goals

This section analyses the components within the readiness phase. Considering the state of the energy sector in Saint Lucia, it is expected that most actions would be taken in this phase of a fleet transition. The section will provide a logical framework that could guide a fleet transition strategy, at the same time that it analyses such framework in light of Saint Lucia's current conditions.

According to Saint Lucia's Vehicle Management Policy (VMP), the fleet administrator is in charge of the elaboration of the Fleet Transition Plan. Such a plan should contain specific goals and objectives in accordance with the EE and RE targets defined by the Government of Saint Lucia, local capabilities (i.e., infrastructure) and governance framework (e.g., National Energy Policy, national procurement standards). The Fleet Transition Plan should include stakeholder engagement during the readiness phase in order to inform all government agencies about their duties, responsibilities and changes (i.e., technological, infrastructural and administrative) in advance to the implementation phase. The Fleet Transition Plan should aim at enhancing fleet efficiency not only through the transition to EV/HEV/PHEV technologies, but also through the improved management of existing and potential fleet technologies. This latter point is of particular relevance when we consider that fleet electrification by itself will not assure meeting pre-established EE and RE targets. Hence any energy-efficient Fleet Transition Plan should consider the following generic goals:

- Gradually transition the vehicle fleet to more energy efficient technologies such as EV/HEV/PHEV.
- Achieve stakeholders' engagement throughout the transition process.
- Define mechanisms to enforce the compliance of vehicle use guidelines established in the Vehicle Management Policy.
- Achieve energy sources diversification to nourish the new fleet.
- Foster managers' and drivers' behavioral change in order to better use and manage vehicles and to facilitate the incorporation of more sophisticated technologies such as EV/HEV/PHEV.

In order to assure the consecution of these goals, it is recommended that the Government of Saint Lucia work towards accomplishing the following objectives:

- Elaborate a fleet baseline inventory.
- Define the most suitable vehicle technology to adopt in the transition.
- Replace fleet units according to the eligibility criteria.
- Select the most suitable charging/fuelling facility for the new fleet.
- Adapt the related infrastructure in order to cope with the transition's technological and operational requirements.
- Adjust the governance framework to the transition requirements.
- Undergo a capacity building process to inform and educate fleet operators and managers about the transition technologies and EE.
- Monitor and verify fleet improvements.

These goals and objectives are general considerations that should guide a Fleet Transition Plan. It is recommended that the Government of Saint Lucia bases its Fleet Transition Plan on these goals and additionally establishes targets, a work plan and timeframes. Timeframes have to be established in accordance with local capabilities and governance framework. Even though this represents the first step within the readiness phase, it is worth noting that objectives and goals should be established in accordance with the NEP and other national development instruments, and based on a comprehensive assessment of the existing fleet in order to set attainable and realistic targets.

B. Vehicle eligibility criteria

Vehicle transition to EV and/or HEV in the context of enhancing EE and incorporating RE is more than simply making a one-to-one replacement. First, replacing internal combustion engine (ICE) vehicles with EV/HEV/PHEV technologies poses some technical challenges mainly related to technology costs, distance range, charge time, battery life uncertainty, vehicle model choices and availability, fleet infrastructure issues, utility impact due to dense charge networks, and technology perception and awareness (EC, 2010; Lutsey, 2015). Second, the replacement process should be cost-effective, which means that it has to make sense not only from a use and performance perspective, but also from a financial point of view. In order to overcome both barriers, vehicle eligibility criteria should be established. Based on the eligibility criteria and on the results of the fleet assessment, decision makers could make an informed decision and determine the potential vehicles to transition. These criteria will allow assuring that the new fleet meets environmental and financial standards as well as EE targets. In this sense, eligibility criteria should answer the following questions (Bibona, 2003; 2015):

- Is the vehicle being fully utilized?
- If it needs to be replaced, is the current specification of the vehicle appropriate?
- If a vehicle is not being fully used, why replace it at all? Perhaps it should be reassigned to a more intensive application.
- Would a different vehicle be better suited for the particular application?
- Is there an equivalent EV/HEV/PHEV model?
- Are there special incentives to replace the vehicle?

By answering these questions early in the transition process, decision makers can avoid purchasing too many or unsuitable units for their fleets and to make sure that EE requirements are met. To answer such questions, fleet administrators need to gather baseline data during the Fleet Assessment.

As the review of best practices shows, three replacement approaches may be used: the economic lifecycle analysis, the mileage/age approach, and the cost of repair approach. In the case of the former, it could be very difficult to implement it from the start of the transition since it requires extensive amounts of data that at the moment are not available and involves quantifying several parameters (e.g., downtime, obsolescence, and other cost factors). To work exclusively with one approach could be insufficient when aiming to ensure the transition’s full cost-effectiveness and the accomplishment of EE and RE goals. For this analysis, nine comprehensive selection criteria are recommended for consideration by the Government of Saint Lucia:

(i) *Age and Mileage*. Priority should be given to vehicles in the last stages of their lifecycles. Older vehicles tend to be less energy efficient and cost-effective due to elevated repair and maintenance costs. It should be noted that electric vehicles must be driven a minimum number of kilometers each year for them to be cost-effective, therefore, before transitioning vehicles it is crucial to collect data on their use and avoid initial replacement of vehicles with low mileage. Idle vehicles are not candidates for initial replacement since it reflects a lack of planning in the fleet’s design and use. According to Saint Lucia’s VMP, the age threshold for vehicle replacement or disposal is seven years. In terms of mileage, the vehicle has to reach or surpass 100,000 miles.

(ii) *Suitability*. Decision makers should determine if the vehicles fall behind or exceed users’ requirements. A vehicle’s class and design are the first determinants of their use (e.g., administrative, field work, cargo), therefore, replacements should be done according to required vehicle’s duties. The use assessment is intended to match the appropriate transition vehicle with its expected functions; therefore, this exercise could be used to determine if scooters could be an efficient component of the fleet. It is also necessary to determine general type, size, and weight of cargo carried (e.g., luggage, construction materials, meeting materials, presentation materials, tools). The type of driving is also an important criterion to consider. Either highway, urban or off-road driving, the type of driving determines the vehicle’s energy needs (i.e., fuel) and performance. In this criterion’s case, over- and under-performing vehicles should be considered for replacement. Saint Lucia’s VMP tasks agency Transportation Officers with monitoring vehicle utilization to ensure optimum use and efficiency. In addition, requests for new acquisitions must include information on the primary use and other uses of vehicles and detailed specifications that would allow selecting the most suitable vehicle. The proposed Fleet Management Information System also considers data collection on the rationale for the assignment of each vehicle to particular agencies and/or uses.

(iii) *Performance*. The vehicle’s performance determines its cost-effectiveness and is directly linked to its environmental integrity. The VMP states that when the performance of the vehicle is such that it is no longer suitable for the purposes for which it is intended, it should be replaced. Performance is closely linked to the suitability criterion.

(iv) *Reliability*. Body condition, rust, interior condition, accident history and anticipated repairs could add to the vehicle’s capital cost and, therefore, make it candidate for replacement. Vehicles spending too much time in the workshop under-perform and are neither reliable nor cost-effective. According to the VMP, vehicles damaged or in need of repairs greater than the 80 per cent of their fair market value should be replaced.

(v) *Environmental integrity*. Vehicles with low standards for GHG emissions or lack of environmental soundness should be considered for replacement. The environmental integrity could be related to the age criteria since old technologies tend to be less environmentally sound. Among the factors that are considered in the VMP when deliberating on the procurement of vehicles are fuel type and consumption, engine capacity and emissions rating.

(vi) *Replacement availability*. Vehicles that are candidates for replacement should have an equivalent weight class or horsepower EV/HEV/PHEV. Exceptions should be done when the replaced vehicle's use was not according to its weight class. Vehicles without a suitable EV/HEV/PHEV replacement should not be considered in initial stages of the transition. In addition, and based on the intended use, scooters could be an ideal replacement to promote efficiency. Hence, before analyzing technology alternatives, it is fundamental to know the intended use of every vehicle to ensure a transition to efficient equivalents. This would also allow determining the ideal fleet size.

(vii) *Vehicle routing*. The vehicle's geographical fencing is determinant when choosing a replacement due to EV/HEV/PHEV terrain and distance range constraints. Replaced vehicles should be suited with fuelling infrastructure that matches their range and time of duty. If this criterion is not assured, replacement of such vehicles is not recommended.

(viii) *Costs and procurement*. Replaced vehicles should have an equivalent/functional EV/HEV/PHEV that does not exceed the budget's threshold predefined for these items. Even if, when used properly, EV/HEV/PHEV performance is mid- to long-term cost-effective, budget and potential funders' conditionalities could represent a restraint when purchasing a new vehicle. Replacement vehicles should meet the procurement guidelines stated in the Vehicle Management Policy.

(ix) *Available grants*. Replacement vehicles with special incentives (e.g., dealer, fiscal) should be prioritized. This criterion could also consider battery disposal when selecting a vendor, as some offer disposing or recycling options.

The above-mentioned criteria will allow gathering baseline information, which will inform the fleet assessment. It should be noted that, even if the most relevant data is considered in Saint Lucia's VMP, the collection systems have not yet been implemented. The existing Vehicle Tracking System and the data analyzed for this report evidence the efforts of the Government of Saint Lucia in collecting information on its fleet; however, information such as suitability and environmental integrity are not yet considered, and other information such as routing is not always collected. An upgrade of existing tracking systems could allow for collection of additional information while a centralized and standardized information system is deployed.

The Vehicle Management Policy directly considers most of the proposed criteria for vehicle eligibility. Information on vehicle performance and other characteristics will be gathered by the Fleet Management Information System; driving patterns and uses are also expected to be recorded in mandatory log books. Additionally, the policy incorporates considerations of efficiency, fuel use and emissions as part of procurement and selection processes. The implementation of the policy and its monitoring instruments will allow for a comprehensive understanding of the fleet that could inform a Fleet Transition Plan.

The fleet assessment filters, categories, and aspects presented in the following sections were chosen in accordance with the above mentioned criteria.

C. Fleet assessment

During the fleet assessment, the fleet's total costs (i.e., operation and maintenance), use, driving patterns, drivers' behavior, environmental soundness and potential transition technologies are examined. The assessment's ultimate goal is to establish a baseline scenario to determine which vehicles could be eligible for an EV/HEV/PHEV replacement according to the pre-established eligibility criteria. It is expected that the assessment could provide additional inputs in order to reduce costs, environmental impacts, and to guide policy on vehicle emissions and incentives. Even more, the fleet assessment could be the base tool for prospective fleet tracking and monitoring.

As a first step, an assessment task group that would operate under the fleet administrator's supervision should be assigned to carry out a fleet assessment according to the stipulations of the VMP (see box 1). The group must gather and analyze information from all available sources (Table 3) and determine which vehicles are eligible for replacement. It also should define the assessment's periodicity for data analysis. This task requires defining periods (i.e., start- and endpoint) within which the vehicle's information will be recorded and analyzed. In this sense, the VMP states the yearly recording of some aspects (e.g., fuel consumption) and exposes the need for periodical information gathering; nevertheless, no specific periods to record the rest of the aspects are determined. Best practices show that, in order to evaluate a fleet, it has to be monitored during the life-cycle of the vehicles. It is suggested that an initial assessment is applied to vehicles matching the disposal criteria established in the VMP (Section 2.4).

The fleet assessment consists of the application of a series of pre-defined filters. Once the vehicles have been assessed, they should be profiled (through a technology assessment) in order to determine their transition eligibility.

Box 1
Fleet administrators

According to the Applicability of the Vehicle Management (section 2.1: Vehicle Management) of the Vehicle Management Policy (VMP)"The overall administrators for the Government of Saint Lucia's fleet of vehicles are the Director of Finance and the Permanent Secretary in the Ministry of the Public Service. These Officers shall hereafter be referred to as Fleet Administrators". The fleet administrators' main duty is to manage the Government of Saint Lucia's fleet of vehicles. Each fleet administrator has the following responsibilities by virtue of their designation within the Government of Saint Lucia:

a. Director of Finance

(i) Overseeing the management of the overall fleet; particularly as it relates to fleet administration and matters such as acquisition, allocation, replacement and disposal of government vehicles.
(ii) The maintenance and management of a fleet management information system for all vehicles owned, leased and or operated by the Government of Saint Lucia.
(iii) Receive driver log books, documents and reports related to the government's fleet (upon request). Additionally the Fleet Administrators shall receive collated data on vehicle usage, and any other vehicle data (such as fuel) upon request.
(iv) Advising Agencies on procurement options; redeployment of existing vehicles and intra government transfers.
(v) Monitoring the maintenance and servicing of vehicles.
(vi) Receive driver log books, documents and reports related to the government's fleet (upon request). Additionally the Fleet Administrators shall receive collated data on vehicle usage, and any other vehicle data (such as fuel) upon request.
(vii) Ensure agencies and officers entrusted with government vehicles are aware of their responsibility as it relates to the proper care, operation and maintenance and protection of these vehicles.
(viii) Source and advice agencies on preferred vehicle servicing facilities, making best use of warranty options (for vehicles still under warranty) and favorable rates for repair for out of warranty servicing.

b. Permanent Secretary within the Ministry of the Public Service

(i) Articulating the Government of Saint Lucia's policy on fleet management through the developing of policies, procedures and other means.
(ii) The maintenance and management of a fleet management information system for all vehicles owned, leased and or operated by the Government of Saint Lucia. Details of the Fleet Management Information System can be found in Section 2.2 of this document.

Box 1 (concluded)

(iii) Ensure that driver training sessions are organized as the need arises or upon the request of agencies. iv. Issue additional guidance relating to motor vehicle management as may be necessary.

Source: Vehicle Management Policy, 2016.

1. Fleet assessment: filters

The fleet assessment is composed of four filters (Table 3) which should be applied hierarchically and will serve to profile the fleet's units and to determine their eligibility according to pre-established criteria. Some experiences show how fleet administrators tend to prioritize or neglect some of this criterion. It is suggested that a full fleet assessment is undertaken in order to assure the accomplishment of the EE enhancement goals and to comply with the VMP's stipulations (Section 2.2: Fleet Management Information System).

Each fleet assessment filter considers several categories and features to be assessed (Table 3). The categories and features were obtained from a review of best practices and from Saint Lucia's VMP. In addition, the main sources of information are the Vehicle Tracking and Monitoring System and the Fleet Management Information System.

As was mentioned above, several government agencies in Saint Lucia have established fleet tracking systems. However, when considering fleet assessment categories, the data reviewed shows some information gaps in filters such as type of driving, driving patterns, routing, and usage, which hinder the ability of carrying out a complete fleet assessment. These elements can be included in system upgrades and in updated requirements for driver logbooks. The VMP considers these matters.

It is expected that once the VMP is implemented these information gaps will be solved. In this regard, it is worth highlighting the importance of developing a centralized and standardized Fleet Management Information System that can be managed by each individual agency. A standardized system would ensure that all the required information is collected by every agency and would avoid the creation of a diversity of systems. Besides considering different types of data, decentralized tracking systems could also present potential problems for interoperability, and maintenance of diverse systems might be more costly. Once information is collected by each agency, a centralized database should inform decision making and future projects.

The fleet assessment considers the following filters, categories and features.

(a) Vehicle particulars registry

The vehicle particulars registry is not an assessment filter but an important stage in the process of profiling the vehicles. At this stage, the vehicle's particular information is recorded (i.e., registration number, manufacturer, model, engine number, and chassis number). Insurance information is also recorded (i.e., insurer, policy number, period of insurance and class of coverage).

(b) Age and mileage

Age and mileage are two of the main replacement eligibility categories. Through an age and mileage assessment, decision makers could prioritize which vehicles should be transitioned first. The vehicle's maximum useful life and the insurance periods could allow decision-making in relation to how many years it is worth to keep the vehicle. Taking into consideration financial and technical constrains in Saint Lucia, an initial transition could focus on those vehicles that have completed their age and/or mileage cycles. The analyzed tracking information shows good data collection for these categories, which could inform a phased transition starting with older vehicles (as classified by the

VMP). It should be noted that a transition based on age and/or mileage should be accompanied by a usage assessment in order to determine the most suitable replacement vehicle.

Table 3
Fleet assessment categories, features and sources

Categories	Features	Source
	Age and mileage filter	
Age	1. Year model 2. Maximum useful life	• Vehicle Tracking and Monitoring System • Fleet Management Information System
Mileage per year (MPY)	1. MPY	
Insurance	1. Insurance period	
	Use Assessment	
Classification	1. Class A 2. Class B 1. Class C	• Vehicle Tracking and Monitoring System • Fleet Management Information System
Type of driving	1. Urban (*i.e.*, normal driving) 2. Off-road 3. Highway	
Driving patterns	1. Braking 2. Accelerating 3. Idling	
Routing and allocation	1. Geo-fencing	
Driving schedule	1. Hours per day	
Usage	1. Administrative 2. Fieldwork 3. Cargo	
	Lifecycle analysis	
Incidents	1. Crashing events	• Vehicle Tracking and Monitoring System • Fleet Management Information System
Vehicles condition	1. Rust 2. Interior condition 3. External conditions	
Vehicle purchase cost	1. Manufacturer's suggested retail price	
Actual maintenance costs	1. Oils 2. Spares 2. Workshop	
Estimated operating costs	1. Annual fuel consumption Kilometers per gallon 3. Insurance payments made	
Environmental integrity	1. Carbon Dioxide Equivalent	
	Replacement Assessment	
Equivalent technology	1. EV 2. HEV 3. PEV	• Inputs from the Technology Assessment
Funding alternatives	1. Dealer 2. Fiscal	• Funding/financing assessment

Source: Author's compilation.

(c) Use

At this stage, use patterns and characteristic are analyzed. This will allow for determining the vehicle's suitability to its current assignments and potential secondary uses. Driving patterns are also assessed since it could give initial clues on the vehicle's performance. These categories are of particular relevance when transitioning to battery electric vehicle (BEV) technologies since these kinds of patterns impact on fuel economy.[1] The evaluation of the vehicle's intended use should inform the technology assessment, as functions should be matched with adequate and efficient equivalent

[1] Quick acceleration and heavy braking can reduce fuel economy by up to 33 per cent on the highway driving and 5 per cent on urban driving (DOE, 2016).

technology. Based on the fleet's requirements, it would be valuable to explore the incorporation of scooters. Replacement of vehicles without a detailed description of their main uses and areas covered could have counterproductive effects on EE, as it could result in a one-to-one transition that only considers the vehicle's model rather than a fleet optimization that matches specific uses and routes with suitable replacement technologies.

Route predictability may be among the most important characteristics that could facilitate uptake of new technology, mainly grid-enabled vehicles. In addition to reducing upfront costs, high levels of route predictability would reduce fleet operators' dependence on public charging infrastructure by allowing EV/HEV/PHEV to be matched with the patterns that are most conducive to their use. Thus, the importance of establishing vehicle classifications and standards based on their weight and recommended uses. Even if they differ from international standards, the Government of Saint Lucia has already established this categorization (Table 4).

Table 4
Vehicle classification, use and electrification availability

<table>
<tr><th>Group</th><th>Government of Saint Lucia classification (gross weight</th><th>Standard classification (gross weight)</th><th>Usage examples</th><th>Electrification availability</th></tr>
<tr><td>Light duty</td><td>• Class A
(less than 1,134 kg)
• Class B
(from 1,134 kg to 1,587 kg)</td><td>Class 1
(<6000lbs)</td><td>• Staff and support</td><td>Yes</td></tr>
<tr><td rowspan="2">Light duty trucks</td><td rowspan="8">• Class C
(1,588 kg and over)</td><td>Class
(1<6000lbs)</td><td rowspan="2">• Field engineering
• Crew support
• Cargo</td><td>Yes, but PHEV models are limited</td></tr>
<tr><td>Class 2
(<6000lbs)</td><td>Yes</td></tr>
<tr><td rowspan="4">Medium-duty trucks</td><td>Class 3
(10,001–14,000 lbs.)</td><td rowspan="4">• Trouble-shooter
• Repair
• Crew support</td><td rowspan="6">In development</td></tr>
<tr><td>Class 4
(14,001–16,000 lbs.)</td></tr>
<tr><td>Class 5
(6,001–19,500 lbs.)</td></tr>
<tr><td>Class 6
(9,501–26,000 lbs.)</td></tr>
<tr><td rowspan="2">Heavy-duty trucks</td><td>Class 7
(26,001-33,000 lbs.)</td><td rowspan="2">• Special configuration functions
• Cargo</td></tr>
<tr><td>Class 8
(> 33,000 lbs.)</td></tr>
</table>

Source: EEI, "Transportation Electrification", June, 2014.

Subsequently, type of driving and driving pattern will be classified according to the categories defined in Table 4. These categories are important since they provide an explanation on how the vehicle is being used, which has an impact on the vehicle's performance. This component will also evidence harmful behaviors, thus providing information on necessary training or awareness campaigns among users and drivers.

Routing and allocation is highly related to the type of driving and provides inputs in relation to the geographical borders where the vehicle is used. This is of particular relevance when choosing vehicle distance range and designing charging infrastructure in the eventuality of an electrical or hybrid transition. In this same direction, the driving schedule could provide information about the amount of time and exact periods in which the vehicle is being used.

Lastly, the use category helps in determining the potential purpose of the vehicle. Probably the most notorious information gaps identified in the Government of Saint Lucia database are in this category. The information assessed for this report lacks data on uses, while information on routing is not complete for all vehicles. Although the existing tracking system features geo-fencing, not all vehicles reported on it. These types of information are also crucial for determining the number and location of charging stations. Therefore, a usage profile is required to determine the prospective types of vehicles to purchase in the future and the number, type and location of charging stations.

(d) Lifecycle analysis

This analysis is deployed in order to determine the vehicles' cost-effectiveness[2] and to compare them to potential EV/HEV/PHEV replacement alternatives. Maintenance, operational costs, and purchase costs are calculated in order to estimate capital costs. For the purpose of the vehicles' inspection, the Government of Saint Lucia already has in place a "Weekly Vehicle Inspection Report" that facilitates assessing the vehicles' reliability. Aspects such as lights, tires, fluids, windscreen and internal and external conditions are checked. The vehicle's environmental soundness it is also checked in order to determine the impact it has on the environment. This aspect relates to the equivalent GHG emissions. The Motor Vehicles and Road Traffic Act (2005) (Section 193) provisions for the establishment of exhaust emission standards and specifies the maximum levels of air contaminants that motor vehicles or trailers may emit into the outside atmosphere. At the moment of elaboration of this report no standards and levels where available; however, the Saint Lucia Bureau of Standards could collaborate in accomplishing this requirement. Insurance information is also recorded.

(e) Replacement analysis

This analysis will allow determining if there is equivalent or functional EV/HEV/PHEV available in the market. It will also provide clues about funding opportunities in order to replace the vehicle. This last filter is applied once the vehicle has been preliminarily profiled in order to determine the available replacements in the market. Replacement should be done as a function of the vehicles' use and routing more than of the class, thus the expected use and routing of the vehicle should determine the replacement alternative.

(f) Vehicle profiling

Although vehicle profiling is not a filter, it is the end result of applying the abovementioned filters. Once the vehicles have been assessed, the results should be analyzed in light of the eligibility criteria in order to determine their transition potential.

[2] Several Lifecycle Assessment tools are available online for public use (*e.g.,* Fraser Basin Council, 2006; EECA, 2016).

D. Technology assessment

The technology assessment is the third step within the readiness phase. It is suggested to carry out an in-depth review of existing technology once the vehicles have been profiled in order to determine which technology best suits the fleet's needs. In this section the available EV/HEV/PHEV technology is overviewed. Additionally, technical, financial, and environmental aspects are used to compare EV/HEV/PHEV with ICE.

The following sections provide a general overview and comparison of existing technologies. This report details potential replacement technologies and characterizes each type of solution. However, in order to continue the selection process a detailed vehicle profile through a fleet assessment is a pre-requisite to identifying the most suitable type of replacement technology and vehicle. In this regard, this section does not correspond to a final technology assessment but a first look at the available alternatives.

1. General technology overview

EV/HEV/PHEV alternatives have significantly grown since the development of the technology in the early 1990s; nowadays it has become a competitive means of transportation. These technologies present considerable variations and differ from one another depending on their design, type, and technical specifications.[3] An overview showing the main distinctions on the available EV/HEV/PHEV technologies is presented in Table 5.

The overview includes ICE vehicles in order to present a first comparison between existing and competing technologies. The main distinctions between electric and hybrid technologies have to do with aspects such as regenerative breaks, battery charging, and hybrid capabilities. The relevance of these distinctions lies in the fact that they determine the vehicles' distance range and cost.

Table 5
Vehicle technology overview

Type	Regenerative Breaks	Drive only with electric motor	Plug-in battery charging	Gasoline engine	Examples
ICE	-	-	-	+	Ford Fiesta
Mild HEV	+	-	-	+	Honda Civic Hybrid
HEV	+	+	-	+	Toyota Prius
PHEV	+	+	+	+	Ford Fusion Energi
EV	+	+	+	-	Nissan LEAF

Source: Adapted from Sonnenschein, Jonas, "Preparing for the Roll-Out of Electric Vehicles", International Institute for Industrial Environmental Economics, Lund, September, 210
Key: - (does not include), + (includes).

From the vehicles shown, only energy in ICE comes exclusively from a fossil fuel gas engine. All the other vehicles have a regenerative break technology that allows them to regain energy through

[3] Range Extended Electric Vehicles (E-REV) are also available in the market. VIA VTRUX offers pick-up truck and van models. With this technology a 100 KW electric generator is utilized to add more power together with a 23 kWh battery. Driving range is up to 40 miles working only with the electric motor, adding 400 miles more with the generator. It is important to take into account extra load which will reduce driving range. An E.REV technology uses also a gas electric generator to charge the battery when needed.

the process of slowing down. Such energy is stored in the battery and used later by the vehicle in different ways.

In the case of HEV, there are three types of vehicles divided depending on their power trains: (i) series, (ii) parallel or (iii) series-parallel. In the series technology the power to turn the wheels comes from plugging the car to an electric motor or from an efficient gas generator. In the parallel type, the engine and the electric motor are the power providers. This means that both the engine and the electric motor are connected to the transmission, outdoing the conversion losses from the engine and converting it to electric energy. The series-parallel combines both technologies, allowing the driver to choose which motor will be used to move the vehicle (Friedman, 2003). The main difference between HEV and PHEV is the plug-in battery charging. PHEV technology allows charging the electric motor with an external energy source (e.g., grid and/or batteries). REV technology also uses a gas electric generator to charge the battery when required. Lastly, the EV technology uses only electrical power coming from the battery that must be charged from an external source as with the PHEV.

For the purpose of this report, only PHEV, HEV and EV technologies are taken into consideration. ICE were not considered as they represent the base technology to be replaced.

2. Electric, hybrid and plug-in hybrid vehicles overview

Some of the examples listed and most known EV are within the category of sedan and mini car. Alternatives for SUV are also available. Pick-up truck alternatives are limited since the market is still in development (Table 4). The main constraint for manufacturers comes from reconciling aspects such as power generation needed and battery capacity. Within the EV types of sedan and mini car, distance range varies from 53 miles (e.g., Chevrolet Volt) to 93 miles (e.g., Kia Soul) per full charge. Tesla models range much higher (~230 miles), but are also considerably more expensive. Within the EV van types, several models are available in the market (e.g., Renault Kangoo and Ford Transit Connect). This type of vehicle has a distance range between 80 and 100 miles per charge.

Range depends on factors such as battery capacity and energy consumption. Battery capacity in mini EV varies from 16 kWh (e.g., Mitsubishi MiEV) to 27 kWh (e.g., Kia Soul), having all a similar energy consumption of 28-32 kWh per 100 miles (e.g., Smart Fortwo). In sedans, EV battery capacity average increases. Today it is possible to find models with 28 kWh (e.g., Mercedes B250e) and 30 kWh (e.g., Nissan LEAF) with energy consumption very similar to mini EV. Regarding motor power, mini EV have an average 49 KW to 83 KW motor (e.g., MiEV and Fiat 500e). On the other side, sedan's motor power ranges from 85 KW (e.g., VW e-Golf) to 132 KW (e.g., Mercedes B250e).

Most EV in the market present three different charging levels: (I) 120V, (II) 240V and (III) fast charging (CHAdeMO technology). In level I charging time averages from 6 to 10 hours in all types, depending on battery capacity. This option is the most suitable for residential vehicles. Some vehicles (e.g., Nissan LEAF and VW e-Golf) can be upgraded to level II charging. These vehicles come with a 6.6-kW charger that essentially doubles the charging speed, fully charging the vehicle in 4 hours. Level III charging (fast charging) stations are more suitable for cities and/or highways and could work similarly to gas stations. With this technology, drivers could charge as much as 80 per cent of their vehicle's battery in a period between 30 minutes and one hour. Fast charging electric stations are very popular in European and North American countries, surpassing the 14,000 stations in the USA in 2016.

HEV are fuelled with gasoline only but combine the benefits of gasoline engines and electric motors. HEV do not have electric motor range since the electric motor is only assistive to the internal combustion engine. They recharge/recapture some energy during braking and store it as electricity which can help power the car. HEV cannot be plugged in and charged, but they can be very fuel efficient. According to DOE (2016), HEV present several advanced technologies that make them more efficient than comparable conventional vehicles (i.e., ICE):

- Regenerative braking recaptures energy normally lost during coasting or braking. It uses the forward motion of the wheels to turn the motor in reverse. This generates electricity and helps slow the vehicle.
- Electric motor drive provides power to assist the engine in accelerating, passing or hill climbing. This allows a smaller, more-efficient engine to be used. In some hybrids, the electric motor alone propels the vehicle at low speeds, where gasoline engines are least efficient.
- Automatic Start/Stop shuts off the engine when the vehicle comes to a stop and restarts it when the accelerator is pressed. This reduces wasted energy from idling.

In relation to engine performance, PHEV have an advantage over ICE and EV since they have alternation of an electric motor and a combustion motor. This allows these vehicles to share driving ranges between sources. It is important to note that the electric motor's performance is inferior to the combustion motor. Then, it can be implied that PHEV emit a certain degree of GHG that the EV do not. Depending on the customer's needs, electric motors range from 14 MPG in luxury cars (e.g., BMW 330e) to 53 MPG (e.g., Chevrolet Volt).

PHEV battery capacity decreases in comparison with EV due to the driving alternation between combustion engines. Battery capacity of EV ranges from 7 kWh (e.g., Ford Fusion Energi) to 18 kWh (e.g., Chevrolet Volt). Energy consumption with the electric motor in PHEV is higher than in EV, with ranges that go from 37 kWh to 47 kWh depending on motor size and power. In the case of SUV, their weight could increase energy consumption.

Regarding the charging aspect, PHEV are very similar to EV. PHEV available in the market have a 120 V–3.3 kW charging device. Fast charging is not available for every PHEV since battery capacity in many PHEV is smaller and does not require large amounts of charging time as with EV. Retail prices have a large gamma of possibilities depending on vehicle size, technology, and luxury models.

3. Comparison between electric, hybrid and plug-in hybrid vehicles and internal combustion engines

EV/HEV/PHEV technologies present several advantages over ICE. Nonetheless, even if these technologies are seemingly more energy efficient and cost-effective, it is important to take into account some considerations (i.e., environmental, economic and performance-related) in order to select the best technology for the fleet's purposes.

(a) Environmental concerns

Vehicles' environmental impacts are a widely-discussed topic. Most authors agree on the benefits of EV/HEV/PHEV in relation to the while-driving-CO2-emissions. This is not the case in non-diversified electrical systems, like in Saint Lucia where emissions are still produced by traditional sources of energy. Promoting the use of energy-efficient vehicles in areas where energy production relies on lignite, coil or heavy oil combustion could be counterproductive (Hawkins, 2012). Therefore, if the ICE fleet of the Government of Saint Lucia is transitioned to EV technology and if energy is still produced from oil, the vehicles' combustion process will only be transferred from the vehicle's engine to LUCELEC's traditional energy plants. In the case of PHEV, the emissions will significantly increase since these technologies will be nourishing from both gasoline and electricity produced from oil. Even though emissions will be reduced by using efficient engines, it is recommended to conceptualize a long-term transition path that goes beyond fleet electrification and considers actions to clean the grid and increase energy efficiency in the fleet's performance. Actions such as fleet downsizing or re-routing could provide important efficiency gains in the short term.

In countries or regions where energy sources are clean (i.e., renewable energies), EV/HEV/PHEV could have an advantage over ICE since the total amount of emissions could be significantly reduced. Projections done by the International Energy Agency (IEA) estimate that a reduction of 0.5 billion tonnes of CO_2 emissions could be achieved if EV replaces ICE in the medium term (2011).

Battery disposal is another main concern. It is known that battery materials are toxic for human health and, in general, the environment (Hawkins, 2012). Several EV/HEV/PEV manufacturers offer an 8 years/100,000 miles battery warranty, and according to the National Renewable Energy Laboratory, nowadays, batteries have a 12-15 years lifetime in moderate climates and 8-12 years in extreme climates (DOE, 2016). Regardless of the increasing lifetime of batteries, a Fleet Transition Plan must include disposal guidelines to avoid environmental and health issues in the future.

Most EV/HEV/PHEV are powered by nickel-metal hydride (NiMH) or lithium ion batteries, each battery has different performance, lifecycle and disposal features (Table 6). NiHM batteries replaced lead acid batteries in EV and HEV, as they were heavier, had lower energy density and posed hazardous environmental effects. Lithium-ion batteries have higher energy density and efficiency, and are still undergoing improvements to reduce costs and extend lifecycle but are more expensive. Most EV/HEV/PHEV still use these two types of batteries, with an increasing use of lithium-ion as it performs better than other types of batteries.

Regardless of the type of vehicle, both types of batteries should be disposed in specialized facilities and both can be recycled. In addition to incorporating stipulations for disposal and recycling, the transition process could favor those vendors that also offer disposing or recycling of used batteries.

Table 6
Brief description of nickel-metal hydride and lithium-ion batteries

Type of battery	Advantages	Disadvantages	Disposal
Nickel-metal hydride	High energy density (60 per cent of lithium-ion batteries) Light weight battery Simple storage and transportation Environmentally friendly Successfully used in EV and HEV	High cost Limited service life (depending on maintenance and charging behaviors) High self-discharge Heat generation at high temperatures Deterioration after prolonged storage, especially if stored at elevated temperatures Quality of maintenance and storage affect lifecycle Limited supplies of rare earth element Lanthanum	Valuable to recycle due to high price of nickel, cooper and steel
Lithium-ion	High energy density and efficiency High power-to-weight ratio Low self-discharge (half of NiMH) Low maintenance High mileage Preferred in advanced-technology vehicles Most EV and PHEV use lithium-ion batteries	Expensive Moderate discharge current Transportation regulations Still undergoing improvements Safety concerns	Lithium is in high demand but inexpensive Recycling cost of lithium exceeds extraction/mining costs Value lies in aftermarket/secondary uses, especially for energy storage. Life up to 10 years at 70-80 per cent efficiency Difficult to recycle as chemical composition can vary among manufacturers

Source: Author’s compilation.

Literature shows that improvements are being made to both types of batteries, and that new substitutes are also being developed to address the deficiencies experienced by NiMH and lithium-ion batteries. Considering that EV/HEV/PHEV and their accompanying batteries are relatively new technologies (and applications), disposal and recycling facilities are also incipient and undergoing changes. Nevertheless, evidence suggests that, while NiHM can be recycled due to the value of its components, recycling lithium-ion batteries is more costly than mining for new lithium. Therefore, new secondary uses are being identified for lithium-ion batteries, especially for energy storage.

A secondary use after the battery serves its automotive application could also help overcome initial high costs associated with lithium-ion batteries. Once the battery completes its automotive use, it is estimated that it degrades to 70-80 per cent of its original capacity; at this point it does not serve any automotive purpose (UCLA & UC Berkeley 2014; NREL 2015). Considering the growth that EV/HEV/PHEV have experienced and will continue to experience, it is expected that large amounts of used batteries will be produced and can be redirected to satisfying energy storage needs of customers, utilities and operators. The most relevant secondary used identified for lithium-ion batteries is energy storage, which could help integrate variable renewable energy into the grid. According to NREL (2015), "such battery use strategies would not only reduce the nation's dependence on foreign oil and emissions of greenhouse gases by increasing plug-in electric vehicles adoption, but would also improve the reliability, efficiency, and cleanliness of the grid by advancing the deployment of grid-connected storage". The NREL (2010) has identified the three second use applications for EV/PHEV batteries:

(i) Grid-base stationary
  - Energy time shifting
  - Renewables firming
  - Service reliability

(ii) Off-grid stationary
  - Backup power
  - Remote installations

(iii) Mobile
  - Commercial idle off
  - Utility vehicles
  - Public transportation

However, research on these uses is still underway and challenges have also been identified. Some issues are uncertain, degradation rates depend on environment and maintenance conditions, battery refurbishment costs are high and alternative energy storage solutions could have lower costs. Several research and specialized institutes, and vendors are currently investigating new ways to reuse retired batteries and overcome the identified challenges.

(b) Performance and economy concerns

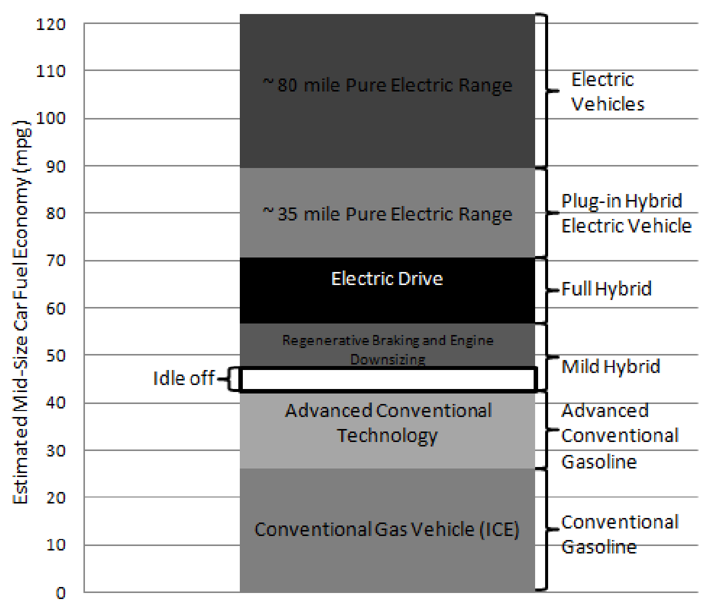
While-driving-performance is one of the key factors when comparing vehicle technologies. Under normal conditions, EV operates much better compared to HEV/PHEV and ICE.[4] Conventional ICE vehicles have an average consumption of 22 MPG, whilst advanced ICE range from 25 MPG to 42 MPG. Performance in HEV ranges from 42 MPG to 70 MPG, depending on the vehicle, but are still far from the 90 MPG and 120 MPG of PHEV and EV, respectively (Figure 2).

[4] Fuel economy in PHEV and EV is highly related to the load carried and the duty cycle, as well as the climate conditions and terrain.

EV/HEV/PEHV, especially PHEV and EV, could reduce fuel costs considerably since electricity rates are generally below the costs of conventional fuel. EV fuel economy is not actually measured by MPG but in kWh per 100 miles. Figure 3 explains the behavior of energy cost per mile in accordance with the electricity rates per kWh and gasoline costs per gallon. Three behavior lines are shown in the graph: blue for EV with a 4 mi/kWh performance; pink for 3 mi/kWh and; brown for 2 mi/kWh. In the case of Saint Lucia,[5] assuming an EV performance average of 3 mi/kWh, the energy cost per mile would be around 11.2 cents. If the same calculation is done for an ICE vehicle with a 22 MPG performance, using a cost of US$ 4.01 per gallon in accordance with global petrol prices in 2016 in Saint Lucia (GPP, 2016), an 18.2 cents per mile rate is obtained.

For PHEV a different way of calculation is applied since this technology uses two types of fuels, making the cost per mile estimation mainly dependent on the distance. PHEV can be driven, on average, as far as 35 miles using only the electric motor. For electric-motor-driven miles the same exercise as EV could be done. Once the electric mileage is covered, the next miles should be calculated depending on the vehicle's MPG. In other words, the more miles driven only with the electric motor, the energy cost per mile would be very similar to an EV, and, as the miles driven with the gasoline engine increase, the energy cost per mile would have the same effect as with an ICE.

Figure 2
Estimated fuel economy



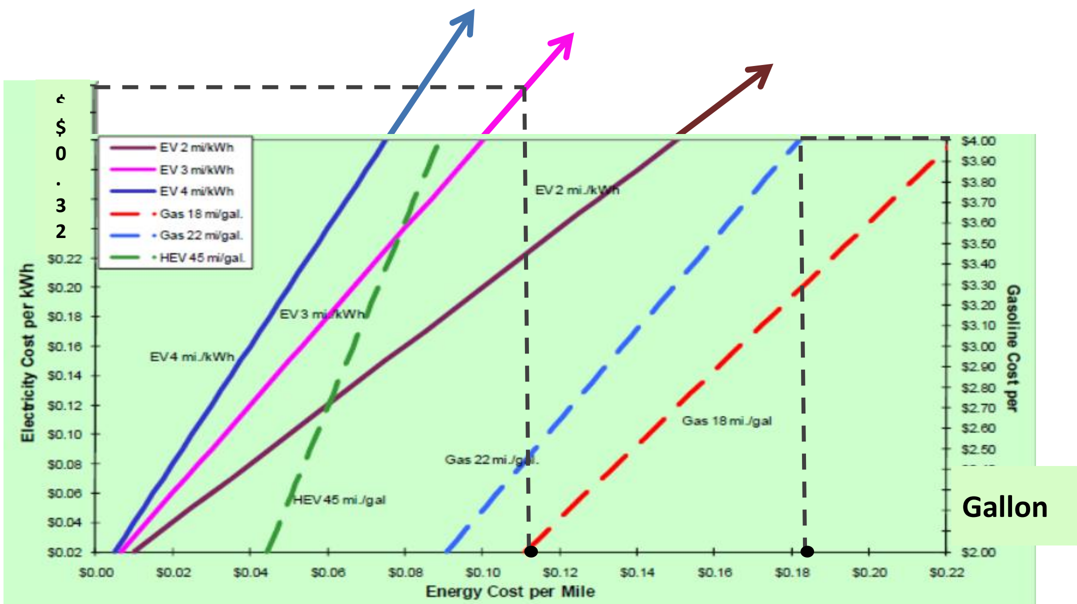
Source: Adapted from Friedman, David, "The technology and potential of hybrid vehicles. Union of Concerned Scientist", 2013.

In applications that involve mostly stop-and-go driving and significant annual mileage, hybrids work very well. For short daily routes or lower mileage applications, plug-in hybrids work better. EV/HEV/PHEV are most effective for medium-duty applications with set routes where the vehicle returns to a central depot overnight. All-electric has not performed well as a propulsion system on very large trucks; although, electrifying accessory loads while reducing or eliminating idle has proved to be cost-effective.

[5] The tariff for electricity applied is US$ 0.34 in accordance to NREL data (2015).

In addition to vehicle's characteristics, driving patterns and behavior also impact the vehicle's performance. Intensive use of air conditioning and extended idle periods have direct effects on the battery's lifecycle and overall performance, as both activities quickly deplete the charge. This highlights the importance of modifying these types of behaviors in order to improve fleet efficiency. The VMP includes specifications for driver responsibility and vehicle use and operation, such as operating the vehicle in accordance with the manufacturer's instructions and advises against leaving the engine idle while unattended. Driver training on technical requirements and raising awareness on the environmental effects of transportation are recommended and considered in the VMP.

Figure 3
Comparing energy costs per mile



Source: Adapted from INL, "Advanced Vehicle Testing Activity", 2016.

4. Advantages of electric, hybrid and plug-in hybrid vehicles

The greatest advantage of EV/HEV/PHEV over ICE is their efficiency in energy consumption (DOE, 2016). While in ICE 17-21 per cent of the energy goes to the wheels, in EV this increases to around 60 per cent, and for HEV 25-40 per cent is used to move it down the road, depending on the drive cycle. Additionally, EV are environmentally friendlier when used properly since they produce zero tailpipe emissions. This fact does not take into consideration the energy sources from which the vehicle is fueled. Therefore, switching to EV, HEV, and PHEV in general should only be considered if renewable sources would be deployed to accompany them. Some other benefits from EV are (EC, 2010):

- *Reduced fuel costs*. EV offer significant reductions in fuel costs on a per-mile basis. For example, considering a relatively efficient internal combustion engine (30 MPG) and a gasoline cost of US$ 3 per gallon, the average fuel cost per mile would be 10 cents. A SUV getting 20 MPG has an average fuel consumption cost of 15 cents per mile, and a medium-duty urban delivery vehicle getting 10 MPG has an average fuel consumption cost of 30 cents per mile. Comparatively, a light-duty battery electric vehicle or a PHEV in charge-depleting mode would have fuel costs of just 2.5 cents per mile; assuming an electricity price of 10 cents per kilowatt hour (kWh) and an electric motor efficiency of 4 miles per kWh. At 2 miles per kWh, the fuel consumption cost for a medium duty PHEV or EV truck would be of 5 cents per mile.

- *Energy dependence*. EV/HEV/PHEV technology is less energy dependent since electricity is obtained from diversified domestic energy sources. An electricity-powered vehicle, therefore, is one in which an interruption in the supply of one fuel can be replaced by others, at least to the extent that there is spare capacity in generators powered by other fuels, which is generally the case. This ability to use different fuels as a source of power increases flexibility in the transport sector. Added to that, electricity prices are significantly less volatile than oil or gasoline prices.
- *Reduced emissions*. Electric drive technology can provide significant reductions in CO_2 emissions compared to vehicles powered by conventional fossil fuels. Today's full hybrids offer as much as a 30 per cent improvement in emissions when compared to similarly sized conventional ICE vehicles.
- *Cleaning the grid*. Fleet electrification could induce a process of diversification of the energy matrix in order to achieve cost-effectiveness targets. It should also promote the modernization of current grid infrastructure.
- *Maintenance and repair costs*. EV/HEV/PHEV maintenance and repair costs are likely to be significantly less than those associated with ICE. This is a result of the fact that electric drive systems tend to have fewer moving parts and wear items than internal combustion engines. The maintenance savings are most significant for EV, which have the simplest design. EV maintenance costs are 50 per cent lower than maintenance costs of an ICE. PHEV that tend to operate in charge-depleting mode can also have sharply reduced maintenance costs. The benefit is least significant for HEV.

5. Fleet electrification challenges

The cost of high-energy battery electric vehicles (i.e., EV/HEV/PHEV) compared to ICE vehicles is one of the key barriers to their increased deployment. One component that adds to the incremental cost of EV/HEV over ICE vehicles is the electric vehicle battery packs. Estimations about this technology show that the average costs of EV/HEV increases about US$ 8 000-US$ 16 000 in relation to conventional vehicles. Even if estimated battery pack costs for the 2015-2020 timeframe have decreased considerably, it can still be considered a barrier. Figure 4 illustrates the estimated mid-range and optimistic EV technology costs in the 2015-2025 period. The figure shows how the estimated cost for EV/HEV/PHEV moves from US$ 550 - US$ 650/kWh in 2010 to US$ 240 - US$ 350 in 2025. Additionally, due to the assumption that competitive high-volume production (i.e., over 100 000 units/year) reduces per-unit costs, it is estimated that, in that period, motor prices would decline by about half, from US$ 12/kW to US$ 6/kW. Other recent analyses indicate that market-leading companies are manufacturing battery packs at US$ 300/kWh. This represents a reduction in battery pack costs faster than the optimistic projections presented in Figure 4 with technology leaders essentially achieving projected 2020 costs in 2015 (Lutsey, 2015). Small EV prices are between US$ 22 995 (MiEV) and US$ 35 950 (Kia Soul) while medium size EV vary from US$ 29 010 (Nissan Leaf) to luxury models which estimated cost is around US$ 46 250 (BMW i3).

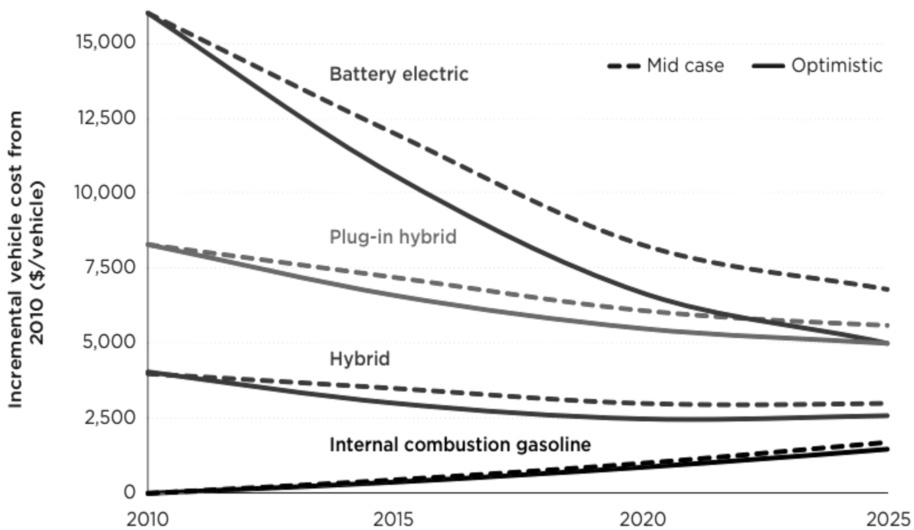
Full lifetime costs should be considered when replacing an ICE with an EV/HEV/PHEV. Lifecycle cost tools can be run in order to determine the vehicles' lifetime cost.[6] It should consider capital costs (i.e., purchase price, interest, inflation rate, depreciation and incentives), maintenance and operating costs (i.e., fuel, insurance, car tax, and inspection) and other associated costs (i.e., charging infrastructure costs). In this sense, EV/HEV/PHEV upfront (capital) costs are higher than for ICE,

[6] Lifecycle cost analysis tools are available at: *http://www.e3fleet.com/cost_analysis.html* and *http://ec.europa.eu/transport/themes/urban/vehicles/directive/doc/clean_fleets_lcc_tool_en.xlsm*

nevertheless, operating and maintenance costs, when the fleet is properly managed, are significantly lower (EC, 2010).

Another concern about EV/HEV is the battery pack capacity, as it is related not only to the vehicle's cost, but its distance range. Most early battery electric vehicle models (e.g., Nissan Leaf and BMW i3) have real-world average electric ranges of approximately 75 to 100 miles, whilst the Tesla Model S offers a range of more than 200 miles. Two generations following, the EV Chevrolet Bolt has a range of 200 miles, while plug-in HEV Chevrolet Volt has a range about 50 miles more. These increases represent more than double in relation to the current EV 2015 Chevrolet Spark range of 82 miles and at least a 30 per cent increase from the 2015 Chevrolet Volt's range of 38 miles. Tendencies indicate that a combination of continued cost and range improvements can be expected within next generations of EV/HEV/PHEV.

Figure 4
Incremental technology cost of EV/HEV/PHEV and ICE through 2025



Source: Lutsey, Nic, "Transition to a global zero-emission vehicle fleet: a collaborative agenda for governments", International Council on Clean Transportation (ICCT), 2015.

Charging availability is another factor that could represent a barrier for EV/HEV/PHEV widespread adoption. For most all-electric vehicles, batteries take in average of about 4 to 8 hours for level II charging (i.e., 240 volt, generally 3-10 kW), and 25 to 40 minutes for level III (i.e., 480 volt, generally 40-90 kW). Charging availability is a medullar point when incorporating this kind of technology since it will increase the functional daily range of vehicles. Despite being many times faster than a typical homer charger, the charge rate remains low compared to refilling a gas tank and requires new infrastructure. For example, on a long trip, this would mean stopping every 60 miles for approximately half an hour and would require changes in infrastructure (such as new transmission, sub-transmission, and distribution lines) (Lutsey, 2010). In terms of charging infrastructure, the costs are significant. With level II charger costs averaging up to a couple thousand dollars per unit, the cost of installing enough chargers to support a fleet of several dozen EV/HEV/PHEV could be a challenge. Level III charging offers faster charging times and reduced unit requirements, but costs are even higher. EV/HEV/PHEV may be appropriate replacement for some applications but they are not an adequate replacement for most primary vehicles unless a secondary vehicle is available to be used for longer trips.

In terms of utility impacts, adopting a fleet of EV or PHEV in small charging spaces will bring an unusually high consumption and impact, and may require upgrades to local utility distribution networks. In particular, transformers serving charging facilities may not be robust enough to support the simultaneous charging of multiple vehicles. Utilities will need access to information and regulatory support to deal with these and other issues (EC, 2010).

After analyzing each technology separately and presenting their advantages and incorporation challenges, a list of positive and negative aspects is mentioned in Table 7. Each technology has advantages and disadvantages; therefore, it is important to understand that the application of any of them depends on a series of factors to consider as explained before.

Table 7
Comparison between EV/PHEV and ICE

Type	Positive aspects	Negatives aspects
ICE	• Vehicles for all types of duties • Adaptable to any environment • No driving anxiety for mileage • No need for extra installations • Lower initial costs	• Lower performance while driving • Higher cost of fuels • Required maintenance and costs • Contribution to climate change (CO_2)
PHEV	• No driving anxiety for mileage • No need for extra installations • Higher MPG • Lower cost of fuels	• Required maintenance • Higher initial costs • Contribute to climate change (CO_2)
EV	• Highest MPG • Zero tailpipe emissions • Best performance while driving • Lowest cost of fuels • Reduce energy dependence	• Higher initial costs • Driving anxiety for mileage • Few options for all types of duties • Need for extra installations • Recharging time

Source: Author's compilation.

E. Energy supply alternatives and infrastructure

1. Charging systems

Charging options for PHEV and EV are divided in on-board and off-board systems. The former is not compatible with level III charging and consists of alternating current (AC) and direct current (DC): an AC power, an AC/DC rectifier, a DC/DC boost converter used for power factor correction, and a DC/DC converter to charge the battery (Goli and Wajiha, 2015). At the moment of purchase, not all EV include it; nevertheless, it is possible for users to purchase it separately. The latter consists of an external installation device.

As reviewed in last chapter, PHEV and EV have three different charging levels (i.e., I, II, and III) depending on the amount of energy delivered to the battery. Levels I and II are most commonly seen in residences with normal electric installations and parking space. In the case of the latter, it is a more complex system that requires adding a voltage plug-in in order to obtain battery charge. AC/DC converters are required when using residential charging devices. This piece is included with the vehicle equipment. Fast charging infrastructure allows battery charge time reduction, and the possibility to deploy them along intercity roads providing opportunities for longer trips and reduction of mileage anxiety (EC, 2009).

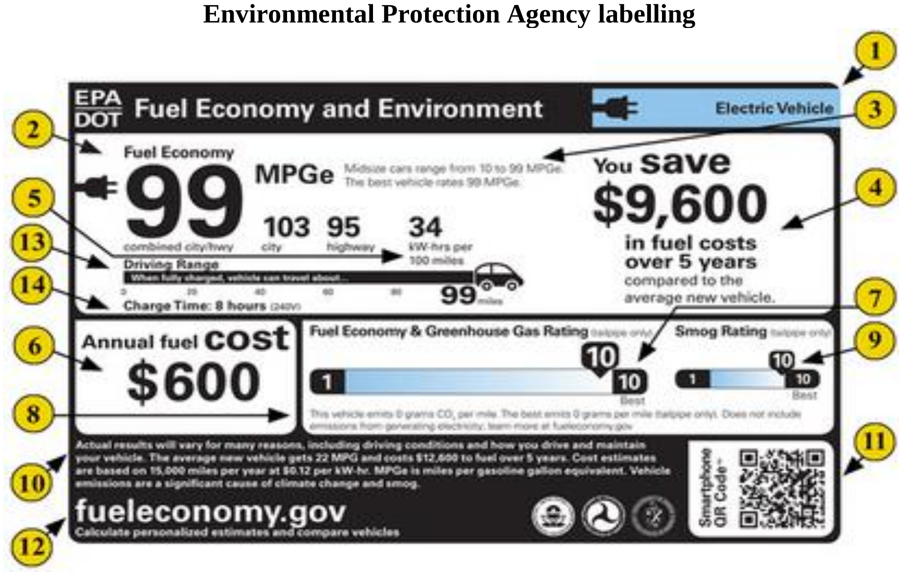
Since reliable business models have not been demonstrated yet, consumers would need to be willing to pay in order to charge their vehicles with a higher tariff than the residential one. In external charging stations, two options are available: on-grid and off-grid. In the former, charging stations are directly connected to the grid to obtain electric energy. In the latter, energy comes directly from the power source (e.g., PV panels). It is important to note that DC systems have overall higher efficiency and, for the case of EV and PHEV, fewer conversion loses. For both, on-grid and off-grid systems, the use of renewable energies are highly important and recommended in order to avoid total GHG emissions. Considerations such as the energy demand measurement, installation architectures, grid impacts and policy elements have to be considered once the charging port’s size and available locations have been determined.

2. Energy consumption measurement and estimation

One of the most common energy consumption measurement models is provided by the EPA labelling (Figure 5). This calculation model includes city and highway test procedures in which the battery is fully charged and driven in city and highway cycles until it discharges. After this process, the battery is fully recharged again from a normal AC source so the energy consumption can be measured in kWh/mile or kWh/100mi. The conversion factor to calculate energy consumption in MPG is 33.705 kWh of electricity per gallon of gasoline (EPA, 2012).

The label given by EPA summarizes EV and PHEV aspects regarding fuel economy, range and emissions, among others. Through this tool, an easy calculation and comparison between models can be done with considerably less time and budget. EPA vehicle labelling is not always reliable due to the absence of many factors (i.e., roads, speed, load, weather conditions). When measuring energy consumption it is also important to consider energy losses while converting or distributing energy from the power sources since such information would considerably change the estimations.

Figure 5
Environmental Protection Agency labelling



Source: EPA, “Electric Vehicles: Learn More about the New Label”, 2016.
Key: 1 - Technology vehicle and fuel; 2 - Fuel economy; 3 - Comparing fuel economy to other vehicles; 4 - You Save/Spend More over 5 Years Compared to Average Vehicle; 5 - Fuel Consumption Rate; 6 - Estimated Annual Fuel Cost; 7 - Fuel Economy and Greenhouse Gas Rating; 8 - CO2 Emissions Information; 9 - Smog Rating; 10 - Detail in Fine Print; 11 - QR Code; 12 - www.fueleconomy.gov; 13 - Driving Range; 14 - Charge Time.

In addition to EPA measurements, another model approach is the “micro-trips” concept. The main purpose of this model is to divide a “road trip” into smaller groups that consider more aspects and provide more information about the trip-type and congestion levels. Micro-trips are defined “as the non-zero vehicle speed profile between two vehicle stops for a time period of up to 30 seconds”

(Shankar and James, 2012). Therefore, a new typology of roads that consider an overall understanding of the local context of Saint Lucia must be defined (see example in annex 3). After each road is classified, a parameter measurement is done taking into consideration the congestion levels, average speed and acceleration. Additional parameters may help in the measurement of energy consumption during micro trips that correlates Saint Lucia with its geographical conditions.

Most authors agree that case-based models are necessary to calculate energy consumption from PHEV and EV. In the case of Saint Lucia, more complete information and studies relating to the fleet's electric consumption should be deployed once the first units have been purchased. This will provide decision makers with a more realistic panorama on how the fleet electrification performs in local conditions.

3. Charging facilities: installation, engineering and architecture

Once the type of vehicle technology has been chosen and the energy demand assessed, it is necessary to conduct an evaluation on potential charging facilities. Nowadays the market provides several options according to users' needs.

Among the main aspects to consider when choosing between alternatives are solar insolation, array orientation, and system sizing and performance evaluation.

(i) Solar insolation: To gather solar insolation data it is important to consider space conditions and location. There are tools that show horizontal solar insolation (measured in kWh/m2/day) in most regions of the world. According to NASA's database for climate, Saint Lucia's average daily horizontal solar insolation is about 6.08 kWh/m²/d per year (Table 8), similar to the regional and global averages (between 5 and 6 kWh/m²/day and 6 kWh/m²/day, respectively). If more accurate and up-to-date measurements want to be used, PV sensors could be placed at the exact spots where the charging facility will be located.

Table 8
Daily solar horizontal insulation in the Hewanorra International Airport
(kWh/m²/d)

Month	Daily solar insolation horizontal
January	5.43
February	6.10
March	6.66
April	6.88
May	6.74
June	6.15
July	6.41
August	6.50
September	6.04
October	5.68
November	5.17
December	5.17
Annual	6.08

Source: NASA, "RetScreen4: Surface meteorology and Solar Energy", 2013.

(ii) Array orientation: Specifications for array orientation and spacing are normally calculated by the PV system supplier using already existing models and standard configurations.

The main important consideration when installing PV panels is their adjustability, since solar insulation varies from season to season. It is important for implementers to consider shade effect due to its impact on PV panel performance.

(iii) System sizing: Proper system sizing is important since it allows covering the fleet's energy demand peak load. Within net metering arrays (on-grid) it is not recommended to surpass the energy consumption in order to avoid energy waste. System sizing has to consider future demand in the periods of the project lifetime in order to avoid insufficient and non-adjustable installations.

Not all carport models are equipped with charging devices. Therefore, combining carports installation with EV/PHEV charging infrastructure could provide several benefits in terms of costs saved/shared (BRE, 2016). Another benefit is the efficiency enhancement by saving conversion losses, since PV systems produce DC energy which is also used to charge EV and PHEV. There are different methods to integrate electric vehicles to photovoltaic charging facilities (PCF) (Figure 6) (Goli and Wajiha, 2015).

Different arrangements can be implemented depending on local conditions and expected performance, therefore, it is important to consider the following regulations (BRE, 2016):

- PV system standards
- Structure regulations
- Construction products regulation
- Wind loadings
- Impact from vehicles
- Design life
- Overhead glazing regulations
- Lighting regulations
- Drainage regulations
- Car park layout

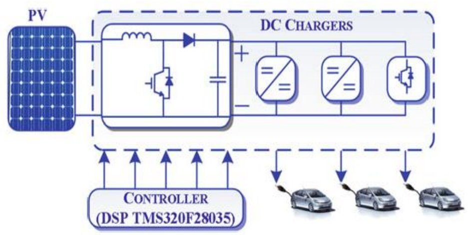
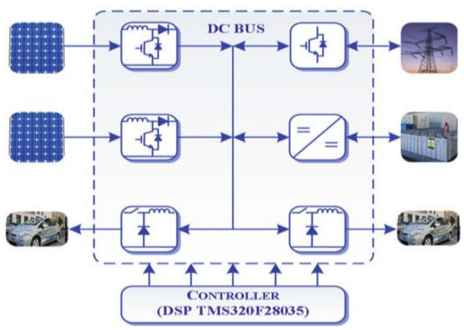
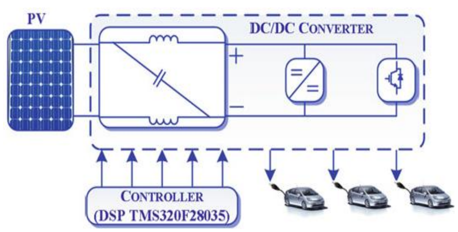
4. Potential impacts on local infrastructure

The positive impacts or advantages of having solar carports connected to the local grid are numerous. First, it will work as an extended storage system that could collect the excess of energy generated by the PV system. Second, the grid is a more reliable energy supplier that works constantly during peak energy demand hours and cloudy days or at night (Carli and Sheldon, 2013).

The negative impacts on the grid depend on technical features attributed to the PV charging facility and the vehicle fleet, such as optimal power levels (i.e., demand and charging level), system sizing (i.e., installed capacity), energy distribution method (i.e., PV power facility architecture), safety, grounding, and power paths.[7] The main negative impact of connecting a solar carport to the grid is the decreased performance which could lead to service interruptions. It is important for implementers to consider changing patterns in order to adjust them to peak electricity consumption (NAS, 2015).

[7] It refers to the power behaviour between EV/PHEV fleet, the grid, and battery system. It can follow four different paths: PV to vehicle battery, PV to grid, grid to vehicle battery, and vehicle battery to grid (Carli and Sheldon, 2013).

Figure 6
Photovoltaic charging facilities

System depiction	PV Charging Facilities
Centralized architecture	
	• Consists of a central DC/DC boost converter integrated with the PV charging system. • Multiple vehicles can be charged if the corresponding amount of PV panels and power converters are also installed. This facility type is used to charge small vehicles with short distance ranges and it does not support fast charging systems.
Distributed architecture	
	• Consists of several strings of PV panels connected in series, in which each parking spot has its own PV panel that supports vehicle charging. Each PV panel has its own DC/DC converter and shares a common DC Bus, which is connected to an AC utility grid through a bi-directional DC/AC converter. • This system is appropriate where the electrical demand for vehicles and their duration of stay has a large variation. • The reliability of this system can be increased if a battery bank is used.
Single stage conversion with Z-converter	
	• This system has a single DC/DC converter. The Z-converter is able to modulate the grid current at the same time as the EV battery. • The unit can be employed for both power absorption and injection with simultaneously controlled battery charging. • Allows increasing voltage range on the PV or on the grid.

Source: Goli, Preetham and Shireen, Wajiha, "Control and Management of PV Integrated Charging Facilities for PEVs", Springer Singapore, 2015.

Aspects related to the electrical system's ramifications and distribution networks should also be considered when connecting the charging stations to the grid. Controlled and uncontrolled charging directly affects transformers' loss-of-life. This can be minimized through distributed charging and controlled off-peak charging (Goli and Wajiha, 2015).Depending on the state of the local grid, there could be several scenarios when connecting vehicles to the traditional grid. First, if a large number of vehicles are being simultaneously charged, the power system stability could be affected due to voltage drops and current phase imbalances. Second, if a single vehicle is being charged during peak electricity consumption on that specific distribution system some components could overload, affecting service drop, local distribution transformers, feeders, and/or substation transformers (NAS, 2015). If there are no substantial grid updates in a common grid system, it could not be able to support more than one rapid charging vehicle at the time (BRE, 2016).

When installing solar car parks it is important to consider areas where sufficient supply capacity at favorable tariff rates is available. Areas with saturated distribution networks are often not recommendable due to the necessity to reinforce the grid. Investment levels to reinforce the grid would depend on the integration of EV/PHEV chargers, solar carports and battery storage systems (BRE, 2016).

In terms of the relation between building architecture and grid system, government fleet facilities could require both external and internal electrical upgrades to support the new charging infrastructure. External utility service transformers are typically sized based on the square footage and the type of building. Upgrading these transformers could result in increased costs. Additionally, such upgrades can also require more expensive conductors, electrical panel boards, and service wires. Upsizing the internal transformers within building serving as charging stations, may require upsizing conduits (often encased in concrete or difficult to access), increasing conductor sizes, and installing larger panel boards (EC, 2010).

The Government of Saint Lucia has already carried out a grid assessment and LUCELEC studied the potential impacts of renewable energies on the grid. It is expected that these studies would inform the development of charging facilities. Additionally, the Government of Saint Lucia is currently developing a project to identify potential charging stations throughout the country; it is expected that the report will consider criteria such as distance to urban centres, land ownership and insolation.

The determination of the charging facility characteristics and specifications will depend on the adaptations and upgrades the Government of Saint Lucia and LUCELEC introduce to the current system. These should consider the impact of the fleet’s energy demand and future projections. In regards to the last point, grid adaptations should consider the future transition of private vehicles to EE technologies. Furthermore, the technology selected will also be a decisive factor in regards to the characteristics and specifications of the required charging facility. For example, if the Government of Saint Lucia decides to transition to HEV, there is no need for a charging facility. In the case of EV/PHEV, depending on the model, the Government of Saint Lucia should consider different levels of charging (i.e., I, II and III). Once the charging needs are clear and the potential sites assessed, the Government of Saint Lucia should decide if a solar carport is needed or if a solar farm could provide the energy.

F. Governance assessment

Given the all-encompassing nature of energy, energy sectors are complex and governed by a variety of institutions and regulations that oversee sectoral users and uses. The governance assessment identifies accomplishments and gaps that could favor or hinder the implementation of a fleet transition plan. This section analyses the governance of the energy sector in Saint Lucia by highlighting the most relevant components of the institutional and regulatory frameworks, as well as the multiple ongoing efforts of the Government of Saint Lucia in the subject. Considering the multi-sectoral relevance of energy, this section will focus on the Government of Saint Lucia institutional, and policy and regulatory frameworks, as well as other sustainable energy initiatives that enable this transition.

In recent years, and in light of the country’s dependence on imported fossil fuels, the Government of Saint Lucia has enacted a series of regulations and established specialized agencies to promote a comprehensive transition to modern and sustainable energy. These efforts have also signaled the country’s commitment to promoting EE initiatives, increasing the use of RE sources, and GHG emissions; the latter is especially relevant considering that Caribbean SIDS produce less than one per cent of global GHG emissions, but are disproportionately affected by the adverse impacts of climate change.

In a context of global transitioning to sustainable energy, Saint Lucia has undertaken multiple policies and strategies to develop a modern energy sector. However, throughout the years the need for a comprehensive energy policy accompanied by clear implementing mechanisms has become more evident, and has prompted the Government of Saint Lucia to experiment with a variety of measures ranging from tax incentives and labeling, to the recent establishment of a National Utilities Regulatory Commission.

1. Institutional framework of the energy sector

The energy sector is governed by four ministries and supported by specialized agencies (Table 9), such as the National Utilities Regulatory Commission and the Saint Lucia Bureau of Standards. According to the National Energy Policy (NEP), the ministry in charge of energy planning is responsible for formulating and monitoring the implementation of the energy policy and strategy, as well as any other accompanying plans. In order to accomplish this, the tasks of the ministry include coordinating studies, compiling data, evaluating the impact of specific policies, encouraging participation of the private sector, and advising the Cabinet on energy-related issues.

The ministry in charge of public utilities is in charge of protecting consumer interests, ensuring access to efficient, reliable and cost-effective services, and issuing licenses for electricity generation, transmission and distribution. It should be noted that the National Utilities Regulatory Commission was established in 2016 to undertake regulatory tasks.

Table 9
Institutional organization of the energy sector

Institution	Functions
Ministry of Sustainable Development, Energy, Science and Technology	Overall energy planning, strategic direction and future development
Ministry of Infrastructure, Port Services and Transport	Regulates the energy sector; consumer protection, quality of service and licensing
Ministry of Finance, Economic Affairs, Planning and Social Security	Pricing of petroleum products
Ministry of External Affairs, International Trade and Civil Aviation	Policy for petroleum products import

Source: REDP-GIZ, "A review of the status of interconnection of distributed renewables to the grid in CARICOM countries," October, 2013.
IDB, "Challenges and opportunities for the energy sector in the Eastern Caribbean: Saint Lucia Energy Dossier", Technical Note IDB-TN-852, Energy Division, October. 2015.

The Ministry of Finance, Economic Affairs, Planning and Social Security, and the Ministry of External Affairs, International Trade and Civil Aviation have specific tasks related to petroleum products. According to the NEP, the first is responsible for monitoring the pricing scheme for petroleum products, thus ensuring reasonable prices and avoiding excessive transportation, loss and insurance costs. The Ministry of External Affairs, International Trade and Civil Aviation is responsible for the petroleum products import policy.

In addition to the tasks performed by these ministries, the institutional framework also includes specialized agencies that support the electricity subsector. The following sections analyze the role and tasks of several specialized agencies, such as Saint Lucia Electricity Services Limited and the Saint Lucia Bureau of Standards, as well as the recently created National Utilities Regulatory Commission.

(a) National Utilities Regulatory Commission

The need to establish a regulatory commission was incorporated in the Sustainable Energy Plan of 2001 and in the NEP of 2010 as a measure to allow liberalized and non-discriminatory participation of stakeholders interested in investing in a competitive energy sector. Even though the commission was not established until 2016, the Government of Saint Lucia was still able to introduce innovative strategies to improve EE and promote the use of RE sources. However, according to the Ministry of Sustainable Development, Energy, Science and Technology (2016), "we had seen examples of efforts in the Caribbean where people had embarked on energy reform initiatives and then stumbled, fallen short or come up against brick walls because they had not anticipated certain problems. So, one of the first issues we realized we had to tackle was the legislative and regulatory environment".

These lessons learned and the absence of a regulatory commission highlighted the need for an enabling regulatory and institutional environment to allow more comprehensive transformations and sectoral development. Thus, the National Utilities Regulatory Commission (NURC) was approved in November 2015 and established by Act no. 3 of 2016. The following are cited as the most relevant tasks of the NURC (IDB 2015; Government of Saint Lucia 2016):

- Ensuring the economic regulation of utility supply services
- Establishing, approving, monitoring and reviewing tariff schemes and tariffs, including net metering for self-generation
- Monitoring and ensuring compliance with standards
- Establishing terms and conditions for the issuance of generation, transmission and distribution licenses
- Ensuring the protection of the interest of consumers in relation to the provisions of the utility supply service
- Promoting competition and monitoring anti-competitive practices in the utility supply service
- Establishing guidelines for independent power producers
- Reporting to and advising the Minister with responsibility for Public Utilities on the economic, financial, legal, technical, environmental and social aspects of the utility supply services sector.

The NURC is expected to increase transparency in the sector, which would foster competitiveness and investments in EE and use of RE. At the same time, the establishment of feed-in tariffs, net metering and other similar schemes will promote small scale and self-generation using renewable sources, bringing the country closer to its target of obtaining 35 per cent of its electricity from renewable sources by 2020. By establishing clear participation guidelines and setting competitive tariffs, it is expected that the NURC will create an enabling environment that increases trust among investors, thus increasing investments in the energy sector. As it has been noted, a fleet transition should be guided by principles of energy efficiency and, even if the NURC will not be directly involved in vehicle transition, it is a key player in establishing a leveled playfield that allows increased participation of new stakeholders that would result in overall EE improvements. The most relevant task of the NURC is to allow an increased use of RE in the country, which would ultimately nourish an EE fleet.

(b) Saint Lucia Electricity Services Limited

Saint Lucia Electricity Services Limited (LUCELEC) is responsible for generation, transmission, and distribution of electricity. The Power Supply Regulation (Ordinance no. 27 of 1964) grants LUCELEC a legal monopoly and an 80-year license, until June 2045. The 1964 regulation was replaced by the Electricity Supply Act of 1994; however, LUCELEC's exclusive rights for generation, transmission, and distribution of electricity were maintained.

Even though the Electricity Supply Act (ESA) introduced some of the first modern EE and RE measures in Saint Lucia, it also evidenced the persistence of some challenges. Most notably, the ESA guarantees fixed return rates on its investments and allows LUCELEC to pass on the cost of fuel to consumers via a fuel surcharge, also referred to as cost of service. As fuel surcharges apply to all consumers, fluctuations of oil prices have negatively affected access to electricity by low-income consumers. This situation has also eliminated the company's exposure to market risks, resulting in fewer incentives to invest in innovative generation mechanisms, such as RE sources (IDB 2015, OAS 2011).

Notwithstanding this risk aversion, LUCELEC has remained receptive to incorporating RE sources into its grid, "(…) the Company will purchase this source of power [renewable energy] from any third party at a price that is equal to or lower than the cost at which the Company can generate power" (LUCELEC 2007). It is worth mentioning that PV systems are allowed to be connected to the grid under a net-metering arrangement; the permitted size for residential consumers is 5 kWp, and 25 kWp for commercial users. LUCELEC has also developed a study on the potential impacts of renewable energies on the grid. It is expected that LUCELEC will introduce improvements to the grid and increase the contribution of RE in the energy matrix, this would have positive impacts on a fleet transition as it would ensure that the fleet is nourished by a clean grid.

However, the absence of a regulatory commission resulted in LUCELEC being regulated in a limited manner by the Ministry of Infrastructure, Port Services and Transport, which in practice meant that the company was being effectively self-regulated (IDB 2015).

In this regard, the establishment of the National Utilities Regulatory Commission should improve sectoral regulation and accountability. As mentioned previously, the NURC will be responsible for issuing generation, transmission and distribution licenses to LUCELEC and other independent power producers, these licenses will have a limited period of validity of 25 years. Other relevant changes relevant to LUCELEC are (NEP 2010; IDB 2015):

- LUCELEC will establish separate cost centers for its generation, transmission, distribution and sales processes in order to improve monitoring and accountability.
- LUCELEC is responsible for reaching the RE targets established in the NEP
- Previous approval by the NURC, LUCELEC will request the installation of new fossil-fuel-based plants.
- In cooperation with LUCELEC, the NURC will establish application procedures and grant licenses to independent power producers (IPP).
- Bilateral power purchase agreements will allow IPP to deliver and sell electricity back to the national grid.
- The NURC will establish total installed self-generation capacity limits (currently set at 3MW), and assess this capacity limits every four years.

(c) Saint Lucia Bureau of Standards

The Saint Lucia Bureau of Standards (SLBS) was established in 1990 under the Standards Act No. 14, and began operations in 1991. The SLBS mandate includes the development and promotion of standards for products and services to protect consumers' health and safety, promote industrial development and protect the environment.

In 2010 the expertise of the Bureau was incorporated in the National Energy Policy, which determined that the SLBS would establish standards for the operation of oil-related facilities in order to address environmental and safety matters and protect consumers. It is worth noting that standards are developed in consultation with interested groups, and drafts are made available for public comment before being officially declared, strengthening participation and awareness among the population. Standards are also subject to review every five years.

The Bureau has been active in issuing EE standards and the country has already adopted EE standards for LED and CFL bulbs, air conditioning units and refrigerators. In addition, three more standards are being proposed for adoption and are open for public comment (deadline 20 September 2016). These standards are in line with the SLBS goal of improving performance of household equipments and appliances. One set of standards includes regulations for appliances such as television sets, microwaves, stereo systems, computers, hairdryers and toasters; the other two standards address fans and lighting chains respectively. Currently, compliance is voluntary; however, the SLBS intends to make them obligatory by aligning appliance and equipment import policies with established standards.

Considering that the SLBS is equipped with a laboratory, it is suggested that the institution develop efficiency standards for vehicles in coordination with the Ministry of Sustainable Development, the Ministry of Health and other relevant agencies, and in light of the stipulations of the Motor Vehicles and Road Traffic Act (2005). Vehicle efficiency standards could be established for both EV/HEV/PHEV and ICE vehicles in an attempt to set emission caps and minimum performance criteria. Even though the current initiative targets the government's fleet, prospective planning for widespread penetration of EE vehicles should be considered. Even if it is expected that efficient vehicle penetration will continue to increase, other consumers might continue using traditional or efficient ICE vehicles, underscoring the need of setting emissions and performance standards for vehicles in general. In line with this task, it is also suggested that the SLBS, in coordination with the Ministry of Sustainable Development, establishes disposal and recycling guidelines for EE vehicles and their batteries. This exercise could also result in identifying the most apt and environmentally friendly batteries to suit Saint Lucia.

2. Policy and regulatory framework

The energy sector in Saint Lucia is governed by the Electricity Supply Act and the NEP of 2010, which has the primary objective of creating an enabling environment to promote energy sustainability in the country. In addition, Saint Lucia has developed a series of strategies, regulations and policies to support the implementation of the NEP, these initiatives vary from tax incentives and energy awareness weeks, to climate change adaptation and environment management policies. The varying scope of these initiatives underscores the multi-sectoral nature of energy and the need for a comprehensive approach that provides public and private stakeholders with enabling conditions to undertake this transition.

The NEP was enacted after the implementation of the 2001 Sustainable Energy Plan (SEP) was obstructed by inadequate regulatory and policy frameworks, thus emphasizing the need for legal and institutional arrangements that support the country's energy transition. Despite these challenges, the SEP was an ambitious plan that set in motion Saint Lucia's efforts towards becoming a Sustainable Energy Demonstration Country[8] (see Box 2).

This section analyzes the policy and regulatory framework of the energy sector in Saint Lucia. The analysis attempts to understand the most important accomplishment of the Government of Saint Lucia in this matter, and to identify opportunities for improving the transition to a more efficient energy sector that incorporates the use of RE. It will also identify challenges and opportunities in the transport sector, especially considering the government's intentions to improve the efficiency of its fleet.

[8] The Government of Saint Lucia committed to becoming a clean energy demonstration country at the Conference of the Parties in 1998 (COP5).

Box 2
Sustainable Energy Plan

The Sustainable Energy Plan established a series of goals that are reflected in its implementation plan. The implementation plan divided its activities into five groups: (i) policy activities, (ii) project/market development mechanisms, (iii) EE/demand-side management mechanisms, (iv) information, education and training activities, and (v) transportation related activities. The following are the main activities for the policy, EE and transportation components:

Policy activities

a. Preparation of the Renewable Energy Portfolio Standard (RPS): The RPS will establish the policy by which electricity generation must achieve minimum percentages of renewable energy contributions by the years 2005 and 2010.

b. Preparation of policies to enable auto-generation (or co-generation): Legislation shall be prepared to enable auto-generation and also to introduce ways to sell excess capacity back to the utility.

c. Preparation of policies to enable Independent Power Production (IPP): The Government shall develop rules and regulations describing relationships between the IPP and the utility. Rules shall be developed to permit and encourage independent power production.

d. Establish renewable energy regulations and a regulatory authority: Following the implementation of policies that enable private power production and auto-generation, it will be critical that the government prepare regulations and a regulatory agency with enforcement capabilities to govern the sector.

e) Preparation of solar hot water system tax relief policy: Tax deduction for the purchase costs of solar water heating systems (household, commercial, industrial, etc.) would greatly expand the number of systems utilized.

EE/demand-side management mechanisms

a. Survey of energy end use and market assessment for EE: An analysis/survey of the market potential for EE measures shall be undertaken to review the energy generation and consumption patterns throughout the country and in each of the key sectors.

b. Establish an energy service company (ESCO) in Saint Lucia: The Government shall facilitate the establishment of energy services businesses on the island. Interested private sector partners shall be invited to present proposals and contributions for formation of an ESCO.

c. Launch national demand side management initiative: The energy end use studies and analyses may be utilized in the design of appropriate EE measures and in developing a comprehensive Demand Side Management program for the local utility.

d. Guidelines for EE practice by the government and standards for new buildings: The Government shall establish regulations setting EE standards and building codes to incorporate energy conservation for new construction of all Government and commercial buildings.

Transportation-related activities

a. Demonstration fleet of alternative fuelled vehicles: The Government shall explore the possibilities of introducing a fleet of alternative fuelled vehicles (such as electric, biofuels, CNG or hybrid).

b. Establish regulations or provide incentives for the purchase of higher efficiency vehicles: The Government shall explore the introduction of incentives or regulations to encourage use of fuel-efficient vehicles.

Source: Saint Lucia Sustainable Energy Plan. Near Term Implementation Plan. Working draft, August 21, 2001.

(a) National Vision Plan

The National Vision Plan (NVP) was established in 2008 as a framework for development. Considering the scope of this report, the analysis will focus on the energy and transportation components.

Given the high levels of traffic congestion and ribbon development in the North-West Quadrant of Saint Lucia, the NVP considers a series of initiatives to improve mobility in the island, reduce congestion and minimize travel time. These measures include traffic calming, road expansion and/or improvement, promotion of public transportation services ─such as water taxis, establishment of transportation hubs and designated parking areas, and creation of alternate routes and city rings.

Regarding energy generation and transmission, the NVP seeks to reduce electricity rates, supply existing and future electricity demand, diversify the energy matrix and maintain system reliability. For this purpose, it focuses on further exploration of the potential availability of natural gas, geothermal and wind energy. In terms of transmission, the plan identifies the need to upgrade the transmission voltage between Vieux Fort and Cul de Sac.

Even though more specific regulations in the country address EE, sustainable transportation, and promotion of renewable energy sources, the NVP does not establish a sustainable energy path or specific goals in terms of this energy transition. Transportation measures are focused on infrastructure development or adaptation, while issues of vehicle efficiency and use of biofuels are not considered. In the energy sector, some challenges that are not addressed are EE, grid modernization and perspectives for RE use.

(b) National Energy Policy

The NEP establishes guidelines to improve the country’s EE and to promote the use of RE sources in an attempt to reduce their dependence on imported fossil fuels and contribute to climate change mitigation.

The institutions responsible for energy planning and public utilities (i.e., the Ministry of Sustainable Development, Energy, Science and Technology and the Ministry of Infrastructure, Port Services and Transport respectively), the Energy Policy Advisory Committee and the Regulatory Commission for the Power Sector are at the core of the NEP as supporting agencies. Other institutions are relevant for the petroleum and electricity subsectors, namely the Ministry of Finance, the Saint Lucia Bureau of Standards and LUCELEC.

The NEP (2010) set eight priority areas:

(i) Procurement of energy supplies at the least cost through liberalization of the energy sector and broad private sector participation

(ii) Energy security and reliability

(iii) Diversification of the energy base

(iv) Exploitation of indigenous RE resources

(v) Higher efficiency in energy production, conversion and use with the overall objective of reducing energy intensity

(vi) Reduction of adverse environmental effects and pollution by rehabilitating existing energy sector facilities and introducing new standards for energy-related products, as well as mandating appropriate environmental impact assessments of new projects and options

(vii) Implementation of appropriate pricing policies to ensure that adequate energy supplies are efficiently delivered to all economic sectors, and fostering of an environment to facilitate an improved and sustained energy supply network with sufficient incentives to encourage private sector investments

(viii) Establishment of an appropriate regulatory framework to set clear guidelines for investors and protect the interests of consumers.

In addition, it established guidelines for co-generation, RE sources and tariff design. Most notably, the policy permits co-generation for self-consumption, which remains one of the most important actions to increase the use of RE sources.

Co-generators are expected to prove their ability to recover part of the waste heat for productive purposes and that their co-generation unit will help reduce overall energy consumption and emissions. In terms of access to electricity, co-generators are allowed to stay connected to the transmission and distribution grids for backup purposes and additional electricity needs. In the case where co-generators produce excess electricity, they are allowed to sell it to the grid operator and will be reimbursed on the basis of avoided annual average electricity generation costs. The following limits are established for co-generating entities:

- Maximum electrical name-plate capacity: 500 kW
- Maximum capacity for co-generating plants of a single entity shall not exceed 30 per cent of capacity needed to supply the average electricity consumption of the entity
- Total installed capacity for self-supply from co-generation: 3 MW

In order to allow effective co-generation, the policy also established considerations for tariff design; this task is the responsibility of the NURC and should reflect the full cost of producing electricity, indexation of fuel cost fluctuations, adjustments for inflation and the long-run marginal cost of supply to each consumer category. Aiming at improving utility performance and investment capacity, the tariff design should also ensure that LUCELEC is capable of recovering its operating and capital costs and that its earnings and rate of return on equity are within acceptable margins.

Regarding the use of indigenous RE sources, the most remarkable disposition is the country's commitment to establishing annual average contribution quotas for electricity from RE sources. Even though the targets defined in the NEP have not been accomplished (5 per cent in 2013 and 15 per cent in 2015), the country has continued to strengthen their efforts and take advantage of the momentum enjoyed by energy transitioning. These efforts along with ongoing initiatives are expected to suffice for the accomplishment of the 2020 goal of 35 per cent.

In terms of the specific energy sources, the policy considers the use of non-intermittent sources to meet base-load electricity requirements. Electricity from intermittent sources will be preferred over fossil-fuelled power plants, and will be dispatched when in demand, available and as long as it does not affect grid stability. However, according to the International Energy Agency (IEA, 2013), "at shares beyond 20 per cent in annual power generation, wind and solar PV generation are likely to lead to more rapid, frequent, pronounced and less predictable swings in net load". One considerable outcome of these swings is voltage stability issues. Additionally, "without further development, existing grid networks will be unable to successfully address the technical challenges associated with the increased share of RE envisioned by CARICOM and its member states" (WWI, 2013). Therefore, widespread use of RE sources must be accompanied by EE measures and most importantly, a modern and stable (smart) grid. In this regard, the NEP establishes actions to improve EE in three sectors: electricity, building and transportation.

The NEP focuses on a demand side management approach to improve efficiency in the electricity sector by encouraging consumers to modify their consumption and production patterns. On the supply side, the policy considers improvements in transmission grids and reduction of system losses. Additionally, the NEP incorporates energy audits as a mean to reduce energy requirements and increase EE.

The building sector would require the development of an energy-efficient building code that addresses issues of green building, such as insolation, shading, ventilation and natural lighting. This effort would be accompanied by capacity building and energy audits to strengthen modernization and monitoring. This sector also considers the use of tax incentives to promote the use of energy efficient equipment and RE technologies, such as solar water heaters.

The transport sector includes measures to promote the use of energy-efficient vehicles by establishing tax incentives, ensuring obligatory vehicle inspection and raising awareness among drivers, mechanics and driving instructors. Both the NEP and the National Vision Plan consider infrastructure solutions, such as improved roads, maintenance and repairs and transport planning. Specifically, both policies focus on the importance of urban planning, traffic management and road expansion/maintenance.

Since 2010, the Government of Saint Lucia has implemented a wide variety of activities that attempt to improve EE and increase the use of RE. Therefore, it is recommended to update of the policy to include these accomplishments, address emerging challenges, and establish new goals.

(c) Vehicle Management Policy

The Vehicle Management Policy (VMP) was established in 2016 with view to improving effectiveness and efficiency in vehicle use, reducing operational costs and ensuring proper use of government vehicles.

These issues were evidenced on the Report of the Director of Audit on the Management of Government Vehicles of 2013, which analyzed 318 vehicles. The report found that “Ministries purchased new vehicles without consideration for service delivery and operating costs factors. The justifications given for the acquisition of new vehicles were devoid of any information on operations, maintenance cost, and impact on the existing fleet. Most ministries could not confirm the correct numbers of vehicles in their custody and the locations of some vehicles”. The main findings of the audit report are summarized as follows:

- Lack of consideration of delivery and operating costs when purchasing new vehicles
- No information on operations, maintenance cost and impact on existing fleet
- Absence of centralized fleet management arrangements
- Lack of master records of total fleet and insured vehicles
- Improperly maintained log books
- Drivers were not instructed on directives to operate vehicles
- Lack of guidelines on specific use of vehicles
- Use of government vehicles for non-work related activities
- Non-compliance with vehicle use guidelines and traffic regulations
- Use of several systems to purchase fuel

This resulted in vehicle misuse, lack of controls and an overall inadequate management of the fleet. However, according to the report these challenges are not new, and the Government of Saint Lucia has attempted to solve them throughout the years by emitting memorandums and circulars on the subject. Nevertheless, “abuse and unauthorized use has not changed significantly”. The report includes a series of recommendations that are later integrated in the Vehicle Management Policy, which has four main objectives:

(i) Provides guidance on the best practice fleet management for the Government of Saint Lucia’s vehicles.

(ii) Promotes the optimal and effective use of the Government of Saint Lucia’s vehicles for the rendering of services.

(iii) Promotes cost effective and efficient usage of available funding in respect of operating costs associated with the government’s fleet of vehicles.

(iv) Minimizes the potential for abuse/misuse of government vehicles.

In order to ensure monitoring and enforcement of the policy’s dispositions, it designates fleet administrators to oversee the maintenance and management of the government’s fleet. The policy also has a strong component of awareness raising and capacity building among administrators, vehicle operators and other applicable officers to ensure understanding and compliance. This approach is consistent with the policy’s section on fleet management information system, which requires ministries and agencies to keep log books, records, accounting and reporting procedures for vehicles assigned to each institution. In addition, a master record will be maintained for all government vehicles.

Table 10
Fleet Management Information System

Institutional information system	Master record
✓ Vehicle information (make, model, year, engine number, chassis number, registration number) ✓ Insurance particulars ✓ Unit/officers with assigned vehicles and contact information ✓ Maximum useful life ✓ Replacement criteria ✓ Average annual fuel consumption cost ✓ Maintenance and service history	✓ Agency vehicle allocations ✓ Vehicle information ✓ Designated driver ✓ Mileage ✓ Fuel usage ✓ Repairs, maintenance and service history ✓ Insurance policy details ✓ Estimated value of vehicles

Source: Government of Saint Lucia, "Vehicle Management Policy", 2016e.

The policy is clear in designating roles and responsibilities among drivers and other personnel related to vehicle maintenance and monitoring. Vehicles are required to be inspected once a week to ensure optimal functioning; this includes proper levels of oil, water and antifreeze, and inflation of tires. Vehicles shall also be equipped with GPS to strengthen monitoring, tracking and accountability.

The procurement process is designed to ensure efficiency in service delivery and cost management, and requests for acquisition should clearly define the primary use and other uses intended for the vehicle. These specifications would allow acquisition officers to identify the most suitable vehicle to match the requirements of the requesting agency. Some characteristics to be considered when purchasing a vehicle are (VMP 2016):

- Carrying capacity
- Fuel type and consumption
- Engine capacity
- Transmission
- Emissions rating
- Preferred wheel and tire features

Although it could be assumed that energy-efficient vehicles would be preferred, the VMP does not establish selection criteria or performance standards to favor these types of vehicles. The policy incorporates fleet efficiency in terms of adding redundancy or enhancing service delivery, with insufficient emphasis on considerations to promote a transition to an energy-efficient fleet, including energy efficient vehicles, power and storage facilities ─strongly intertwined with modern and stable grids, and use of sustainable fuels. The policy does not establish EE or sustainable transport targets. However, the country does have incentives in place to promote the use of fuel-efficient vehicles, and the current fleet transition project could provide valuable information for a policy update.

As has been mentioned, one of the limitations of this study was lack of availability of data, especially regarding information needed to carry out a fleet assessment. However, these data gaps are expected to be solved by the implementation of the Fleet Management Information System presented in the VMP. In this regard, it is crucial that one system is designed to be implemented in every agency as this would avoid the creation of multiple systems that could be incompatible and that measure different variables. It would also simplify maintenance and operation activities and costs, and would ensure that every agency collects the same data.

(d) Electricity Supply Act

The Electricity Supply Act (ESA) of 1994 is the main regulation governing the energy sector in Saint Lucia. As it was mentioned, the ESA maintained LUCELEC's exclusive license for generation, transmission, distribution and sale of electricity until 2045. This has resulted in the company's aversion to undertaking risky exploration of potential renewable sources, such as geothermal. However, the law also established a series of dispositions to improve EE and promote the use of RE sources.

The ESA granted LUCELEC tax exemptions and duty free imports of all equipment necessary for generation, transmission and distribution of electricity; this benefit could be used for the acquisition of RE technologies. It also allows the government, by request of LUCELEC, to acquire land for the generation of electricity. This disposition is particularly relevant for future development of wind and/or solar farms.

The regulation also permits self-generation for own consumption, and net-metering arrangements are in place for residential and commercial connection of PV systems to the grid. Also, in coordination with the Cabinet, LUCELEC is allowed to grant sub-licenses for generation, transmission and distribution of electricity under certain conditions.

Additionally, and in accordance with the NEP, commercial entities are allowed to co-generate electricity and remain connected to the grid. However, the presence of independent power producers and grid-connected small-scale renewable systems remains scarce, as interconnection regulation and tariffs require further development and socialization. Conditions for co-generation and feed-in tariffs will be developed by the NURC.

3. Ongoing initiatives and planned reforms

Saint Lucia started its energy transition since the 1990s with a series of incentives and regulations to promote the use of RE sources and increase EE. However, as it has been noted, these efforts have not yielded the full scope of anticipated benefits, as many initiatives have been implemented in isolation, not grid-tied and without decisive support from a comprehensive and enabling energy framework. Understanding these challenges and learning from past experiences, the Government of Saint Lucia has incorporated changes to promote an effective energy transition and address the most pressing gaps. Most notably, the recently created National Utilities Regulatory Commission should address many of the persisting challenges; namely, improve the sector's legal certainty, establish clear participation rules, and design competitive tariffs to incentivize the use of RE sources. The most relevant accomplishments so far as summarized as follow:

(a) Demand side management

The NEP states the need to switch to a demand side management approach, which consists of modifying consumers' consumption and production behaviors. An important tool that the Government of Saint Lucia has used to encourage the use of RE and energy efficient technologies is fiscal incentives. The first measure of this type was Cabinet Conclusion No. 464 of 1999, which waived import duties and consumption taxes on RE equipment and materials. In 2001the government approved the decision to make solar water heaters tax deductible, thus promoting its penetration in the Saint Lucian market. According to CREDP/GIZ (2013), solar water heater penetration in Saint Lucia is the second highest within CARICOM, at an estimated 111.4 kWth per 1 000 inhabitants.

Table 11
Key accomplishments towards sustainable energy

1994	Revised Electricity Supply Act
1999	Waived import duties and consumption taxes on RE equipment
2001	Establishment of Sustainable Energy Plan Adoption of model OECS building code Tax deductible purchase of solar water heaters
2003	First annual Energy Awareness Week
2004	Project Efficient Lightning for Saint Lucia
2007	Introduction of levy to control importation of used vehicles
2010	Establishment of National Energy Policy
2014	Revised import duties and excise tax rates on electric and hybrid vehicles Duty and excise tax exemption on the importation of all vehicles and vehicle conversion equipment that allow operation on sustainable fuels
2015	Escalating taxes according to vehicle engine capacity
2016	Establishment of the National Utilities Regulatory Commission Establishment of Vehicle Management Policy

Source: OAS, "Energy policy and sector analysis in the Caribbean 2010-2011. Assessing Antigua and Barbuda, the Bahamas, Dominica, Grenada, Saint Lucia, Saint Kitts and Nevis, and Saint Vincent and the Grenadines," Division of Energy and Climate Change Mitigation, Department of Sustainable Development, Washington DC, 2011.
CREDP-GIZ, "A review of the status of interconnection of distributed renewables to the grid in CARICOM countries," October, 2013.
Government of Saint Lucia, "Intended nationally determined contribution under the United Nations Framework Convention on Climate Change (UNFCCC)," 17 November, 2015C.
NREL, "Energy Snapshot Saint Lucia," February, 2015.

This section focuses on the most relevant ongoing initiatives and planned reforms for the energy sector in order to identify strengths and persisting challenges.

Perhaps the most notable initiative is the annual Energy Awareness Week established in 2003. This initiative aims at raising awareness and providing the population with information on RE sources and alternatives to reduce energy consumption and increase EE. The events include workshops, exhibitions, panel discussions, as well as activities such as carpooling and awareness walks.

(b) Building code

The OECS has developed standards, building codes and guidelines that have informed numerous Caribbean building codes, including Saint Lucia. The country adopted the OECS model building code in 2001 and has been active in subsequent reforms.

The current code considers certain matters of efficiency, such as recommendations for maximizing the use of natural lightning and ventilation, as well as use and location of windows and skylights. However, if traditional equipment are used, the code recommends that the design, installation and operation of mechanical systems is consistent with principles of EE, cost effectiveness, sustainability, conservation, health, and others. In terms of RE, it recommends the use of solar water heaters for buildings that require more than 10 gallons of hot/warm water per day.

Besides joining the OECS in their effort to have a standardized building code, Saint Lucia is also part of a CARICOM initiative focused on improving building code efficiency. The CARICOM Energy Policy highlights the importance of establishing efficient building codes as well as minimum energy performance standards accompanied with incentives to promote use of energy efficient technologies and equipment. However, two important factors could hinder the materialization of these savings: (i) high initial investment costs and (ii) lack of awareness of efficient technologies. In this regard, CARICOM (2015) identified five strategies that could boost improvements in buildings and their components:

- Establish performance standards for cheap and readily available technologies
- Simplify permit procedures by establishing clear guidelines for users
- Implement tax incentives and encourage energy audits
- Fund case studies or pilot projects
- Use post-disaster situations to promote resilient reconstruction processes that incorporate EE and use of RE

Understanding the weight of this sector in the total energy consumption, as well as the impact that energy-efficient buildings and components could have in the region, CARICOM member States held the workshop EE Standards and Regulations in Buildings in 2016 supported by several regional organizations. The meeting agreed to establish a realistic Regional EE Building Code and Minimum Energy Performance Standards in line with the current energy policy, both instruments are expected to be presented to the Council for Trade and Economic Development (COTED) in November 2017.

(c) Electricity

The Government of Saint Lucia has undertaken actions in different areas of the electricity subsector. As regards to lightning, which represents a third of the country's total annual spending on electricity (CDB 2016), the government implemented the project Efficient Lightning for Saint Lucia in 2004 with support from GSEII. It had the objective of providing low-income households, hotels and public buildings with compact fluorescent lamps (CFL). Approximately 10 000 CFL were distributed, and an estimated 120 000 gallons of fuel were saved.

In 2008 the Government of Cuba provided 250 000 additional bulbs to continue the project's expansion. A similar project was approved in 2016 by the Caribbean Development Bank for US$ 10.6 million to replace approximately 21 500 street lights with light-emitting diode (LED) lamps. The energy-efficient lamps are expected to be installed by 2018.

In terms of supply side management, between 2009 and 2010 LUCELEC started the implementation of automated metering infrastructure (AMI). The company installed 11,500 smart meters in 2009 and 9,000 in 2010, reaching approximately 20 per cent of its customer base. In combination with other measures such as training on energy audits and optimization of transformer loads, the installation of AMI has allowed LUCELEC to reduce overall losses in the electrical systems to 9 per cent.

Perhaps the most relevant planned reform in this subsector is the ongoing revision of the Electricity Supply Act. The Electricity Supply Services Bill is expected to govern licensing, interconnection and customer service by updating the 1994 ESA. Most notably, the bill would break LUCELEC's monopoly and open the market to independent power producers (IPP), thus, boosting the use of RE. The bill has been open for public discussion, and the Government of Saint Lucia has organized three rounds of consultation to give stakeholders the opportunity to discuss the bill and provide inputs (the Third Round of National Consultations on the Electricity Sector Reform was held on 6 April 2016). The bill will include regulations for three areas: customer code, fair competitiveness regulations and licensing regulations.

LUCELEC has already started considering the effects that intermittent generation by IPP could have on the grid's stability, and conducted a study on Grid Integration with support from the Carbon War Room. The results of the study will guide the company's strategy to integrate RE into the grid without affecting quality and reliability.

A set of new/modified regulations is also in the horizon. Saint Lucia and Grenada are the first two countries that showed their interest in establishing the Eastern Caribbean Energy Regulatory Authority, which would have the task of overseeing and regulating electricity utilities and achieve cost-efficiency and reduced rates. The project will be implemented by 2018 and is also expected to produce licensing rules, rules permitting IPP, and other guidelines. The following are some reforms included in the project:[9]

- Electricity Supply Services Bill
- LUCELEC License Regulations
- Model generation license
- Model license for RE
- Standards of service regulations
- Wiring regulations
- Electrical Licensing Authority (ELA) regulations
- Interconnection regulations
- Grid code regulations
- Tariff regulations
- Network licensee regulations
- Licensing regulations
- Fair competition regulations
- Fees regulations

(d) Transportation

The Government of Saint Lucia has also introduced fiscal incentives to promote the use of energy-efficient vehicles and sustainable fuels. Since 2007 the country established a levy to control the importation of used vehicles according to their age. The levy for different types of vehicles is established as follows: (i) new vehicles, $ 1 000, (ii) used vehicles up to five years, $ 4 000, and (iii) used vehicles more than five years, $ 6 000.

Subsequently, in 2014 the import duties and excise tax for efficient vehicles were revised. Cabinet Conclusion No. 282 established special duties for electric and hybrid vehicles from June 2014 until November 2016. Depending on the vehicle’s age and engine capacity duties range from 5 per cent import duty, zero per cent excise tax plus $ 1 000, to 10 per cent import duty, 10 per cent excise tax plus $ 6 000. Products are still subject to Value Added Tax (15 per cent). In 2016 the Government of Saint Lucia waived all duties on EV and HEV.

In an attempt to link motor vehicle weight to road maintenance, in 2015 the Government of Saint Lucia revised vehicle license fees and established three weight classes:

(i) Class A: Nissan Cube, Kia Picanto, Hyundai Gets, Chevrolet Spark. Fee for class A is $ 250. Class A applies to all private cars weighing less than 1 134 kg.

(ii) Class B: Hyundai Sonata, Honda Accord. Fee for Class B is $ 300. Class B applies to all private cars with weight ranging from 1 134 kg to 1 587 kg.

[9] http://www.stlucianewsonline.com/energy-efficiency-legislation-consultation-begins-thursday/

(iii) Class C: Toyota Prado, Mitsubishi Pajero. Fee for Class C is $ 350. Class C allies to all private cars with weight of 1 588 kg and over.

The new fee structure also differentiates vehicles based on their use, and established specific tariffs for goods vehicles and hired vehicles.

Currently, the Government of Saint Lucia is in the process of developing a transport policy and strategy to promote efficiency and conservation in the sector.

(e) Other reforms

In addition to the abovementioned initiatives, the Government of Saint Lucia is discussing the following regulations and policies:

- Energy Efficiency Bill: this regulation would establish guidelines and an enabling environment to promote the use of energy-efficient technologies.
- National Energy Transition Strategy: the strategy would guide Saint Lucia’s transition to sustainable energy and ensure that grid stability and reliability is not compromised when renewable sources are integrated. The strategy seeks to contribute to the country’s targets of 35 per cent of electricity generated from RE and 20 per cent reduction in electricity consumption in the public sector by 2020.

III. Implementation

A. Technology substitution

Once the eligibility criteria are determined, the new technology chosen and the vehicles to be substituted selected, the adoption of new technology takes place. The purpose of the technology adoption is to improve the fleet's performance and reduce its impact on the environment and finances. Some of the main premises during this phase are:

- Select the appropriate vehicle class to meet and not exceed operational requirements.
- Select the most practical vehicle size and class to meet operational requirements.
- Select an alternative fuel vehicle when it is cost-effective and operationally feasible.
- When converting a vehicle to alternative fuel, use only aftermarket conversion kits that are certified to ensure that they meet national emission regulations.
- Consider the selection of vehicles with advanced vehicle technology, including hybrids.

B. Operation, maintenance and disposal

During the operation and maintenance phase, departments should consider the following best green practices:

- Consider acquisition of bulk ethanol and biodiesel for bulk fuel facilities to fuel gasoline and diesel vehicles respectively.
- Purchase alternative transportation fuel when driving an alternative fuel vehicle.
- Plan travel and routing to maximize vehicle use efficiency and minimize mileage driven, especially during peak travel times.
- Develop an appropriate EV/HEV/PHEV battery disposal program in order to minimize environmental impacts. Based on the average manufacturer´s warranty period, batteries life span goes from 8 to 10 years. Since battery management and disposal are complex and costly processes that involve investing in technology, infrastructure and human

capital, it is highly suggested that it is handled through the vehicles retailers. In that sense, in order to maximize the vehicle´s performance and environmental soundness, it is suggested that the batteries are not used longer than what the warranty period states. Another alternative for the Government of Saint Lucia is to recycle the batteries through specialized companies. Nevertheless, this alternative stills in its infancy and no recycling plants are located near the region. For more details about battery disposal see table 6.

- Encourage vehicle operators to avoid speeding and idling in order to enhance fuel efficiency.

IV. Follow-up

A. Monitoring and verification

The new fleet’s performance should be monitored and verified in order to evaluate the impact of the implemented changes and to provide inputs for future transitions. The same indicators used in the baseline inventory need to be measured.

- Encourage driver-training programs, particularly those with a speeding and idling component, to minimize practices and habits that increase fuel consumption and vehicle emissions.
- Conduct preventative maintenance regularly, including oil changes, to ensure that vehicles are operating at their optimum.
- Conduct periodic vehicle emission testing. The condition of a vehicle's engine emission controls and electronics is an important variable that affects its fuel efficiency and emissions.
- Monitor vehicle use through regular review of logbooks and sign-out sheets to ensure that all fleet vehicles are being properly utilized and utilized to their maximum capacity.
- Monitor vehicle expenditures and fuel purchases to ensure alternative fuels are being purchased to the maximum extent possible.
- Ensure that fleet management information is being updated and properly tracked.
- Conduct annual assessments of fleet information for ongoing fleet planning and vehicle acquisition.

V. Funding alternatives

From a funding perspective, the initiative of the Government of Saint Lucia to promote EE and deploy RE through the transition of its fleet to EV/HEV/PHEV comes in a very timely manner, as the international community is seeking to transition to more sustainable forms of energy. Through milestones such as the UNFCCC discussions, the Sustainable Development Goals (SDG) (Box 3), and the SIDS Accelerated Modalities of Action (S.A.M.O.A.) Pathway, international cooperation organizations have reaffirmed their commitment to supporting such initiatives in developing countries.

Box 3
Sustainable Development Goals related to energy efficiency enhancement and renewable energy deployment

According to the Sustainable Development Knowledge Platform (2015), from the 17 SDG, two are directly related to the enhancement of EE and deployment of RE in the transportation sector. They are:

SDG 7: Ensure Access to affordable, reliable, sustainable and modern energy for all. Main targets:

1. By 2030, ensure universal access to affordable, reliable, and modern energy services.
2. By 2030, increase substantially the share of RE in the global energy mix.
3. By 2030, double the global rate of improvement in EE.
4. By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including RE, EE, and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.
5. By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, SIDS, and land-locked developing countries, in accordance with their respective programs of support.

SDG 9: Make cities and human settlements inclusive, safe, resilient, and sustainable. Main targets:

1. Develop quality, reliable, sustainable, and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.
2. Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries.
3. Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.

Box 3 (concluded)

4. By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

5.Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.

6. Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and SIDS.

7. Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities

8. Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020.

Source: Sustainable Development Knowledge Platform.

According on the document "Identification of mechanisms for financing of EE and RE initiatives to increase investment in Saint Lucia" (2016), several sources of funding could be consulted in order to transition the vehicle fleet and to build an adequate charging facility. The purpose of this section is to give a general overview of the main funding alternatives which the Government of Saint Lucia could explore. As Saint Lucia is in the readiness phase, studies and assessment are still required. Therefore, this section considers funding options for both technical implementation and development of studies.

A. Global environmental facility

Through GEF-6,[10] the World Bank's (WB) Global Environmental Facility (GEF) has a US$ 1,260 climate change mitigation fund that could support fleet transition. The GEF will support the development, adoption of policies, strategies, regulations, and financial or organizational mechanisms that accelerate mitigation technology innovation and uptake. GEF-6 Program 1 has the goal to "promote the timely development, demonstration, and financing of low-carbon technologies and mitigation options". Program 1 mitigation options may include three activities:

(i) Energy efficiency: lighting, air conditioning, refrigeration, motors, and building codes are candidate areas for potential funding.

(ii) Renewable energy: support may be utilized to minimize key barriers to their deployment, including: support for energy access initiatives at the local level, including demonstrations and piloting of renewable options; support for policy and strategy frameworks to enhance integration of renewable options into energy supply systems, and enhancement of technical and financial capacities to stimulate RE project development. Candidate options include: medium and small-scale hydropower; on-shore wind power; geothermal power and heat; and bio-energy systems using biomass from wastes and residues; solar PV systems and CSP.

(iii) Sustainable transport: GEF may also support sustainable transport projects. According to GEG (2014. p. 61) "sustainable transport urgently requires the timely development, demonstration, and financing of low-carbon systems and supportive policies, given the rapid increase of GHG emissions from the transport sources in developing countries". Options considered for GEF support include:

[10] GEF-6 coverts projects from July 1, 2014 to June 30, 2018.

- Fuel and road pricing
- Policies and strategies to improve fleet fuel efficiency
- Support for alternative fuels and advanced engine technology
- Pilots demonstrations of smart transport grids, and
- Information and communications technology applications for travel demand management.

B. Green climate fund

A principal objective of the Green Climate Fund (GCF) within the UNFCCC is to catalyze funds by multiplying the effect of its initial financing by opening markets to new investments from the public and private sectors. As stated by the fund, it "aims for a 50:50 balance between mitigation and adaptation investments over time". The GCF has identified eight impact areas which will deliver major mitigation and adaptation benefits (GCF, 2016):

(i) Low-emission energy access and power generation.

(ii) Low-emission transport.

(iii) Energy efficient buildings, cities and industries.

(iv) Sustainable land use and forest management.

(v) Enhanced livelihoods of the most vulnerable people, communities, and regions.

(vi) Increased health and well-being, and food and water security.

(vii) Resilient infrastructure and built environment to climate change threats

(viii) Resilient ecosystems.

According to the GCF, only revenue-generating activities are candidates for funds. Another criteria for funding are: (i) impact/result potential (to fund's objective), (ii) paradigm shift, (iii) needs of the beneficiary country, (iv) country ownership and institutional capacity, (v) economic efficiency of the project and (v) financial viability (for revenue generation) (GCF, 2016).

C. Carbon war room

The Carbon War Room (CWR) aims at providing market-based solutions to climate change and focuses on solutions that can be implemented using proven technologies under current policy landscapes.CWR often participate in projects or operations where goods and/or services are procured by an entity or government. The CWR launched the Ten Island Challenge, including Saint Lucia, in order to "accelerate the transition of Caribbean island economies from a heavy dependence on fossil fuels to renewable resources". This project intends to impact Caribbean islands positively in terms of CO2 and costs reduction. It also expects to increase private investment on the islands, improve EE, and reduce each island's dependence on imported fossil fuels. CWR directs its funds and assistance towards (CWR, 2016):

- Renewable, distributed electricity
- Freight and trucking
- Buildings' energy efficiency
- Fuel efficient ships

D. OPEC fund for international development

The Organization of the Petroleum Exporting Countries (OPEC) established the Fund for International Development (OFID) in 1976 in order to stimulate economic growth and alleviate poverty in developing countries. OFID's resources consist of voluntary contributions made by the organization's member countries and the accumulated reserves derived from its various operations. In 2015 the OFID totaled around US$3,462 million in direct contributions, while reserves stood at US$2,603 million. In order to optimize the impact of its contributions, the OFID cooperates with bilateral and multilateral agencies of its member countries, the regional development banks, the World Bank Group, and the specialized agencies of the United Nations, as well as a host of non-governmental organizations. The OFID focuses on the following nine areas (OFID, 2105):

(i) Energy

(ii) Transportation

(iii) Finances

(iv) Agriculture

(v) Water and sanitation

(vi) Industry

(vii) Health

(viii) Telecommunications

(ix) Education

The fund offers investment options for the public, private, and productive sectors through loans and lines of credit, share participation, operations quasi-equity (convertible loans, loans participatory and subordinates, preferred shares, convertible preference shares), credit guarantees and insurance. As of 2015, 23 per cent of the fund's commitments (US$ 4,096 million) corresponded to energy operations. Funding to developing countries is linked with average incomes, but most of the OPEC funding is made on concessional terms. In relation to private sector funding, loan parameters are linked to country and project risks (OFID, 2105).

E. Caribbean Development Bank

The Caribbean Development Bank (CDB) provides funding as co-financer to the public and private sectors through the Basic Needs Trust Fund (BNTF). The energy sector is a transversal topic at the CDB for the period 2015-2019 (ECLAC, 2016). Four focus areas for the period have been identified (ECLAC, 2016):

(i) Promoting EE for more affordable and stable energy costs, and for the establishment of a green economy.

(ii) Promoting RE for more sustainable, affordable, and accessible energy, and for a green energy economy.

(iii) Promoting energy infrastructure to provide cleaner and more reliable power supply.

(iv) Promoting sector reform, good governance and capacity strengthening.

Projects under the BNTF are likely to have limited adverse and site-specific environmental and social impacts that are readily identified and for which mitigation and management measures are known and available (CDB, 2016).Conditionalities for participating in projects and investments in Saint Lucia and the rest of Latin America include:

- Amount: between 70-80 per cent of the cost for public projects and about 40 per cent of private projects
- Interest rates: semi-annually reviewable 7.5 per cent
- Terms: from 10 to 30 years for public projects and up to 14 years for private projects
- Grace periods: up to 5
- Guarantees required: usually government guarantee

F. Technical cooperation

The Caribbean sub-region is supported by several regional and international organizations that could provide technical assistance is the development of specific assessments. In addition, such organizations could promote the exchange of experiences between countries with similar characteristics and challenges. The Economic Commission for Latin America and the Caribbean reaffirms its support to national and regional initiatives that seek to improve EE and promote the use of RE sources through technical assistance.

Agencies such as the United Nations Office for Project Services (UNOPS) could also provide great assistance in the development and implementation of projects. Considering financial constrains in Saint Lucia, and in the sub-region as a whole, the concessions model could be explored. In this regard, UNOPS provides project management, infrastructure and procurement services with a focus on sustainability and national capacity development. The agency provides three services (UNOPS):

- Implementation: implementing partners' projects efficiently and effectively, with the involvement of all stakeholders
- Advisory: developing national capacity in our core mandated areas
- Transactional: providing stand-alone human resource management and procurement services

VI. Final considerations

The initiative to transition the vehicle fleet to more efficient technologies that promote the use of renewable sources of energy is an emerging idea in Saint Lucia. Even if the Government of Saint Lucia has gained some field and that there is momentum within the international community to support the process, actions towards the consecution of this idea are still incipient. Even more, some barriers to be addressed before initiating the transition were identified.

First, even if some of the stakeholders are aware of the proposed transition (e.g., Ministry of Sustainable Development), other institutions (e.g., infrastructure and transportation) had not been fully briefed about it. The field visit showed lack of knowledge about the transition's general aspects (e.g., potential technologies) and infrastructure and governance implications. Second, current fleet administration practices must be updated and improved to satisfy the information requirements that a Fleet Transition Plan supposes. This assertion is supported by the Report of the Director of Audit on the Management of Government Vehicles (2013).These deficiencies are:

- Unavailability of a full vehicle base inventory.
- Absence of full knowledge on vehicle's routes and locations.
- No adequate controls to prevent misuse and abuse of vehicles.
- Expenditure records are not being recorder properly.
- No logbooks are being properly maintained.
- Vehicle's categorization is incompatible with international standards.
- Unavailability of adequate environmental standards and controls for vehicles.
- No usage categorization.

The recently adopted VMP addresses most of these deficiencies. Nevertheless, concrete actions towards the compliance of the policy must be enforced. The most significant example from this project's perspective is the absence of the Fleet Management Information System (VMP section 2.2). This system could provide information to carry out a fleet assessment with most of the inputs required, unfortunately, it is still not running. In this sense, before defining objectives and goals for a potential Fleet Transition Plan, full compliance with the policy has to be assured. Only this way, decision makers and implementers could assure meeting proposed EE and RE targets.

Beyond the existence of the VMP and the Ministry of Sustainable Development's great interest in fostering the transition process, it is important to highlight two valuable initiatives that the Government of Saint Lucia has undertaken which could serve as foundation. The first is the Vehicle Tracking and Monitoring System, which provides a first good insight on one part of the fleet's performance and usage. The system provides valuable inputs related to distance traveled per vehicle, as well as some driving patterns (e.g., driver's behavior) and routing. The possibility to upgrade this system in function of the Fleet Transition Plan's needs should be considered.

The second useful initiative is the report on the potential sites for the installation of a solar carport.[11] Even if the assessment does not take into consideration some relevant aspects such as land ownership and fleet's routing, it confirms the great potential that Saint Lucia has in relation to insolation and land availability. Although the document was not available for consultation at the moment of elaboration of this report, its existence could be of great use in the future. Additionally, the recent establishment of the National Utilities Regulatory Commission should clear the path for further deployment of renewable energies by defining clear policies and promoting certainty among investors. This is relevant as a comprehensive transition should be supported by EE measures and promotion of RE use throughout the country in every energy-related sector.

Thus, based on inputs from the field visit (August 27-30) and from the documentary consultation undertaken for the elaboration of this report, it can be concluded that the Government of Saint Lucia is currently in the **Readiness Phase**.

A. Preliminary fleet assessment

A preliminary fleet assessment with the available information was deployed in order to suggest further steps towards the transition (Table 12). The filters used to assess the fleet where age and technology replacement availability. Limited information did not allow applying other fleet assessment filters. By the time of elaboration of this report, neither the Fleet Management Information System nor a full fleet inventory was available. However, the Government of Saint Lucia has records for 206 vehicles identified under the Vehicle Tracking and Monitoring System. According to the 2013 audit, the GOLS's fleet has 310 vehicles. This means that information of 104 vehicles was not used for the purposes of this preliminary fleet assessment.

From the 206 vehicles in the listing, five main types could be identified (Figure 7): sedan, van, SUV, pick-up truck, and heavy duty trucks. Applying the age filter (vehicles seven years or older by 2016) it is possible to note that a total of 149 vehicles (72 per cent) could be considered for replacement. From those 149 vehicles, 86 (i.e., pick-up trucks and heavy trucks) do not have an equivalent EV/HEV/PHEV replacement. These 86 vehicles should be assessed in terms of their usage in order to determine the most suitable transition technology. This situation reinforces the need to assess beyond age and mileage. It is necessary for decision makers to consider all the suggested filters in order to replace the largest amount of ICE with EV/HEV/PHEV. Since a proper usage assessment could imply important time and resources, an initial quick assessment could be undertaken. For example, if the pick-up trucks are being used to carry cargo and/or staff, replacements could consist of vans. In the case of heavy trucks, since the market does not offer cost-effective alternatives, no replacement is suggested.

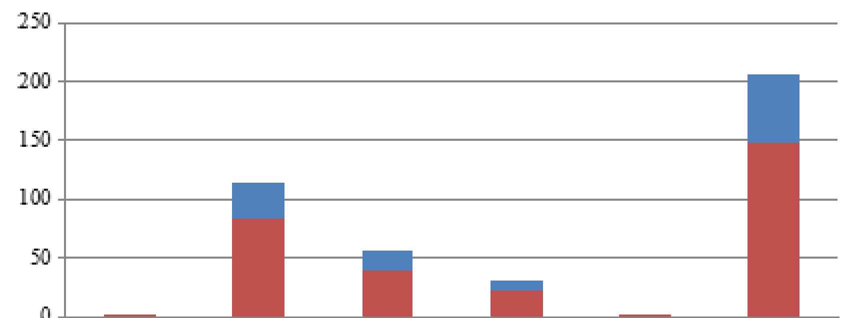
The remaining 63 vehicles could be directly replaced with an equivalent technology, assuming that a usage assessment has been completed and a suitable replacement identified. Vehicles should be replaced with the most EE alternative considering Saint Lucia's current infrastructure conditions. In this sense, since the country's energy mix relies mainly on fossil fuels and the contribution of RE is limited, HEV or, if models availability is limited, PHEV are suggested (Table 13).

[11] It was not possible to incorporate the report's inputs in this analysis since its availability was limited.

These vehicles still use gasoline but have no electrical inputs, avoiding increasing the fossil fuel consumption. Currently, the market offers alternatives to transition all those vehicle types with HEV (see annex 2).

Once the government advances in the deployment of clean energies, the next transitions could aim at the incorporating EV and PHEV. Figure 8 provides a logical framework towards a fleet transition.

Figure 7
Age filter



	Sedan	Pick-up	Van	SUV	Heavy -trucks	Total
Passed	0	31	18	8	0	57
Not passed	1	84	39	23	2	149

Source: elaborated by the authors.

If only the technology availability filter is applied, it is possible to see that 89 vehicles (43 per cent) have an equivalent EV/HEV/PHEV. Those vehicles consist of sedans, vans and SUV. The remaining 117 vehicles (57 per cent) consist of pick-up trucks and heavy trucks. From those vehicles that did not pass the technology availability filter, special care has to be given to the suitability and mileage filters. It is important to corroborate whether the vehicles are being used in an adequate manner and whether they are suitable for the duties assigned. In the event they are not, a replacement with an available technology is recommended. This kind of approach could represent an alternative to guide the transition; nevertheless, it should be accompanied with a usage assessment. The deployment of the filters in a hierarchical order is encouraged.

The preliminary baseline inventory allows confirming the idea that the application of all the filters in a hierarchal manner is sine qua non requirement when determining the vehicle transition eligibility. Considering a vehicle's replacement using only one or two filters does not provide a true image of the fleet's composition or requirements. In this sense, the fleet assessment is a tool that could let decision makers to perceive the fleet in terms of its functionality and composition, and not only as the sum of a series of vehicles. The transition of the Government of Saint Lucia fleet to EV/HEV/PHEV or other suitable types of EE vehicles (e.g., scooter bikes) requires adopting the former perspective when assessing the fleet. Once the fleet assessment has been completed, decision makers can size the fleet according to their needs and local capabilities. This last step will also allow planning for the required charging infrastructure.

Table 12
Preliminary Fleet Assessment

Filter	Categories						Preliminary Fleet Assessment
Vehicle Particulars Registry	Vehicle Particulars Registry (Vehicle Type)			Insurance			**Total 206.** Five main types could be identified : 1. Sedan 2. Van 3. SUV 4. Pick-up truck 5. Heavy duty trucks
Age And Mileage	Year Model		Miles per Year		Insurance Period		**149** vehicles **7 years or older**
Use Assessment	Classification	Type Of Driving	Driving Patterns	Routing And Allocation	Driving Schedule	Usage	No information available
Lifecycle Analysis	Incidents	Vehicle Conditions	Actual Maintenance Costs	Estimated Operating Costs	Environmental Integrity		No information available
Replacement Analysis	Equivalent Technology			Funding Alternatives			• **86** do not have an equivalent EV/HEV/PHEV replacement (i.e., pick-up trucks and heavy trucks). • **63** vehicles could be directly replaced. Considering Saint Lucia's current infrastructure conditions, HEV vehicles are suggested

Source: elaborated by the authors.

Note: Categories with no available information are marked in red.

Table 13
Suggested transition models

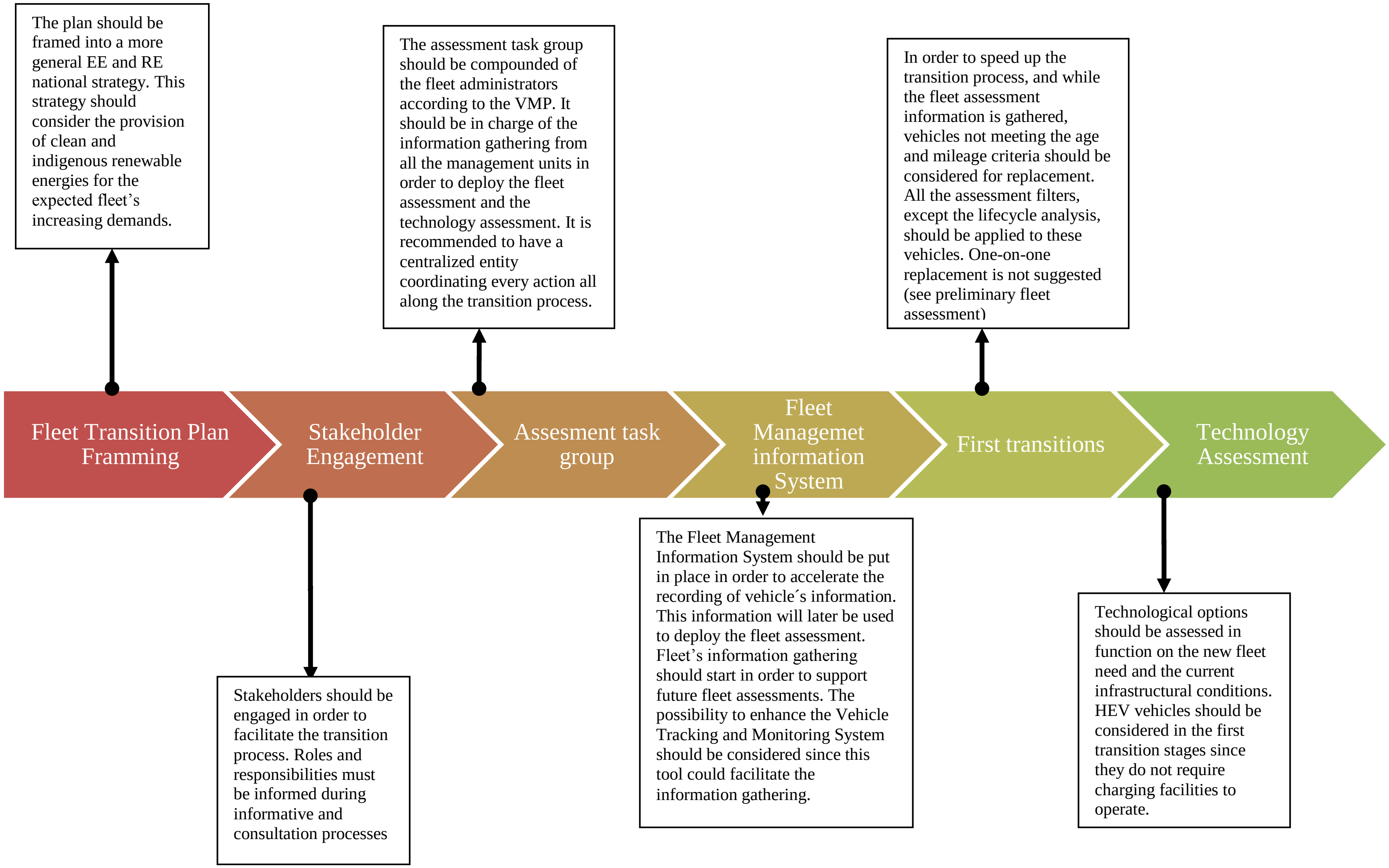
Vehicle type	Amount	Suggested transition model
Sedan	1	Toyota Prius, Hyundai Sonata, Chevrolet Volt
Van	39	Chrysler Pacifica, Honda Odyssey
SUV	23	Mitsubishi Outlander, Toyota Highlander, Toyota Rav4, Nissan Pathfinder

Source: elaborated by the authors

B. Next steps for developing a Fleet Transition Plan

The proper deployment of the Fleet Transition Plan should consist of a comprehensive process in which all the suggested phases and sub-phases are considered. Figure 8 shows the prompt actions the Government of Saint Lucia should pursue in order to speed up the process.

Figure 8
Prompt actions into the Fleet Transition Plan



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Annexes

Annex 1
Government of Saint Lucia vehicle listing

Model Year	Manufacturer	Model	Registration Number
Unknown	Isuzu	Dcab	SLG 3135
Unknown	Hyundai	Unknown	SLG 2088
Unknown	Hyundai	Unknown	SLG 1071
1996	Hyundai	Pajero	SLG 180
1996	Hyundai	LAND CRUISER	SLG650
1996	Hyundai	PICK UP D/C 4WD	SLG654
1996	Hyundai	Hilux	SLG 826
1996	Hyundai	Hiace	SLG 140
1998	Hyundai	NKR Truck	SLG 221
1998	Nissan	S/Cab (4x4)	SLG727
1999	Nissan	Double Cab	SLG --261
1999	Nissan	Double Cab	SLG --048
2000	Hyundai	Panel Van	SLG 178
2000	Hyundai	Double Cab	SLG975
2000	Hyundai	Double Cab 4x4 Pick-up	SLG281
2000	Mitsubishi	Ambulance	SLG - 894
2000	Toyota	Hiace 14 Seater Omnibus	SLG838
2000	Land Rover	Discovery (Series II)	SLG 836
2001	Toyota	Hilux 4X4	SLG 920
2001	Hyundai	Pajero	SLG 876
2001	Hyundai	14 Seater	SLG 183
2001	Hyundai	4 x4 pick up	SLG 413
2001	Hyundai	30 Seater	SLG 179
2001	Hyundai	Double Cab	SLG 938
2001	Hyundai	Double Cab	SLG 915
2001	Hyundai	Hilux	SLG 829
2001	Hyundai	B2500	SLG 856
2001	Hyundai	Double Cab	SLG 893
2001	Hyundai	Xtrail	SLG 912
2001	Hyundai	B2500	SLG 971
2001	Nissan	Double Cab	SLG 937
2002	Hyundai	Unknown	SLG 442
2002	Hyundai	Hilux	SLG 913
2002	Toyota	Pick up Double Cab 4 x 4	SLG - 950
2002	Toyota	Pick up Double Cab 4 x 4	SLG - 948
2002	Toyota	Pick up Single Cab 4 x 4	SLG - 951
2003	Hyundai	Ranger	SLG1022
2003	Hyundai	D/Cab	SLG 985
2003	Hyundai	Coaster	SLG 1002
2003	Hyundai	Pajero	SLG 605

Model Year	Manufacturer	Model	Registration Number
2003	Hyundai	Double Cab	SLG 996
2003	Nissan	Double Cab	SLG 976
2003	Pregio	Panel Van	SLG943
2003	Pregio	Panel Van	SLG942
2004	Hyundai	Unknown	SLG 177
2004	Hyundai	4x4 DC	SLG 1029
2004	Hyundai	Panel Van	SLG1030
2004	Hyundai	Dmax	SLG 1010
2004	Hyundai	Dmax	SLG 1011
2004	Hyundai	Double Cab	SLG 1016
2004	Hyundai	Double Cab	SLG 1019
2004	Hyundai	B2500	SLG 1032
2004	Hyundai	Double Cab	SLG 1026
2004	Hyundai	B2500	SLG 1033
2004	Hyundai	Double Cab	SLG 1017
2004	Hyundai	L200	SLG 1020
2004	Hyundai	Dmax	SLG 1015
2004	Toyota	Ambulance	SLG 3153
2004	Nissan	Ambulance	SLG 3156
2004	Toyota	Ambulance	SLG 3154
2004	Toyota	Pick up Double Cab 4 x 4	SLG -1027
2004	Mazda	B2500	SLG 1056
2005	Toyota	Hiace	SLG 1064
2005	Toyota	Hiace	SLG 1067
2005	Hyundai	Unknown	SLG 1060
2005	Hyundai	Ranger	SLG 1066
2005	Hyundai	Almera	SLG3092
2005	Hyundai	Pickup	SLG1046
2005	Hyundai	B2500	SLG 1054
2005	Hyundai	Pickup	SLG 1045
2005	Hyundai	Double Cab	SLG661
2005	Kia	Sorento	SLG 291
2005	Isuzu	Dmax	SLG 1048
2006	Hyundai	Xtrail	SLG 881
2006	Hyundai	BT50 D/C 4WD	SLG404
2006	Hyundai	Double Cab	SLG1074
2006	Hyundai	Pickup	SLG 1086
2006	Hyundai	Hiace Panel Van	SLG 1085
2006	Hyundai	Panel Van	SLG1063
2006	Nissan	Double Cab	SLG - 2015
2006	Toyota	Hiace Panel Van	SLG1065
2006	Mitsubishi	L300 Panel Van	SLG 1053
2006	Toyota	HILUX D/C 4WD	SLG1068

Model Year	Manufacturer	Model	Registration Number
2007	Toyota	Hiace Panel Van	SLG 2072
2007	Toyota	Hiace	SLG 2073
2007	KIA	Sorento	SLG 1070
2007	Hyundai	Spotage	PG 1523
2007	Hyundai	D/Cab	SLG 2098
2007	Hyundai	Hilux	SLG 2094
2007	Hyundai	Hilux/D/Cab	SLG 2095
2007	Hyundai	Everest	SLG 2033
2007	Hyundai	Hilux	SLG 2086
2007	Hyundai	Panel Van	SLG 757
2007	Hyundai	Panel Van	SLG 199
2007	Hyundai	Cargo Van	SLG 176
2007	Hyundai	Xtrail	SLG 2092
2007	Hyundai	HILUX D/C WD	SLG 634
2007	Hyundai	HILUX D/C WD	SLG 513
2007	Hyundai	Urban Wheel Chair	SLG2018
2007	Hyundai	Urban Wheel Chair	SLG2022
2007	Hyundai	Xtrail	SLG3146
2007	Hyundai	Grand Vitara	SLG497
2007	Hyundai	HILUX D/C 4WD	SLG652
2007	Hyundai	Everest	SLG 2093
2007	Hyundai	Grande Ace	SLG 890
2007	Toyota	Ambulance	SLG - 044
2007	Toyota	Ambulance	SLG - 051
2007	Toyota	Ambulance	SLG - 046
2007	Toyota	Ambulance	SLG - 059
2007	Nissan	Double Cab	SLG - 2079
2007	Toyota	Ambulance	SLG - 045
2007	Toyota	Ambulance	SLG - 984
2007	Toyota	Mid-Roof 16 Str	SLG2071
2007	Toyota	Hilux D/Cab	SLG 2059
2007	Nissan	D/Cab Pick Up	SLG 2003
2007	Nissan	D/Cab Pick Up	SLG 2011
2007	Nissan	Urvan 15 Seater Bus	SLG 1099
2007	Toyota	Hilux D/Cab	SLG 2063
2007	Toyota	Hilux D/Cab	SLG 2052
2007	Nissan	D/Cab Pick Up	SLG 2012
2007	Nissan	D/Cab Pick Up	SLG 2007
2007	Nissan	D/Cab Pick Up	SLG 2008
2007	Nissan	D/Cab Pick Up	SLG 2013
2007	Nissan	D/Cab Pick Up	SLG 2014
2007	LDV	Maxus Standard Roof/ Police Vehicle	SLG 2035
2007	Mitsubishi	L300 Mini Bus	SLG2019

Model Year	Manufacturer	Model	Registration Number
2007	Nissan	D/Cab Pick Up	SLG 2002
2007	Nissan	D/Cab Pick Up	SLG 2010
2007	Toyota	Hilux D/Cab	SLG 2056
2007	Toyota	Hilux D/Cab	SLG 2057
2007	Toyota	Hilux D/Cab	SLG 2055
2007	Toyota	Hilux D/Cab	SLG2069
2008	Hyundai	Fortuner	SLG 3036
2008	Hyundai	CRV	SLG 3018
2008	Hyundai	Fortuna	SLG 3035
2008	Hyundai	Ranger	SLG 3014
2008	Hyundai	NAVARA D/C 4WD	SLG 3021
2008	Hyundai	NAVARA D/C 4WD	SLG 3022
2008	Hyundai	NAVARA D/C 4WD	SLG 3023
2008	Hyundai	Pathfinder	SLG 3037
2008	Hyundai	BT50 D/C 4WD	SLG664
2008	Hyundai	Ambulance	SLG 162
2008	Hyundai	Hilux D/C 4 WD	SLG3030
2008	Hyundai	FUSO Canter Truck	SLG420
2008	Hyundai	Ranger	SLG 3033
2008	Hyundai	RAV-4 (SUV)	SLG3011
2008	Hyundai	Hilux D/C 4 WD	SLG132
2008	Hyundai	Ranger	SLG 3026
2008	Hyundai	Sailor	SLG3123
2008	Hyundai	RAV-4 (SUV)	SLG3012
2008	Hyundai	Navara	SLG 3005
2008	Hyundai	Ambulance	SLG154
2008	Ford	Ambulance	SLG - 058
2008	Suzuki	Grand Vitara	SLG 3008
2008	Toyota	4y Sailor Pick up	SLG3130
2009	Hyundai	Everest	SLG 2078
2009	Hyundai	Forester	SLG 73
2009	Hyundai	Ranger D/C 4WD	SLG3045
2009	Hyundai	Hilux D/C 4 WD	SLG3031
2009	Hyundai	Hilux D/C 4 WD	SLG3032
2009	Hyundai	Hiace 16 st	SLG3034
2009	Hyundai	Double Cab BT50	SLG3057
2009	Chevrolet	Unknown	SLG-3138
2009	Nissan	Urvan	SLG – 636
2009	Toyota	Hilux 4x4 D/Cab	SLG3041
2010	Hyundai	WE BOO	SLG 3104
2010	Hyundai	Navara D/Cab	SLG3071
2010	Hyundai	Hiace 16 st	SLG3051
2010	Nissan	Urvan	SLG - 474

Model Year	Manufacturer	Model	Registration Number
2010	Nissan	Double Cab	SLG3077
2011	Toyota	Hilux	SLG 761
2011	Mitsubishi	Pajero	SLG 802
2011	Hyundai	Hilux Pick-Up	SLG 3027
2011	Hyundai	Hilux D/Cab	SLG 3110
2011	Hyundai	Murano	SLG 3076
2011	Hyundai	Navara	SLG 3087
2011	Hyundai	Quasqau	SLG 3073
2011	Hyundai	Hilux	SLG3080
2011	Hyundai	Hilux D/C 4 WD	SLG 611
2011	Hyundai	Ranger	SLG 3072
2011	Hyundai	Hiace	SLG3108
2011	Hyundai	Navara D/Cab	SLG3085
2011	Nissan	Navara	SLG 049
2011	Nissan	Navara	SLG - 515
2011	Mitsubishi	L200 D-Cab	SLG3090
2011	Mitsubishi	L200 D-Cab	SLG3113
2011	Mitsubishi	L200 D-Cab	SLG3089
2011	Mitsubishi	L200 D-Cab	SLG3091
2011	Mitsubishi	L200 D-Cab	SLG3982
2012	Toyota	Hiace 16 STR (Grandace)	SLG 602
2012	Hyundai	Hiace	SLG 1001
2012	Hyundai	Navara	SLG 3132
2012	Hyundai	Master	SLG 3127
2012	Hyundai	HILUX D/C WD	SLG 3145
2012	Hyundai	Dmax	SLG 895
2012	Hyundai	Sorento suv	SLG3100
2012	Hyundai	Double Cab	SLG3152
2012	Toyota	Ambulance	SLG 042
2012	Toyota	Ambulance	SLG 47
2012	Toyota	Ambulance	SLG 67
2012	Suzuki	APV Panel van	SLG3147
2012	Nissan	Urban	SLG3139
2012	Toyota	Coaster	SLG3129
2012	Chevrolet	Express	SLG3111
2013	Toyota	Hiace	SLG 3159
2013	Hyundai	Santa Fe	SLG 3140
2013	Hyundai	Navara D/Cab	SLG3167
2013	Ford	Ambulance	SLG 3158
2013	Toyota	Hiace	SLG3157
2014	Nissan	Navara	SLG 3163
2014	Nissan	Double Cab	SLG 3168
2015	Nissan	Double Cab	SLG 3179

Annex 1 (concluded)

Model Year	Manufacturer	Model	Registration Number
2015	Nissan	Xtrail	SLG 3181
2015	Mitsubishi	L200	SLG 3175

Source: Government of Saint Lucia, 2016.

Annex 2
Electric, hybrid and plug-in hybrid vehicles overview[12]

Vehicle Model (Type)	Motor power (kW)	Battery capacity (kWh)	Charging level (I,II,III)	Range y performance (EPA y MPG Combined)	Energy consumption (kWh/100miles)	MSRP (Dollars)
			EV			
2017 Mitsubishi i-MiEV (MiniCar)	49	16	I,II,III	62 miles	30	22,995.00
2017 Smart fortwo (MiniCar)	55	17.6	I,II,III	68 miles	32	25,995.00
2016 Chevrolet Spark EV (MiniCar)	105	19	I,II,III	82 miles	28	25,510.00
2016 Nissan Leaf (Sedan)	80	24-30	I,II,III	84-107 miles	30	29,010.00 - 36,790.00
2016 Ford Focus Electric (Compact)	107	23	I,II	76 miles	32	29,107.00
2016 Fiat 500e (Compact)	83	24	I,II	84 miles	30	31,800.00
2016 VW e-golf (Compact)	85	24.2	I,II,III	83 miles	29	28,995.00-35,595.00
2017 Renault Zoe (Compact)	88	22	I,II,III	149 miles	23.5	18,282.00-21,035.00
2017 BMW i3 (Sedan)	125	22	I,II,III	81 miles	27	42,400.00 - 46,250.00
Mercedes B250e (Sedan)	132	28	I,II	87 miles	16.6-17.9	42,400.00
Tesla Model S (Sedan)	193 - 375	70 - 90	I,II,III	218- 294 miles	33-38	71,500.00-109,500.00
Tesla Model X (SUV)	193 - 375	75 - 90	I,II,III	200 - 257 miles	36-38	81,200.00 - 116,700.00
Kia Soul EV (MiniCar)	81.4	27	I,II,III	93 miles	32	31,905.00-35,950.00
Renault Kangoo ZE (Van)	44	22	I,II,III	100 miles	25	25,00.000-28,000.00
			PHEV			
Toyota Prius (Sedan)	53 + 37	9	I,II	22 miles / 52 MPG	29	24,200.00-28,100.00
Hyundai Sonata(Sedan)	50 + 40	10	I,II	27 miles / 40 MPG	34	34,600.00
Ford C-Max Energi (Wagon)	35 + 105	8	I,II	19 miles / 38 MPG	37	31,770.00
Ford Fusion Energi (Sedan)	35 + 88	7	I,II	19 miles / 38 MPG	37	31,120.00
BMW 330e (Sedan)	65 + 120	7	I,II	14 miles / 31 MPG	47	43,700.00
Audi A3 tron (Compact)	75 + 111	9	I,II	16 miles / 35 MPG	40	37,900.00-46,800.00
Chevrolet Volt (Sedan)	111	18	I,II	53 miles / 42 MPG	31	33,220.00-37,570.00
BMW X5 (SUV)	83 + 147	9	I,II	19 miles / 24 MPG	No data available	55,695.00 - 72,495.00
Volvo XC90 T8 (SUV)	65 + 233	9	I,II,III	17 miles / 54 MPG	60	68,100.00 - 71,600.00
Mitsubishi Outlander PHEV (SUV)	60+ 89	12	I,II,III	Range: 52 km	31	38,313.00

12 This list of vehicles is annexed with illustrative purposes and does not represent an exhaustive compendium of EV/HEV/PHEV alternatives. List of prices last updated in July, 2016.

Annex 2 (concluded)

Vehicle Model (Type)	Motor power (kW)	Battery capacity (kWh)	Charging level (I,II,III)	Range y performance (EPA y MPG Combined)	Energy consumption (kWh/100miles)	MSRP (Dollars)
			REV			
Via VTRUX Truck (Pick up)	150	23	I,II,III	40 miles + 400 miles range extended Average miles per year: 15,000 (120 MPGe) Average miles per year: 18,000 (84 MPGe) Average miles per year: 36,000 (30 MPGe)	No data available	90,029
Via VTRUX Van (Van)	100	23	I,II,III	40 miles + 400 miles range extended Average miles per year: 16,000 (255 MPGe) Average miles per year: 19,000 (57 MPGe) Average miles per year: 25,000 (39 MPGe)	No data available	97,853

Source: Authors' compilation.

Annex 3
Example of road types, parameters considered and energy consumption

Table A.1
Road types

Road category	Traffic congestion	Cluster number	Average speed, m/s	Average acceleration, m/s^2	Congestion index
urban	stop and go	1	3.48	0.91	1.02
	congested	2	8.26	0.51	0.26
	free flowing	3	12.61	0.16	0.03
B road	stop and go	4	3.74	1.06	1.01
	congested	5	10.49	0.50	0.19
	free flowing	6	15.43	0.17	0.03
A road	stop and go	7	3.32	1.09	1.18
	congested	8	12.23	0.63	0.19
	free flowing	9	21.50	0.11	0.01
motorway	stop and go	10	2.97	0.94	1.23
	congested	11	9.50	0.62	0.28
	free flowing	12	25.12	0.06	0.01

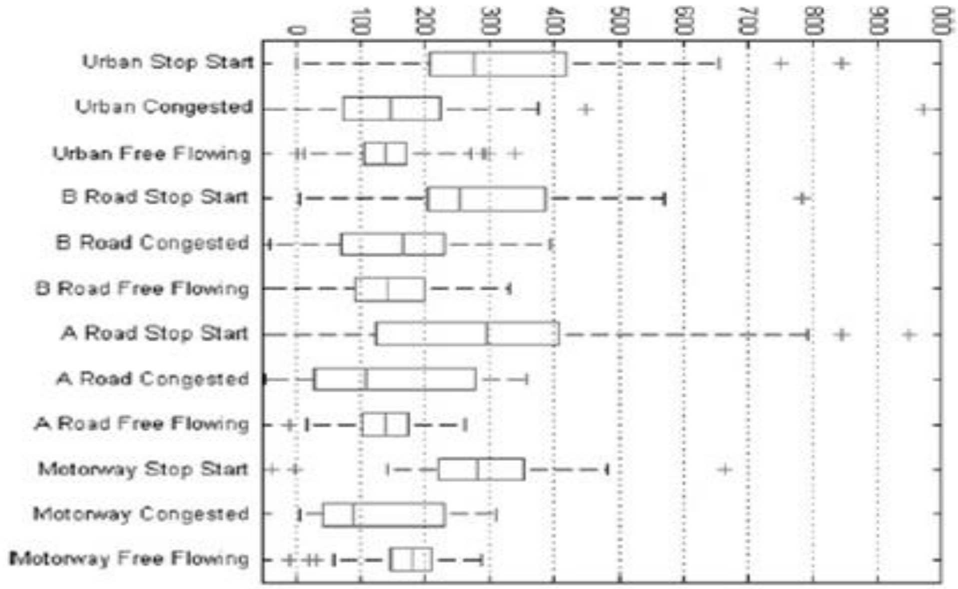
Source: Shankar and James, 2012.

Table A.2
Parameters considered to measure road types

Parameter	Units
average speed	m/s
standard deviation of speed	m/s
maximum speed	m/s
average acceleration	m/s^2
standard deviation of acceleration	m/s^2
maximum acceleration	m/s^2
average deceleration	m/s^2
standard deviation of deceleration	m/s^2
maximum deceleration	m/s^2
relative positive acceleration	m/s^2
number of stops per km	stops/km
stop duration per km	s/km
% of time in speed interval 0–15 km/h	
% of time in speed interval 15–30 km/h	
% of time in speed interval 30–50 km/h	
% of time in speed interval 50–70 km/h	
% of time in speed interval 70–90 km/h	
% of time in speed interval 90–110 km/h	
% of time in speed >110 km/h	
positive kinetic energy	m/s^2
% of time when (va) <0	
% of time when (va) is 0–3	
% of time when (va) is 3–6	
% of time when (va) is 6–10	
% of time when (va) is 10–15	
% of time when (va) >15	
total duration	s
total distance	m

Source: Shankar and James, 2012.

Table A.3
Example of vehicle energy consumption according to road type
(Wh/km)



Source: Shankar and James, 2012.

PROJECT DOCUMENTS

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