Initiative for Climate Action Transparency Phase 2

Draft Electric Power Mitigation Analysis Scenario Report

Antigua and Barbuda

29th December 2023

Submitted to:
The Government of Antigua and Barbuda, Department of the Environment

Prepared by:
Caribbean Cooperative Measurement, Reporting & Verification Hub

DISCLAIMER

PREPARED UNDER

The Initiative for Climate Action Transparency (ICAT), supported by Austria, Canada, Germany, Italy, the Children's Investment Fund Foundation and the ClimateWorks Foundation.

The ICAT Secretariat is managed and supported by the United Nations Office for Project Services (UNOPS)

Table of Contents

List of Figures

List of Tables

Acronyms

ANB	Antigua and Barbuda
ABTB	Antigua and Barbuda Transport Board
APC	Antigua Power Company
APUA	Antigua Public Utilities Authority
CCMRVH	Caribbean Cooperative Measurement, Reporting and Verification Hub
CSI	Climate Smart Initiatives (Pvt) Ltd.
EV	Electric Vehicle
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
GACMO	The Greenhouse Gas Abatement Cost Model
ICAT	Initiative for Climate Action Transparency
ICE	Internal Combustion Engine
IMF	International Monetary Fund
IPP	Independent Power Producers
LEAP	Low Emissions Analysis Platform
MW	Megawatt
NDC	Nationally Determined Contribution
PPA	Power Purchase Agreement
SDG	Sustainable Development Goals
SEI	Stockholm Environment Institute
SIDS	Small Island Developing States
SIRF	Sustainable Island Resource Framework
SLCP	Short-lived climate pollutants
SLIM	Sustainable Low Emission Island Mobility
SUVs	Sports Utility Vehicles
TraCAD	The Transport Climate Action Data Tool

UNFCCC	United Nations Framework Convention on Climate Change
WIOC	West Indies Oil Company

1 Introduction

Antigua and Barbuda is a sovereign Small Island Developing State (SIDS) in the Eastern Caribbean committed to implementing measures to grow its economy in a low-carbon and sustainable manner. The country initially implemented the first phase of the Initiative for Climate Action Transparency (ICAT) Project that focused on the establishment of sustainable national economy-wide greenhouse gas emissions projection and mitigation analysis modelling capabilities.

ICAT aims to help countries better assess the impacts of their climate policies and actions and fulfil their transparency commitments. It does this by increasing the overall transparency capacities of countries, including the capacity to assess the contribution of climate policies and actions on countries' development objectives and providing appropriate methodological information and tools to support evidence-based policymaking.

Upon the successful completion of the first phase of the ICAT project, Antigua and Barbuda has re-engaged ICAT for the implementation of the second project. In addition, Antigua and Barbuda has indicated in its updated Nationally Determined Contributions (NDC) a target to transition all new vehicle sales to electric vehicles by 2030 and have eighty-six per cent (86%) of renewable energy generation from local resources in the electricity sector [1].

This phase takes a deeper look at the transport sector, the strengthening of national modelling capabilities in the transport sector for policymaking, NDC updates and other reporting requirements, and the Sustainable Development Goal (SDG) impact of its electric mobility transition. To achieve this the project involved the following:

- ✓ The review of modelling tools available for the transport sector and the selection of appropriate modelling tools for the greenhouse gas (GHG) analysis of the transport sector for Antigua and Barbuda including an analysis of the power requirements for this transition. The process of this selection was highlighted in the Transport Tool Selection Justification Report also contained in **ANNEX 1** of this report.
- ✓ Training workshops virtual and in-person on the modelling tools selected for analysis: The Transport Climate Action Data Tool (TraCAD) developed by the Climate Smart Initiative (CSI) and the Low Emissions Analysis Platform (LEAP) developed by the Stockholm Environment Institute (SEI)
- ✓ Ensure linkage with the Sustainable Low Emissions Island Mobility (SLIM) Project through the hosting of a Transport implementation project alignment workshop. The detail of this workshop is highlighted in the final report of this workshop also contained in
- ✓
- ✓ **ANNEX** 2 of this report.
- ✓ The development of fully elaborated models for the selected modelling tools TraCAD and LEAP and updates of the models developed from phase 1 of the project LEAP and The Greenhouse Gas Abatement Cost Model (GACMO) with the new datasets obtained.

In the 2019, GHG Inventory report Antigua and Barbuda, the transportation sector was identified as the major GHG emitter in the energy sector contributing more than fifty percent (50%) of total emissions [2]. The transport sector is predominantly fuelled by fossil fuels with the use of over 99% of its approximately forty-four thousand (44,000) vehicles. The transition to electric vehicles emerges as a pivotal component in achieving a hundred per cent (100%) renewable energy in transport by 2040 with a preliminary target of a hundred per cent (100%) sales of all new vehicles to be electric by 2030. Therefore, analysing mitigation reduction potential in the transport sector is of critical importance to the overall reduction and achievement of net-zero emissions targets for the Government of Antigua and Barbuda as defined in their NDCs. In addition to the analysis of the transport sector, the shift to electric vehicles will also impact electricity generation. It is therefore of utmost importance that the transition of the transport sector is analysed with the electricity generation sector. The effect of the transition of the transport sector can have an effect on the goal to transition the electricity sector and vice versa.

This report presents an analysis of the relationship between the transport transition and its impact on the power sector. The report also investigates recommendations to manage these transitions simultaneously. These are presented via the following sections:

Section 2 – Transport-Energy Nexus in Antigua and Barbuda
Section 3 –Methodological Approaches
Section 4 – Modelling
Section 5 – Results and Analysis;
Section 6 – Just Transition Considerations
Section 7 – Suggestions for Model Improvements;
Section 8 – Recommendations;
Section 9 – Conclusions.

2 The Transport-Energy Nexus in Antigua

Electricity generation in Antigua and Barbuda is mainly supplied through fossil fuels. The electricity generation, transmission and distribution and sale of electricity is governed by the Antigua Public Utilities Authority (APUA). APUA a tripartite, government statutory board, governs electricity, water and telecommunications for Antigua and Barbuda [3]. The power is supplied to residences and households mainly through overhead electricity lines at 230 V and commercial or larger facilities at 400V at a frequency of 60 Hz.

Power generation is supplied to APUA mainly by Independent Power Producers (IPP) through an established Power Purchase Agreement (PPA). The IPP operating in Antigua and Barbuda is Antigua Power Company (APC) which operates two facilities of installed capacity of 60.3 MW and 30.4 MW at Crabbs and Black Pine respectively. These two facilities generate the majority of the electricity supply for Antigua and Barbuda. Another fossil fuel plant, Wadadli, operated by APUA with an installed capacity of 36 MW was decommissioned in 2020. Fossil fuel, mainly heavy fuel oil is supplied to generating companies through the main distributor West Indies Oil Company (WIOC). In addition to these facilities, electricity is also provided through renewable energy sources from two solar photovoltaic (PV) farms of 3 MW and 4 MW located at the airport and Bethesda respectively and approximately 2.5 MW distributed solar PV (solar PV on rooftops, carports, etc). The APUA has plans to introduce Liquefied Natural Gas (LNG) to the energy mix.

The Electricity and transport sectors have remained independent of each other with the major commonality being the use of fossil fuel. With the introduction of electric vehicles, this relationship has become more integrated, with electric vehicles (EVs) necessitating charging of the batteries from an electricity supply (grid or otherwise) and also having the ability to supply power to the grid when necessary. At present, EV penetration in Antigua and Barbuda is very low with fossil fuel dominating the fuel use in the transport sector.

Antigua and Barbuda have indicated a clear plan to transition their transport fleet to EVs through their updated NDC with a conditional target of 100% of all new vehicle sales to be electric vehicles by 2030. To support this transition several projects are being implemented such as the SLIM project funded by the Global Environment Facility (GEF). One component of the SLIM project is the preparation for the scale-up and replicability of low-carbon electric mobility and climate-resilient renewable energy. This component will support a funding method under the Sustainable Island Resource Framework (SIRF) for private and public consumers to transition to electric vehicles.

In addition to the projects, Antigua and Barbuda is currently revising its National Energy Policy with the latest version published in 2010 and there is work on going to improve the public charging stations on the island. **Figure 1** shows the current installed EV charging stations from one company Megapower.

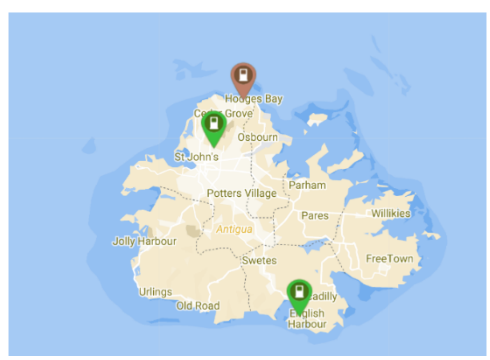

Figure 1: Electric Vehicle Charging Stations in Antigua and Barbuda [4]

3 Methodological Approach

This report specifically focuses on interactions of the power sector with the transport sector. Two modelling tools were recommended from the analysis conducted in the first phase of this ICAT project and documented in the Transport Tool Selection Justification Report contained in **ANNEX 1**. Out of these two tools only one tool possessed the ability to analyse the interactions of the transport sector with the power sector. Therefore, in this report only the Low Emissions Analysis Platform (LEAP) tool results are analysed.

LEAP is a software tool that is used for climate change mitigation analysis and integrated energy policy analysis. This tool was previously used by Antigua and Barbuda in the development of the analysis of economy-wide analysis of GHG emissions in the first phase of the ICAT project and used in the development of NDCs. The tool jointly assesses greenhouse gases, short-lived climate pollutants (SLCP), and air pollutant emissions and builds mitigation and baseline or business-as-usual scenarios. LEAP calculates the emissions and visualises the impact of these GHG emissions [4].

3.1 Transport Methodology

To conduct this analysis, the road transport sector and the power sector requirements for Antigua and Barbuda modelling were conducted. The transport analysis is explained in detail in the Electric Mobility Transition Scenario Impact Assessment Report. The input data for the model is further discussed in **Section** Error! Reference source not found. of this report. Regional data and assumptions based on expert judgment were also included in areas where the local data was either unavailable or incomplete.

For road transport, a stock turnover analysis was undertaken in LEAP. The stock turnover is a detailed analysis of the transport sector and calculates the remaining stock of vehicles per year based on the sales and the survival of vehicles in the year. For this analysis, a clear disaggregation of the stock of vehicles by vehicle type was inputted into the model along with the survival profile of vehicles. The vehicles were grouped into branches as defined in **Figure 2.** Each grouping of personal, commercial and government vehicles contained each type of vehicle, and each type of vehicle was distributed in the different fuel use of vehicles. The vehicle types used in this assessment were as defined by the Antigua and Barbuda Transport Board [5] and disaggregated within their system.

The energy consumption was calculated using information from the vehicle stock, the mileage which represents the annual distance travelled by each vehicle and the fuel economy of the vehicle. This was then used to calculate the emissions for the transport sector as described with the equations below. The stock of vehicles was entered for the years 2010 up to the year 2022 with the year 2010 used as a baseline. The sales data was obtained for the year 2022. All projections and scenario development for the transport sector began in 2023. The initial data and assumptions used in the model are described further in **Section** Error! Reference source not found.**.**

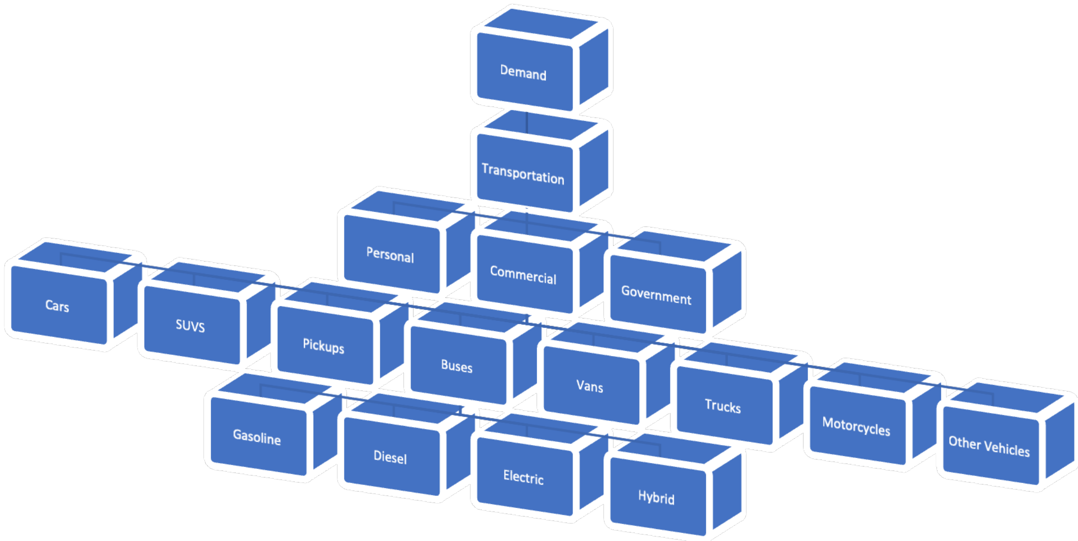

Figure 2: Labels of Transportation Branches in LEAP

3.2 Power Sector Methodology

In the transformation segment of the LEAP model, each generation power was included with the fuel type. In addition, the transmission and distribution network with both economic and non-economic losses were included in the model. In LEAP, the power generation is driven by the demand analysis which is in this case the transport analysis. So power is only generated to meet the requirements of the transport sector, which in this case is generated by the EVs. The hybrid vehicles in the transport analysis are considered as non-plug-in hybrids and therefore do not use electricity to supply power to the vehicles.

3.3 Scenario Development

Forward-looking scenarios were created to project GHG emissions over these time frames. These include the following:

Baseline Scenario: This scenario is a hypothetical scenario assuming that no changes to the current policies for the transportation and power generation sector are implemented. This scenario assumes that the two sectors remain mainly fossil fuel-based and therefore the interaction between the two sectors is minimal. This scenario considers the implications of demographic and macroeconomic changes on the transportation sector without additional policies.

Mitigation Scenarios: These forward-looking scenarios analyse the various targets from the NDC for the transition to EVs in the transport sector and the transition to renewables in the power sector. These include the following:

1. The complete ban on sales of ICE cars and Sports Utility Vehicles (SUVs) only, with the power sector operating with the current grid (mainly fossil fuels).
2. The complete ban on sales of ICE cars and Sports Utility Vehicles (SUVs) only with the power sector operating on 100% renewables.
3. The complete ban on sales of ICE commercial buses only, with the power sector operating with the current grid (mainly fossil fuels).
4. The complete ban on sales of ICE commercial buses only, with the power sector operating on 100% renewables.
5. The complete ban on sales of all ICE private/personal vehicles only, with the power sector operating with the current grid (mainly fossil fuels)
6. The complete ban on sales of all ICE private/personal vehicles only, with the power sector operating on 100% renewables.
7. The complete ban on sales of all ICE commercial vehicles only, with the power sector operating with the current electricity grid (mainly fossil fuels)
8. The complete ban on sales of all ICE commercial vehicles only, with the power sector operating on 100% renewables.
9. The complete ban on sales of all ICE Government vehicles with the power sector operating with the current grid situation (mainly fossil fuels) with full transition by 2035.
10. The complete ban on sales of all ICE Government vehicles with the power sector operating on 100% renewables with full transition by 2035.
11. The complete ban on sales of all ICE vehicles with the power sector operating with the current grid (mainly fossil fuels). Considered as a combination of mitigation scenarios 1,3,5,7 and 9.
12. The complete ban on sales of all ICE vehicles with the power sector operating on 100% renewables. Considered as a combination of mitigation scenarios 2, 4,6,8 and 10.

For scenarios with renewable energy, further renewables are added along with storage and optimized using the LEAP model. This will allow for the supply of electricity with sufficient reserve for EV charging.

4 LEAP Modelling

This section provides an overview of the LEAP model, including major input data and assumptions, scenarios analyzed, and barriers and limitations with the model.

4.1 Input Data and Assumptions

Input data and assumptions are essential components in undertaking modelling analysis irrespective of the software tools used. The input data and assumptions for LEAP are described in this section.

4.1.1 Demographic and Macroeconomic Data

Demographic and macroeconomic data are important non-policy drivers that can influence the growth of the demand sector. In LEAP, the power generation is supplied to meet the growth in the demand sector and therefore these non-policy drivers also indirectly influence the power generation sector. The historical population data and the National Gross Domestic Product (GDP) data were obtained from the Antigua and Barbuda Statistics Division, Ministry of Finance and Corporate Governance. This information was supplemented by data from the United Nations (UN) and the IMF World Economic Outlook for projections of the key data. The historical and projected population and GDP are shown in **Figure 3** and **Figure 4** respectively**.** Additional data such as growth rates, household statistics, gender distribution of the population, per capita and sectoral contribution to GDP was added to the model. The complete demographic and macroeconomic data sets can be found in **Section 10.1.**

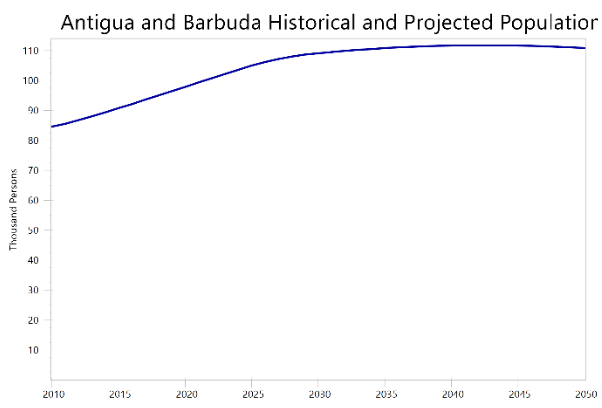

Figure 3: Antigua and Barbuda Historical Population [8] [9] [4]

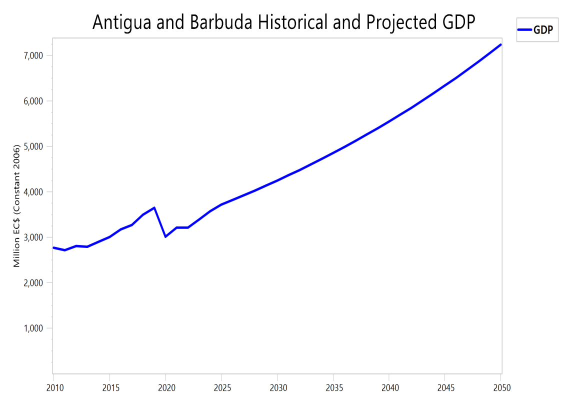

Figure 4: Antigua and Barbuda Historical and Projected GDP [8] [10]

These non-policy drivers were used to project transport use, where the population was used for personal vehicles and GDP was used as the driver for commercial and Government vehicles with an elasticity.

4.1.2 Road Transport Data

The data entered for this section does not differ from the input data for the LEAP model in the Electric Mobility Transition Scenario Report. The majority of the information was obtained from the Antigua and Barbuda Transport Board (ABTB), the SLIM project and other data collected in the country by the ICAT Antigua and Barbuda. The following categories of data were inputted into the model to conduct the transport analysis.

- **Vehicle stock data –** total number of registered vehicles by category, type and fuel use as shown in **Figure 2.**
- **Vehicle sales data –** the number of newly registered vehicles.
- **Vehicle mileage data -** the average annual distance travelled by a type of vehicle
- **Vehicle Fuel Economy -** the unit of fuel used per distance travelled per vehicle type
- **Vehicle Costs –** the retail cost of vehicles without any subsidies
- **Vehicle Emissions Factor** – tier 1 emissions factors obtained from the 2006 IPCC guidelines and coincide with values used in the 2019 GHG Inventory
- **Vehicle Lifecycle Profile** – the age profile of the stock of vehicles, assumed the same across the categories.
- **Vehicle Survival Profile -** the fraction of vehicles surviving after a number of years. Assumed for Government vehicles lifespan is 7 years and for all other vehicles 20 years.

The full data set for transport data can be found in **Appendix 10.2 Transport Data**.

4.1.3 Power Sector Data

- **Transmission and Distribution Losses**

The transmission and distribution (T&D) losses for the electricity grid were mainly obtained from data provided by the Antigua Power Utility Authority (APUA). The T&D losses were assumed to be constant from the year 2021 at 18%.

- **Electricity Generation Data**

The electricity generation sector for Antigua and Barbuda is currently mainly fossil fuel-based. No historical production for the power plants was used as the transport sector was not a consumer of electricity due to the very limited number of EVs registered on the island. **Table 1** shows the input variables for the power sector used in the LEAP model for the historical information.

Table 1: Power plant data entered for LEAP in historical information

Plant Type	Feedstock	Installed Capacity (MW) (2022)	Efficiency (%)	Merit Order	Maximum Availability (%)
Thermal Plant APUA Wadadli	Residual Fuel Oil	0	40	2	100
Thermal Plant APC Crabbs	Residual Fuel Oil	60.3	40	2	100
Thermal Plants APC Black Pine	Residual Fuel Oil	30.4	40	2	100
Utility Solar airport	solar	3	100	1	Based on yearly shape availability for Antigua and Barbuda
Utility Solar Bethesda	solar	4	100	1	
Barbuda Plant	solar	1	100	1	
Distributed Solar	solar	2.5	100	1	
Additional Solar Plants	solar	0	100	1	
Liquified Natural Gas (LNG) Plant	Natural Gas	0	40	2	100
Wind farms	solar	0	100	1	100

For the baseline scenario **Table 2** shows that installed capacity, merit information and availability remain the same.

Table 2: Power plant data entered for LEAP in historical information for the baseline scenario.

Plant Type	Feedstock	Installed Capacity (MW) (2022)	Installed Capacity (MW) 2030
Thermal Plant APUA Wadadli	Residual Fuel Oil	0	0
Thermal Plant APC Crabbs	Residual Fuel Oil	60.3	60.3
Thermal Plants APC Black Pine	Residual Fuel Oil	30.4	30.4
Utility Solar airport	solar	3	3
Utility Solar Bethesda	solar	4	4
Barbuda Plant	solar	1	1
Distributed Solar	solar	2.5	2.5
Additional Solar Plants	solar	0	0
Liquified Natural Gas (LNG) Plant	Natural Gas	0	30
Wind farms	solar	0	0

In addition to this data, the 2022 hourly load profile was obtained for Antigua and Barbuda, this provided the demand profile for generation needs. Because the historical production for the power plants was not used, the actual generation did not meet this load profile as generation was only required for the transport sector. **Figure 5** shows the hourly energy profile, separated for weekends and weekdays and the wet and dry seasons.

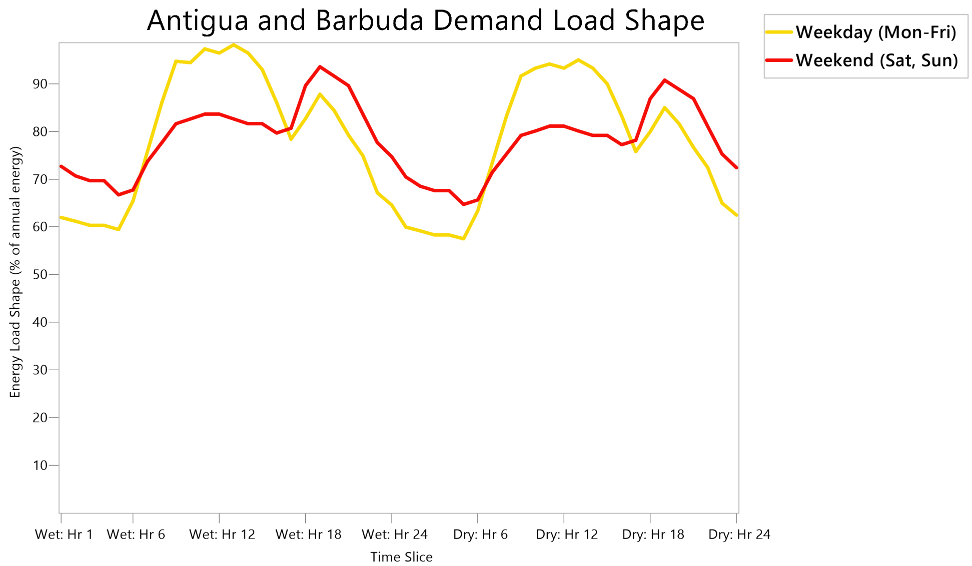

Figure 5: Hourly Load Shape for Antigua and Barbuda

4.2 Electric Power Mitigation Analysis Scenarios Used for Modelling

Note that separate scenarios were used to analyse the electric generation requirements for the transport sector, but additional generation was added to the various scenarios to ensure that all electricity requirements were met within the model. The electricity generation is accounted for by the increase in EVs in the transport sector and the mitigation scenarios highlighted in **Section 3.3.**

In these scenarios the following assumptions are made:

- The ban on the sale of ICE vehicles will begin in 2025 and the full implementation of the ban will occur at the end of the 5 years 2030.
- The ban on sales of ICE vehicles is implemented for both new and used vehicles.
- The ICE vehicles would be proportionally replaced with a suitable EV of the same type.
- All vehicles would follow the baseline trend until 2025 when the policy is implemented, and other policies would not affect the sales trend of vehicles.
- The model will indicate when the stock of ICE vehicles will be depleted based on the survival profile.
- The survival profile for Government vehicles indicates a lifetime of 7 years. Once ICE Government vehicles are 7 years old, they will need to be replaced with EVs to ensure a complete phase-out of ICE Government vehicles by 2035.
- The survival profile is also applicable to electric vehicles, once 7 years are achieved, they would need to be placed or sold.
- The current grid situation assumes a renewable energy penetration of 12.3% in 2022 with the operationalization of a Liquified Natural Gas (LNG) plant in the year 2030.
- All fossil-fueled vehicles including hybrid vehicles are transitioned to electric vehicles.
- Plug-in hybrid vehicles are not considered.
- All electric vehicles are charged through the electric grid, no account is made for vehicles charged from standalone systems.

For the installed generation capacity in the mitigation scenarios, the following methods were used.

1. For the mitigation scenarios using electricity generation from the current grid, the model was allowed to install needed generation to the APC Crabbs facility in increments of 10MW (a typical size of a diesel plant generator).
2. For the mitigation scenarios using 100% renewables, the model was optimised to include additional solar, wind and battery storage as required to meet the electricity demand of the additional EV vehicles.

4.3 Barriers or Limitations in the Model

The following barriers and limitations are within the model developed:

- The model does not allow for off-peak charging to be considered as a scenario.
- Lifecycle GHG emissions of renewables are not taken into consideration in the model. All renewables are considered to have zero GHG emissions.
- The model does not allow for different survival profiles to be considered as a scenario; the survival profile of vehicles is considered the same from the historical to the mitigation scenarios for each vehicle type.

5 Results and Analysis

In this section, the results of the modelling for electric power analysis are presented to ensure that the power demand for the transport sector is met within the country and also to maintain the necessary reserve to limit blackouts and brownouts within the country.

5.1 Power Demand Requirements

With the addition of electric vehicles to the transport sector, electricity generation is expected to increase to maintain this demand. The increase in electricity generation demand is expected to be the same whether the vehicles are supplied with renewable energy or from fossil fuels. **Figure 6** and **Table 3** shows the energy generation requirements for the mitigation scenarios.

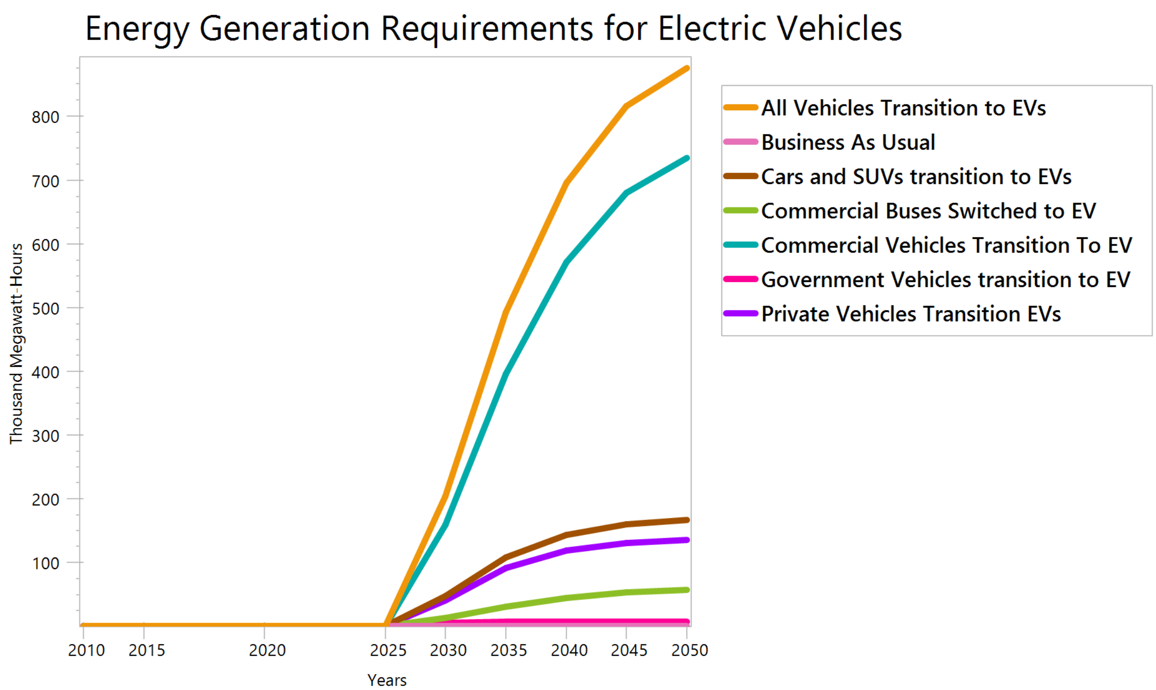

Figure 6: Electricity Generation requirements for transition to electric vehicles

Table 3: Electricity Generation requirements for transition to electric vehicles

Electricity Generation Requirements in GWh							
Scenario	2022	2025	2030	2035	2040	2045	2050
Business As Usual	0.2	0.2	0.2	0.2	0.2	0.2	0.2
All Vehicles Transition to EVs	0.2	0.5	203.4	493.1	696.0	815.9	876.0
Cars and SUVs transition to EVs	0.2	0.3	46.8	108.2	142.9	159.3	166.5
Commercial Buses Switched to EV	0.2	0.2	12.5	30.8	44.3	52.7	57.0

Electricity Generation Requirements in GWh							
Scenario	**2022**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Commercial Vehicles Transition To EV	0.2	0.4	158.9	395.7	571.4	679.5	734.7
Government Vehicles transition to EV	0.2	0.3	5.2	6.9	6.9	6.9	6.9
Private Vehicles Transition EVs	0.2	0.3	39.8	91.0	118.2	129.9	134.8

As shown in **Table 3** and **Figure 6,** the transition to electric vehicles more than **203 GWh** of electricity generation in 2030, and for a full transition of electric vehicles over **800 GWh** of electricity is required to supply power to the transport sector from 2045 onwards. It should be noted that this is an additional power requirement to the normal demand as shown in the business-as-usual scenario this demand is only **0.2 GWh**.

For comparison purposes, the total production from fossil fuel for 2019 was **351 GWh** obtained from data submitted by APUA.

5.2 Additional Capacity for Power Generation

To meet the additional power requirements, additional power is required in some scenarios. These additional power requirements are dependent on the availability of the resource. In the case of variable renewables, the capacity added is much more than the fossil fuel plants because of their limited availability to supply electricity during the year. The additional generation capacity installed every 5 years for fossil fuel generation is shown in **Table 4**.

Table 4: Additional Generation Capacity Installed per scenario without RE.

Additional Capacity Added (MW) by the following year							
Scenario	**2022**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Business As Usual	0	0	30				
All Vehicles Transition to EVs	0	0	30	30	60	40	20
Cars and SUVs transition to EVs	0	0	30				
Commercial Buses Switched to EV	0	0	30				
Commercial Vehicles Transition To EV	0	0	30		50	40	10
Government Vehicles transition to EV	0	0	30				
Private Vehicles Transition EVs	0	0	30				

5.3 Total Installed Capacity Required

In **Section 5.2**, the additional capacity required for fossil fuel generation is given. In this section, the total capacity required to be installed per scenario is given in **Table 5**. It should be noted that the installed capacity required for renewables is much higher than the installed capacity for fossil fuel as

Antigua and Barbuda is limited in their renewable potential to mainly variable renewables of solar and wind which have less availability throughout the year when compared to electricity generated from fossil fuels.

Table 5: Total Capacity Required per Scenario

Total Capacity Installed (MW)							
Scenario	**2022**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Business As Usual	101.2	101.2	131.2	131.2	131.2	131.2	131.2
All Vehicles Transition to EVs	101.2	101.2	131.2	161.2	221.2	261.2	281.3
Cars and SUVs transition to EVs	101.2	101.2	131.2	131.2	131.2	131.2	131.2
Commercial Buses Switched to EV	101.2	101.2	131.2	131.2	131.2	131.2	131.2
Commercial Vehicles Transition To EV	101.2	101.2	131.2	131.2	181.2	221.2	231.2
Government Vehicles transition to EV	101.2	101.2	131.2	131.2	131.2	131.2	131.2
Private Vehicles Transition EVs	101.2	101.2	131.2	131.2	131.2	131.2	131.2
All Vehicles Transition to EVs with RE	101.2	370.5	455.1	812.6	842.9	916.6	917.9
Cars and SUVs transition to EVs with RE	101.2	203.2	242.1	242.8	245.1	274.0	301.1
Commercial Buses Switched to EV with RE	101.2	506.2	536.1	536.8	537.7	544.6	560.7
Commercial Vehicles Transition To EV with RE	101.2	201.4	321.6	472.8	601.9	717.6	827.7
Government Vehicles transition to EV with RE	101.2	324.9	701.7	702.4	703.3	704.3	716.9
Private Vehicles Transition EVs with RE	101.2	289.6	325.1	325.8	326.6	327.7	562.4

5.4 Total Storage Required

This section presents the installed capacity of storage required for each scenario with renewables. Storage is necessary to be able to allow the supply of electricity throughout the day and not just on the availability of renewables. The load capacity of the storage is given as 4 hours which is the number of hours the battery will operate at its maximum power.

Table 6: Installed Storage Capacity Required

Total Installed Capacity of Storage (MW)							
Scenario	**2022**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Business As Usual	0	0	0	0	0	0	0
All Vehicles Transition to EVs with RE	0	80.0	172.5	358.6	447.2	469.2	473.2
Cars and SUVs transition to EVs with RE	0	20.4	93.2	115.4	132.5	157.4	166.8

Total Installed Capacity of Storage (MW)							
Scenario	**2022**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Commercial Buses Switched to EV with RE	0	54.3	59.4	59.4	61.0	61.0	63.1
Commercial Vehicles Transition To EV with RE	0	41.4	156.7	261.6	344.4	419.3	499.6
Government Vehicles transition to EV with RE	0	26.7	136.0	136.0	136.0	136.0	173.9
Private Vehicles Transition EVs with RE	0	28.5	78.7	97.7	108.1	152.9	273.9

5.5 Discussion of Results

Based on the results presented, the transition to EVs requires an additional 203 GWh of energy generation in 2030 to supply power for charging these EVs. The power requirements in the tables above do not consider the power demands of the other demand sectors nor does it account for any increase in demand for other demand sectors such as the residential, hotel sector, industrial sector and others.

The results show that an installed capacity of 455 MW of renewables is required to supply the generation capacity needed to supply the transition of the transport sector when compared to an installed capacity of 131 MW of fossil fuel generation.

It is therefore important that a careful and considerate approach is considered for the transition of the transport sector. In addition, Antigua and Barbuda should consider other forms of renewable energy generation where possible. Consideration can be given to the transmission lines across islands, noting that the island of Nevis a part of the Federation of St. Kitts and Nevis has explored and discovered great potential in geothermal energy which is a baseload renewable source.

6 Suggestions for Model Improvements

For the modelling in the software tools of LEAP, several assumptions were made. The model can be improved by reducing these assumptions with country-specific data. In addition, some recommendations are made below to improve the overall model.

- Improved country-specific data for emissions and fuel type
- Improved data on vehicle mileage and fuel economy
- Further optimization in the model for storage and renewable energy capacity

7 Recommendations

- Full island-wide assessment for solar PV potential should be undertaken to help improve the models.
- Suggestions for a phased approach to the EV transition considering the scenarios created in this model.

8 Conclusion

By building the model for Antigua and Barbuda within LEAP, the model is readily available for future updated mitigation assessments and NDC tracking for the transport sector targets. In addition, in-country experts were trained in using LEAP to ensure that the government retains the capacity to use the models.

9 References

[1] Government of Antigua and Barbuda, "Antigua and Barbuda Updated Nationally Determined Contribution," Government of Antigua and Barbuda, 2021.

[2] Government of Antigua and Barbuda, "Antigua and Barbuda Greenhouse Gas Inventory Report 2016-2019," Government of Antigua and Barbuda, 2023.

[3] Antigua Public Utilities Authority, "APUA," 2023. [Online]. Available: http://www.apua.ag/.

[4] Megapower, "Megapower," 2020. [Online]. Available: https://www.megapower365.com/services/charging-network/.

[5] C. Heaps, LEAP: The Low Emissions Analysis Platform [Software version: 2020.1.106], Somerville, MA: Stockholm Environment Institute, 2022.

[6] Antigua and Barbuda Transport Board, "Fuel Types for Motor Vehicles Registered in Antigua," Antigua and Barbuda Transport Board, St. John's Antigua, 2022.

[7] Antigua and Barbuda Statistics Division, Ministry of Finance and Corporate Governance, "Demographic and Macroeconomic Data," St. Johns, 2023.

[8] United Nations - World Population Prospects, "Antigua and Barbuda Population Growth Rate," 2023.

[9] International Monetary Fund (IMF), "IMF World Economic Outlook," 2023.

[10] C. S. I. (. SI), Transport Action Data Tool (TraCAD), Initiative for Climate Action Transparency (ICAT), 2023.

[11] International Renewable Energy Agency (IRENA), "Antigua and Barbuda: Renewable Energy Roadmap," International Renewable Energy Agency, Abu Dhabi, 2021.

[12] C. Analytics, "Antigua and Barbuda's National Greenhouse Gas Reduction Report," 2020.

[13] IRENA, "Technology plan for road transport electrification with renewables," International Renewable Energy Agency (IRENA), 2022.

[14] US Department of Energy, "www.fueleconomy.gov," US Department of Energy and US Environmental Protection Agency, 2023. [Online]. Available: https://www.fueleconomy.gov/.