Initiative for Climate Action Transparency Phase 2

Electric Mobility Transition Scenario Impact Assessment Report

Antigua and Barbuda

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Electric Mobility Transition Scenario Impact Assessment Report

Initiative for Climate Action Transparency – ICAT

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Table of Contents

List of Figures

List of Tables

Acronyms

ANB	Antigua and Barbuda
ABTB	Antigua and Barbuda Transport Board
CCMRVH	Caribbean Cooperative Measurement, Reporting and Verification Hub
CDM	Clean Development Mechanism
CIF	Cost, Insurance and Freight
CSI	Climate Smart Initiatives (Pvt) Ltd.
EV	Electric Vehicle
GDP	Gross Domestic Product
GHG	Greenhouse gas
GACMO	The Greenhouse Gas Abatement Cost Model
ICAT	Initiative for Climate Action Transparency
ICE	Internal Combustion Engine
IMF	International Monetary Fund
LEAP	Low Emissions Analysis Platform
NDC	Nationally Determined Contribution
SDG	Sustainable Development Goals
SEI	Stockholm Environment Institute
SIDS	Small Island Developing States
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
VAT	Value Added Tax
XCD	Eastern Caribbean Dollar

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, in its long-term ambition, to phase out the use of internal combustion engine (ICE) vehicles by 2040 [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.

This report presents the documentation of the methodology and assumptions used in the development of the transport models and the analysis of the results obtained from modelling tools. In addition, the report presents a comparison of the results of the tools, a brief analysis of the just transition of the transport sector and recommendations for improvement in the development of the models. These are presented via the following sections:

Section 2 – Electric Mobility Scenarios Used for Modelling
Section 3 –Methodological Approaches, Models & Tools Used;
Section 4 – Input Data and Assumptions;
Section 5 – Results and Analysis of Modelling Impact;
Section 6 – Just Transition Considerations for the Transport Sector;
Section 7 – Suggestions for Model Improvements;
Section 8 – Recommendations;
Section 9 – Conclusions.

2 Electric Mobility Transition Scenarios Used for Modelling

The electric mobility transition scenarios used in the modelling tools were all based on the targets provided by the Antigua and Barbuda Updated NDC report of 2021. **Table 1** describes the mitigation targets as described in the 2021 NDC. It should be noted that these targets are all considered conditional upon Antigua and Barbuda receiving sufficient climate finance to undertake actions to meet these targets. The scenarios developed were adjusted to the two modelling tools TraCAD and LEAP based on targets in Table 1 and highlighted in this section.

Table 1: NDC Mitigation Targets with Transport Actions [1]

	NDC Code	Targets	Completion Date	Year Communicated
Mitigation Targets	1	86% renewable energy generation from local resources in the electricity sector	2030	2021
	2	100% all new vehicle sales to be electric vehicles	2030	2021
	3	Explore the potential for emissions reductions in the waste sector	2025	2021
	4	Explore the potential for emissions reductions in the Agriculture, Forestry and Other Land Use (AFOLU) sector	2030	2021
Transport Related Targets	3a	Change fiscal policies on fossil fuel by 2025 to enable the transition to 100% renewable energy generation in the transportation sector	2025	2021
	3b	Ban on the importation of new internal combustion engine vehicles (with an indicative start year of 2025)	2030	2021
	3c	100% of government vehicles will be electric vehicles	2035	2021
	3d	Establish efficiency standards for the importation of all vehicles	2020	2015

2.1 Change fiscal policies on fossil fuel by 2025 to enable the transition to 100% renewable energy generation in the transportation sector (3a)

This target aims for the country to phase out fossil fuel use in the electricity sector by 2030 and in the transport sector by 2040. This target is directly linked to Mitigation Action 1 which targets eighty-six per cent (86%) of renewable energy generation from local resources in the electricity sector. The transition to one hundred (100%) renewable energy generation in the transportation sector is linked to the transition of the electricity grid to renewables.

The scenario developed based on this target was only analysed in TraCAD. The fiscal policy analysed in the TraCAD model is the impact of the increased levies on ICE vehicles which is expected to support the transition to electric vehicles. An increase of fifteen per cent (15%) of the levies on ICE vehicles was considered in the scenario developed related to this target.

A specific scenario related to fiscal policies was not analysed in the LEAP model, but an analysis was done of the impact of one hundred per cent (100%) renewables on the other scenarios analysed based on the other targets.

2.2 Ban on the importation of new internal combustion engine vehicles (with an indicative start year of 2025) by 2030 (3b)

This target aims to phase out the sale of ICE vehicles by 2030 with an overall ambition to transition the transport sector to electric vehicles by 2040. During the Transport Alignment workshop, the SLIM project indicated that the overall ambition for the transition of the transport sector was being considered over a period from 2040-2045.

The scenarios developed in LEAP analysed the gradual decline in sales of ICE vehicles from 2025 with the electric vehicle (EV) sales increasing in the same proportion, with the full transition of sales of ICE vehicles to EV vehicles by 2030. This analysis was used for the following scenarios:

- The complete ban on sales of all ICE vehicles,
- The complete ban on sales of ICE cars and Sports Utility Vehicles (SUVs) only,
- The complete ban on sales of ICE commercial buses only,
- The complete ban on sales of all ICE private/personal vehicles only and
- The complete ban on sales of all ICE commercial vehicles only.

In LEAP, each of these scenarios was analysed with the grid electricity supply as fossil fuel with minimal renewable energy penetration and consideration of one hundred per cent (100%) renewable energy supply to the electricity grid to power the transport sector.

In TraCAD, the modelling of the scenario considered was the transition of all stock of vehicles to electric vehicles by 2045. The 2045 year was compared to the 2040 year in the Updated NDC for the following reasons:

- The ICAT project is expected to work closely with the SLIM project, therefore the range provided in the SLIM project was 2040-2045, so the final year of the transition period was used in the analysis.
- In 2023, there are still limited options for the transition of electric trucks, therefore a 22-year period for a full transition will allow for more development in the EV space for suitable vehicles in that specific category.

2.3 100% of government vehicles will be electric vehicles by 2035 (3c)

This target aims to phase out all ICE Government vehicles to EVs by the year 2035. The scenario developed for this target used a similar analysis as the scenario developed for target 3b. In this case, only Government vehicles were considered.

In LEAP, the scenario was developed with an indicative ban on all purchases of all ICE vehicles by the Government from 2025 and a full ban on the purchase of ICE vehicles by 2030. All vehicles purchased from 2030 onwards were EVs and the vehicle stock was ensured to fully transition to EVs by 2035.

In TraCAD, the full stock of ICE Government vehicles was transitioned to electric vehicles by 2035.

2.4 Establish efficiency standards for the importation of all vehicles by 2020 (3d)

This target aims to establish standards for the importation of all vehicles. No specific scenarios with the use of this target were developed in either of the two tools. In TraCAD, the available methodologies for use were not compatible with the aim of the target on the establishment of energy efficiency standards and are explained in **Section 4** of the report. In LEAP, the establishment of energy efficiency standards for the importation of vehicles would be considered for only the sale of vehicles and was therefore considered as the standards for electric vehicles considered for the scenarios developed under target 3b.

3 Methodological Approaches, Models & Tools Used

This ICAT project focused on the transport sector and the GHG analysis of the transition of the transport sector to electric vehicles. To conduct this analysis, a review of the modelling tools available was conducted and documented in the Transport Tool Selection Justification Report contained in **ANNEX 1**. As a result of this analysis, two modelling tools were selected as suitable based on their appropriateness for use in the Antigua and Barbuda context. The modelling tools selected were the following:

- Low Emissions Analysis Platform (LEAP) - This tool is used for integrated energy planning and climate change mitigation assessment. It 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].

- ICAT Transport Climate Action Data Tool (TraCAD) - This ICAT tool was developed for transport sector data collection, policy impact assessment and tracking, and mitigation cost analysis. TraCAD provides a consistent and structured approach to data collection and assessment, which should improve the credibility of the impact evaluation of policies and actions to boost the country's capacity to meet its national climate and sustainable development targets, as well as provide the required information to deliver high-quality reporting under the Paris Agreement [3].

The transport analysis is only focused on road transport. This is because the appropriate transition technologies for marine and air transport to electric vehicles are mainly in their infancy stages and the data required to assess these sectors were not readily available for Antigua and Barbuda.

The data needs for both tools were identified and data available in Antigua and Barbuda were sourced as inputs to the model. The details of data used in the model development can be found in **Section 4** 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.

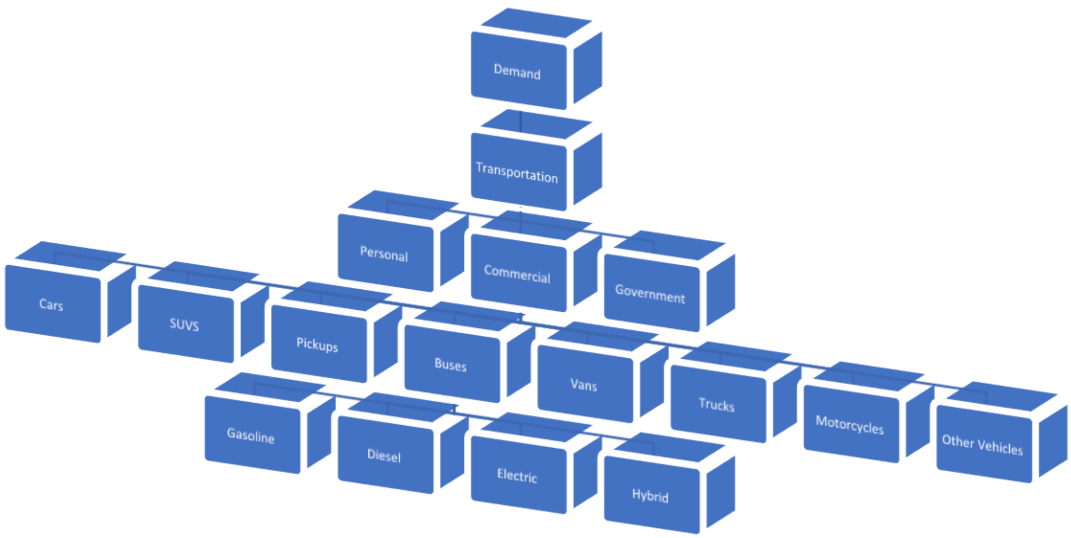
The methodology used for the development of the models for modelling tools is described below in this section.

3.1 Low Emissions Analysis Platform (LEAP)

The Low Emissions Analysis Platform (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.

For this project, the tool was used to analyse the road transport sector for Antigua and Barbuda. To undertake this analysis a stock turnover analysis was undertaken in LEAP. The stock turnover is a detailed analysis of the transport sector that 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 is required, a survival profile of vehicles. The vehicles were grouped into branches as defined in **Figure 1**. 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 4.**

Figure 1: Labels of Transportation Branches in LEAP



The GHG emissions for the transport sector analysis were calculated using the following equations in the LEAP model.

Equation 1: Equations used in the LEAP model.

$$Stock_{t,y,v} = (Sales_{t,v} \times Survival_{t,y-v})$$
$$Stock_{t,y} = \sum_{0..y} Stock_{t,y,z}$$
$$FuelEconomy_{t,y,v} = (FuelEconomy_{t,v} \times FeDegradation_{t,y-v})$$
$$Mileage_{t,y,v} = (Mileage_{t,v} \times MIDegradation_{t,y-v})$$
$$EnergyConsumption_{t,y,v} = (Stock_{t,y,v} \times Mileage_{t,y,v} \times FuelEconomy_{t,y,v})$$
$$Emission_{t,y,v,V} = (EnergyConsumption_{t,y,v} \times EmissionFactor_{t,y,p} \times EmDegradation_{t,y-v,p})$$

Where:

t is the type of vehicle (i.e. the technology branch)
v is the vintage (i.e. the model year)
y is the calendar year
p is any criteria for air pollutant

T is the number of types of vehicles
V is the maximum number of vintage years which is determined automatically from the survival lifecycle profile
Sales: Is the number of vehicles added in a particular year
Stock: is the number of vehicles existing in a particular year
Survival: is the fraction of vehicles surviving after a number of years which is entered as the lifecycle profile
Fuel Economy is fuel use per unit of vehicle distance travelled.
FeDegradation: this is a factor representing the decline in fuel economy as a vehicle ages.
Mileage: is the annual distance travelled per vehicle
MIDegradation: is a factor representing the change in mileage as the vehicle ages.
Emissionfactor: the emission rate for pollutants.
EmDegradation: is a factor representing the change in the emission factor for pollutants as the vehicle ages [4]

Forward-looking mitigation scenarios were created as described in **Section 2** for the transportation sector from 2023 to 2030 and 2050 to project GHG emissions over these time frames. In addition, another forward-looking scenario called a baseline scenario or business-as-usual that reflects emissions based on currently implemented policies and strategies was created. This baseline scenario shows a hypothetical scenario assuming that no changes to the current policies for the transportation sector are implemented. This scenario considers the implications of demographic and macroeconomic changes on the transportation sector without additional policies.

3.2 ICAT Transport Climate Action Data Tool (TraCAD)

TraCAD is an online software tool that features standard methodologies, calculations, and reporting. TraCAD assessments allow users to create climate actions including relevant information for each action and facilitate data collection and entry from different stakeholders. The climate action data entered can then be used to produce GHG impact assessments and marginal abatement cost assessments which give details on the overall environmental and financial impact of the implementation of the different climate actions. TraCAD was used to model three (3) of the four (4) key transport-related NDC targets as highlighted in **Section 2**. The standardized methodologies used were available within the tool. These include ICAT transport pricing and Clean Development Mechanism (CDM) methodologies.

Based on the assessment of the targets defined in **Section 2** and the relevant scenario development which in the case of TraCAD is called climate action the most appropriate calculation methodology was selected. Noting that TraCAD is a recently developed tool and the timeframe for conducting the assessment was limited, the methodologies selected were all found within the tool and no new methodologies were created or added to undertake this assessment.

Table 2 highlights the various methodologies used for the GHG impact assessment for each climate action.

Table 2: Methodologies used for TraCAD modelling.

NDC Target	Methodology
Change fiscal policies on fossil fuel by 2025 to enable the transition to 100% renewable energy generation in the transportation sector (3a)	ICAT Transport Pricing Methodology: Assessing the GHG impacts of transport pricing policies
Ban on the importation of new internal combustion engine vehicles (with an indicative start year of 2025) by 2030 (3b)	

NDC Target	Methodology
100% of government vehicles will be electric vehicles by 2035 (3c)	AMS-III.C Small Scale Methodology: Emissions reductions by electric and hybrid vehicles

3.2.1 ICAT Transport Pricing Methodology [6]

This methodology is provided by one of the policy and action impact assessment guides developed by ICAT. Specifically, these guides were created to assess GHG, sustainable development and transformational impacts of a policy and to do so in an integrated and consistent way within a single impact assessment process. The ICAT Transport Pricing methodology is used to specifically assess the GHG impacts of pricing policies in the transport sector. It provides step-by-step guidance on the assessment of the impact of the following types of transport pricing policies:

- **Fuel subsidy removal**: The removal of subsidies which reduce the price of vehicle fuel below its fair-market cost.
- **Increased fuel tax or levy**: An increase of the tax imposed on each unit of vehicle fuel.
- **Road pricing (road tolls and congestion pricing)**: Motorists pay directly for driving on a particular roadway in a particular area.
- **Vehicle purchase incentives for more efficient vehicles**: Governments increase the fuel efficiency of the vehicle fleet and/or promote a shift to lower-carbon fuels by providing incentives for the purchase of selected vehicles.

The methodology involves 4 key stages for conducting an assessment, highlighted in ***Figure 2*** below.

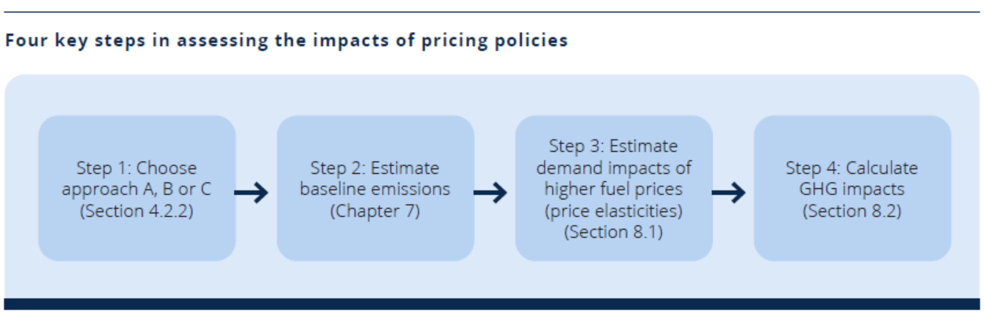


Figure 2: Four key steps in assessing the impacts of pricing policies.

It is applicable to policies at any level of government in all countries or regions, policies in any phase of development (planned, adopted, or implemented), and new or modified policies. The methodology covers three main approaches, which vary based on their data requirements, boundaries, and scope, as shown in ***Figure 3***. For the purpose of this assessment, Approach C was determined to be the most appropriate based on the available data, desired fuel types and scope of the assessment.

		Boundaries and coverage		
Approach	Data requirements	Geographical system boundaries	Passenger/freight	Fuel types
A	Only general fuel consumption data (Basis for calculation: top-down energy-use data)	National, subnational or municipal	Ground transport (passenger and freight)	Fuel mix (unspecified mix of gasoline, diesel and/or other transport fuels)
B	Specific gasoline and diesel consumption data (Basis for calculation: top-down energy-use data)	National, subnational or municipal	Ground transport (passenger and freight)	Gasoline and diesel
C	Comprehensive bottom-up travel activity data (e.g. distance travelled by mode j) (Basis for calculation: top-down energy-use data and bottom-up travel activity data)	Regional, urban	Only passenger transport in an urban context However, the assessment can be conducted for several (large) cities to enable a more extensive geographical coverage	Gasoline, diesel and electricity

Figure 3: Overview of approaches covered by the methodology.

Once the most appropriate approach was identified, a projection of baseline emissions was estimated. This was done by first estimating the base year emissions, the base year is the year in the assessment from which the projection will be made into the future. ***Figure 4*** highlights the key formulae used during the estimation of the baseline emissions.

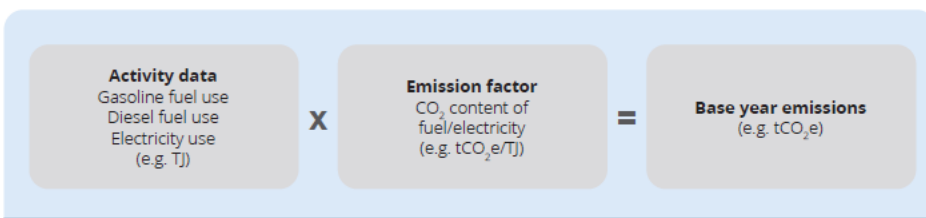


Figure 4: Base year CO2 emissions calculation for Approach C

Note that the base year for this assessment did not align with the base year of the NDC, which was 2006 as all the relevant data was not available for that year. In addition, it was useful to align the start year and final of the projections to the start year and final year of the NDC target. The input data used for the assessments is highlighted in **Section 4**.

The effects of the policy change were analysed in the year 2026, noting that the expected completion year of this NDC target was given as 2025, as highlighted in **Section 2.** An ex-ante assessment was carried out with the use of price elasticity values to predict changes in transport demand and GHG emissions reductions compared with the projected baseline emissions obtained. The result of this assessment is described in **Section 5**. In this assessment only carbon dioxide (CO_2) emission is included, all other emissions are excluded from the assessment.

3.2.2 AMS-III.C Small Scale Methodology: Emissions reductions by electric and hybrid vehicles [7]

This methodology was developed by the United Nations Framework Convention on Climate Change (UNFCCC) for assessing CDM project activities to assess the emission reduction as a result of the displacement of fossil fuel through the introduction of electric and/or hybrid vehicles.

This methodology was used to estimate the emissions reduction that would occur when the vehicle fleet was converted from petrol & diesel driven vehicles to EVs in a specified year. The methodology features two main approaches to calculating baseline and project emissions:

- Approach 1: Using distance travelled by project vehicles.
- Approach 2: Using the electricity used to charge the vehicles.

For the assessment of both climate actions 3B & 3C, approach 1 was used in both the baseline and project scenarios. The following calculations shown in ***Figures 5, 6, 7 and 8*** were completed within the software to complete the assessments. An ex-ante assessment was completed with additional assumptions as highlighted in **Section 4.**

$$BE_y = \sum_i EF_{BL,km,i} \times DD_{i,y} \times N_{i,y} \times 10^{-6} \qquad \text{Equation (1)}$$

Where:

BE_y	=	Total baseline emissions in year *y* (t CO_2)
$EF_{BL,km,i}$	=	Emission factor for baseline vehicle category *i* (g CO_2/km)
$DD_{i,y}$	=	Annual average distance travelled by project vehicle category *i* in the year *y* (km)
$N_{i,y}$	=	Number of operational project vehicles in category *i* in year *y*

Figure 5: Baseline Emissions Calculation using Approach 1

$$EF_{BL,km,i} = SFC_i \times NCV_{BL,i} \times EF_{BL,i} \times IR^t \qquad \text{Equation (3)}$$

Where:

SFC_i	=	Specific fuel consumption of baseline vehicle category *i* (g/km)
$NCV_{BL,i}$	=	Net calorific value of fossil fuel consumed by baseline vehicle category *I* (J/g)
$EF_{BL,i}$	=	Emission factor of fossil fuel consumed by baseline vehicle category *i* (g CO_2/J)
IR^t	=	Technology improvement factor for baseline vehicle in year *t*. The improvement rate is applied to each calendar year. The default value of the technology improvement factor for all baseline vehicle categories is 0.99
T	=	Year counter for the annual improvement (dependent on age of data per vehicle category)

Figure 6: Emission Factor Calculation for baseline vehicle.

$$PE_y = \sum_i EF_{PJ,km,i,y} \times DD_{i,y} \times N_{i,y} \qquad \text{Equation (4)}$$

Where:

PE_y	=	Total project emissions in year *y* (t CO_2)
$EF_{PJ,km,i,y}$	=	Emission factor per kilometre travelled by the project vehicle type *i* (t CO_2/km)
$N_{i,y}$	=	Number of operational project vehicles in category *i* in year *y*
$DD_{i,y}$	=	Annual average distance travelled by the project vehicle category *i* in the year *y* (km)

Figure 7: Project Emissions Calculation using Approach 1

$$EF_{PJ,km,i,y} = \sum_i SEC_{PJ,km,i,y} \times EF_{elect,y}/(1 - TDL_y) \times 10^{-3} + \sum_i SFC_{PJ,km,i,y} \times NCV_{PJ,i} \times EF_{PJ,i} \times 10^{-6}$$

Equation (6)

Where:

$SEC_{PJ,km,i,y}$	=	Specific electricity consumption by project vehicle category *i* per km in year *y* in urban conditions (kWh/km)
$EF_{elect,y}$	=	CO_2 emission factor of electricity consumed by project vehicle category *i* in year *y* (kg CO_2/kWh)
$SFC_{PJ,km,i,y}$	=	Specific fossil fuel[3] consumption by project vehicle category *i* per km in year *y* in urban conditions (g/km)
$EF_{PJ,i}$	=	CO_2 emission factor of fossil fuel consumed by project vehicle category *i* in year *y* (g CO_2/J)
$NCV_{PJ,i}$	=	Net calorific value of the fossil fuel consumed by project vehicle category *i* in year *y* (J/g)
TDL_y	=	Average technical transmission and distribution losses for providing electricity in the year *y*

Figure 8: Emissions factor calculation for project vehicles.

4 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 and TraCAD are described in this section.

4.1 Common Input Data and Assumptions

To ensure that there was some comparability between the two tools, the input data and assumptions for the following areas were commonly used.

4.1.1 Demographic Data

Demographic data is an important non-policy driver that can influence the growth of the transportation sector. In both TraCAD and LEAP, the population was used in the modelling. The historical population data was obtained from the Antigua and Barbuda Statistics Division, Ministry of Finance and Corporate Governance. This data was available from the year 2000 to the year 2026. Although United Nations (UN) data was available up to the year 2050, the locally obtained data was used in this analysis.

In addition to the historical population, the projected population data was also required for the modelling. The population growth data was used to obtain the projection up to 2050 for the modelling analysis. The population growth data was obtained from the Antigua and Barbuda Statistics Division up to 2026 and then data from the UN population projections from 2027 to 2050. The historical and projected population is shown in **Figure 9**, this graph was obtained from the LEAP model. The complete population and population growth data sets can be found in **Section 9.1.**

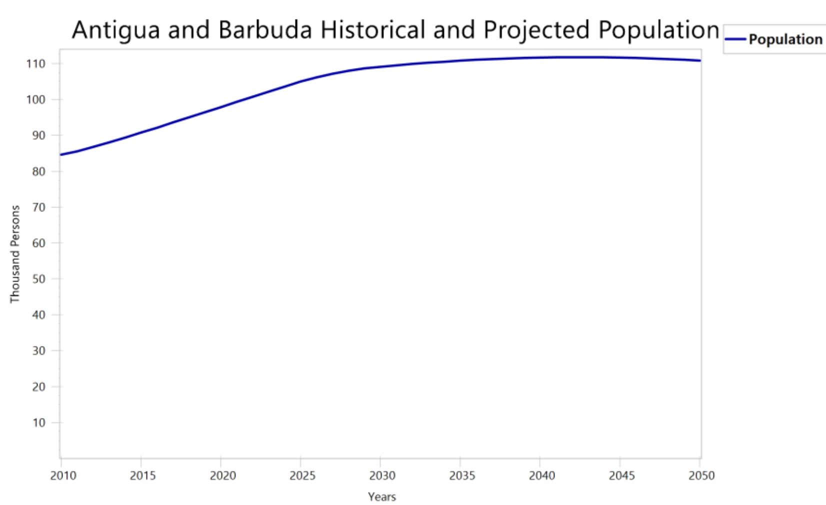


Figure 9: Antigua and Barbuda Historical Population [8] [9] [4]

4.1.2 Macroeconomic Data

Similar to demographic data, macroeconomics is an important non-policy driver that can be used to project trends in the transportation sector. The National Gross Domestic Product (GDP) data was obtained from the Antigua and Barbuda Statistics Division, Ministry of Finance and Corporate Governance at constant 2006 prices in million Eastern Caribbean Dollars (XCD). The historical GDP data was obtained from 1977 to 2021 and projection was used based on GDP growth rate obtained from the IMF World Economic Outlook for 2022 -2028. It should be noted that beyond 2028, an annual constant growth rate of 2.7% was applied to obtain the projected GDP for 2050.

In TraCAD the option was available to use either population or macroeconomic data as drivers for the projections. In LEAP macroeconomic data was used as drivers for projections for commercial and government vehicles. The historical and projected GDP is shown in **Figure 10**, this graph was obtained from the LEAP model. The complete GDP and GDP growth data sets can be found in **Section 9.1.**

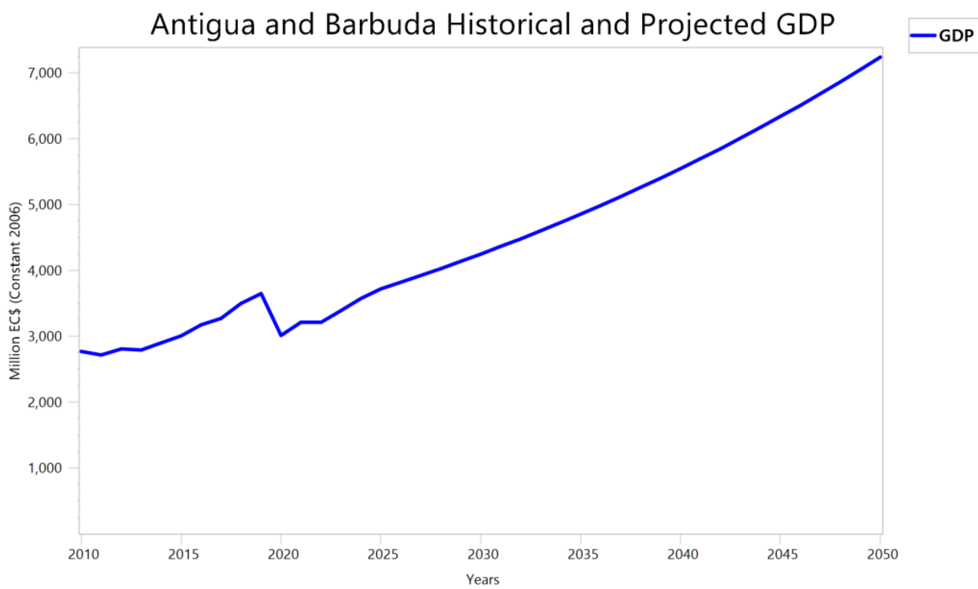


Figure 10: Antigua and Barbuda Historical and Projected GDP [8] [10]

4.1.3 Road Transport Data

The transport data obtained refers to fuel use and registered vehicles for on-road transportation. 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 team. The full data set for transport data can be found in **Appendix 9.2 Transport Data**.

- **Vehicle Stock Data**

The total registered vehicles and type of vehicles were obtained from the year 2011 to 2022 from the ABTB. The trend curve was extrapolated to obtain data for 2010. The vehicle data was split into categories as described in **Figure 1.** **Figure 11** and **Figure 12** show the values for the registered vehicles distributed by categories of Personal, Commercial and Government and the vehicles distributed by vehicle types such as cars, SUVs, trucks etc. The full data set for transport data can be found in **Appendix 9.2 Transport Data**

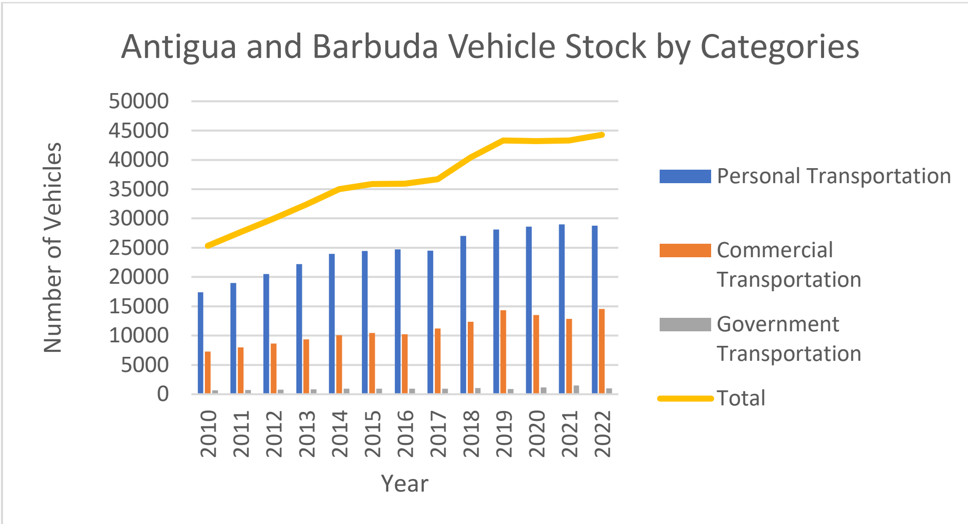


Figure 11: Antigua and Barbuda Vehicle Stock by Categories

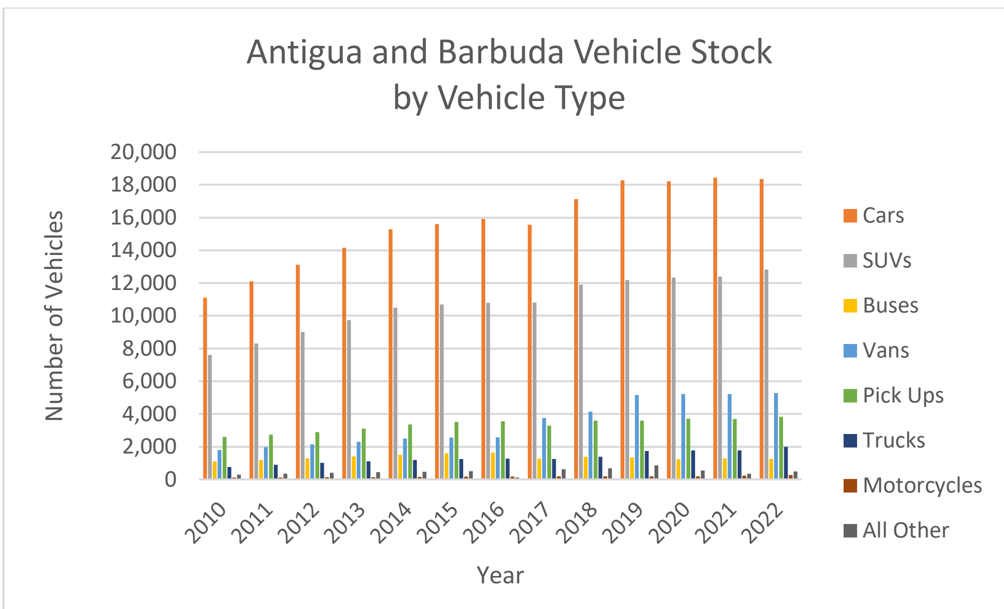


Figure 12: Antigua and Barbuda Vehicle Stock by Vehicle Type

- **Vehicle Sales Data**

The total vehicle sales were assumed to be equal to the newly registered vehicles. This data, however, was only available for the years 2015 to 2019. Using the trend obtained from the registered vehicles and the trend for the newly registered vehicles, the data was analysed and extrapolated to develop suitable sales data for 2021 to 2022. **Figure 13** and **Figure 14** show the values for the vehicle sales, distributed by categories of Personal, Commercial and Government and the vehicle distributed by vehicle type such as cars, SUVs, trucks etc. The full data set for transport data can be found in **Appendix 9.2 Transport Data.**

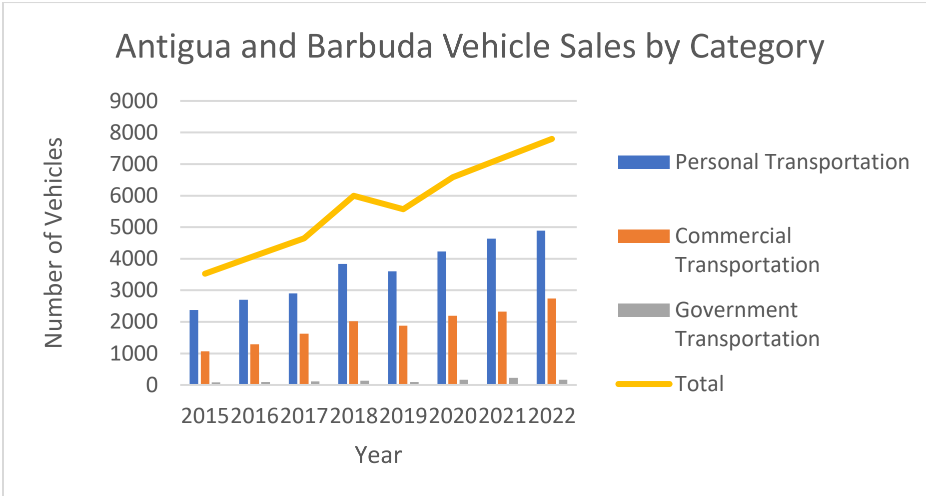


Figure 13: Antigua and Barbuda vehicle sales by category.

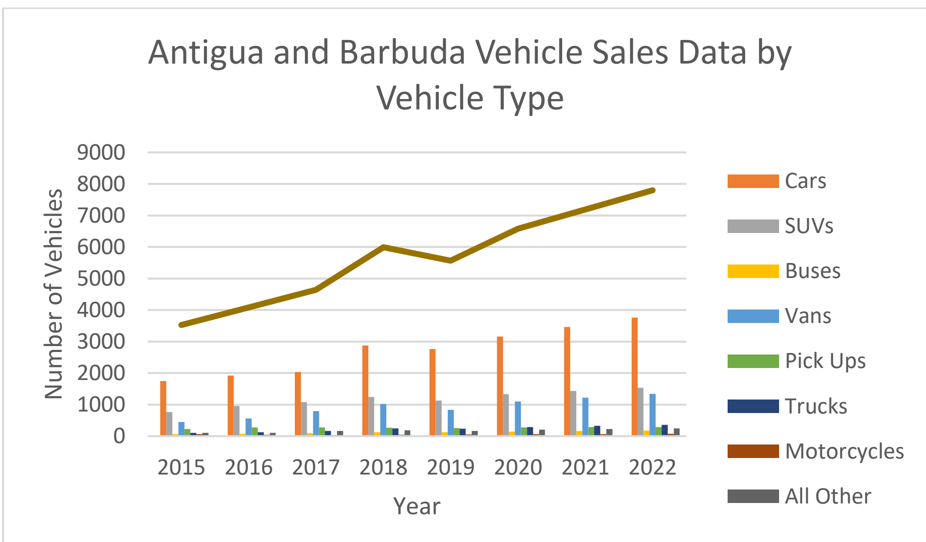


Figure 14: Antigua and Barbuda vehicle sales by vehicle type.

- **Vehicle Mileage Data**

The vehicle mileage is the average annual distance travelled by a type of vehicle. This mileage was estimated based on data from the SLIM project on daily mileage by Government Officers, regional data, data used in phase I of the ICAT project and data obtained from the Antigua and Barbuda: IRENA's Renewable Energy Roadmap [11], Antigua and Barbuda's National Greenhouse Gas Reduction Report [12] and Antigua and Barbuda: IRENA Technology plan for road transport electrification with renewables [13] done under the SLIM project. The final mileage ensured consistency across the previously mentioned data sources and consistency with the total fuel consumption in the transport sector which was estimated from data supplied by West Indies Oil

Company (WIOC). It was assumed that the fuel type of the vehicle does not affect the vehicle mileage, therefore an electric, hybrid, gasoline and diesel vehicle of each type travels the same distance annually. **Table 3** below shows the final mileage used in the models. The full data set for transport data can be found in **Appendix 9.2 Transport Data.**

Table 3: Vehicle Mileage Data by Vehicle Type and Categories

Vehicle Type	Private	Commercial	Government
	Distance in kilometres travelled		
Cars	10,000	25,000	10,000
SUVs	10,000	25,000	10,000
Buses	30,000	35,000	25,000
Vans	20,000	30,000	20,000
Pick Ups	10,000	25,000	15,000
Trucks	30,000	35,000	25,000
Motorcycles	20,000	25,000	10,000
All Other	10,000	13,000	6,000

- **Vehicle Fuel Economy**

The fuel economy of a vehicle is the unit of fuel used per distance travelled. In this analysis, the data on the type of ICE vehicles in the country was analysed and the most common vehicle of each type including fuel considerations was used to obtain the average fuel economy for the vehicle type and fuel use. The fuel economy was obtained from various online sources and data collected by the SLIM project and the final values used are displayed in **Table 4**. The full data set for transport data can be found in **Appendix 9.2 Transport Data** with justification and explanations of the vehicle used for reference of the fuel economy and source of information**.**

Table 4: Fuel Economy for Vehicle Types and Fuel Use [14]

Vehicle Type	Fuel	Fuel Economy	
		MPG	L/100km
Cars	Gasoline	32	7.35
	Diesel	31.3	7.51
	hybrid	41	5.73
	electric	34kWh/100mi	21.14 kWh/100km
SUVs	Gasoline	25	9.4
	Diesel	24	9.8
	hybrid	39	6.03
	electric	36kWh/100mi	22.32 kWh/100km
	Electric (small SUV)	30kWh/100mi	18.6kWh/100km
Buses	Gasoline	18.96	12.4
	Diesel	29.4	8

Vehicle Type	Fuel	Fuel Economy	
	hybrid	37.9	8.06
	electric	109kWh/ 100mi	67.6kWh/100km
	electric minibus	40kWh/100mi	25kWh/100km
Vans	Gasoline	22.4	10.5
	Diesel	22.19	10.6
	hybrid	33.6	7
	electric	40kWh/100mi	25kWh/100km
Pickups	Gasoline	21	11.2
	Diesel	23.5	10
	hybrid	24	9.8
	electric	69.2kWh/100 mi	42.9kWh/ 100km
Trucks	Gasoline	6.4	36.75
	Diesel	7.5	31.36
	hybrid	7.5	31.36
	electric	322kWh/100mi	200kWh/ 100km
Motorcycles	Gasoline	36.7	6.4
	electric		8.2kWh/ 100 km
All Other	Gasoline	6.4	36.75
	Diesel	7.5	31.36
	hybrid	7.5	31.36
	electric	322kWh/100mi	200kWh/ 100km

❖ **Vehicle Costs**

- The cost of vehicles in Antigua and Barbuda was determined by a survey of vehicle retailers on the island. The final cost of the vehicles was averaged based on the data received in the country and analysed for compatibility from the datasets on vehicle costing found in Antigua and Barbuda: IRENA Technology plan for road transport electrification with renewables [13] completed under the SLIM project. The price of vehicles contained in **Table 5** considers that all taxes and duties applicable to vehicles are paid including the environmental levy. The duties and taxes imposed on vehicles are determined by the applicable tariff code and the customs procedure code and include the following:
    - Customs Duties on the Cost, Insurance and Freight (CIF) value of the vehicle, average 20%.
    - Environmental Levy
        - Vehicles up to 1 year - XCD 1,000 or USD 370
        - Used vehicles over 1 year - XCD 4,000 or USD 1480
    - Value-added tax (VAT) of 15%

The full data set for transport data can be found in **Appendix 9.2 Transport Data.**

Table 5: Capital cost of vehicles in Antigua and Barbuda in USD

Cost of Vehicles in USD			
The final cost used in the model	**Fossil fuel**	**Hybrid**	**EV**
Cars	33126	36126	44352
SUVs	47603	50603	51161
Pickup	60731	63731	73731
Bus	59627	62627	72627
Vans	47113	52113	62113
Motorcycles	2500		5000
Other vehicles	101218	104218	119218
Trucks	101218	104218	114218

- **Vehicle Emissions Factor**

The emission factors used for vehicles are dependent on the type of fuel used. The fuels used in the transport sector in Antigua and Barbuda are motor gasoline and diesel oil. Hybrid vehicles are assumed to use motor gasoline and electricity. The emission factors used were default values for Tier 1 emission factors for road transport from the IPCC guidelines and to ensure comparability to the emission factors used in the development of the 2016-2019 GHG Inventory. **Table 6** shows the emission factors used in the modelling tools.

Table 6: Emission Factors for the transport sector

Emission Factors						
	Values used in TraCAD			Values Used in LEAP		
	Heating Values	**CO_2**		**CO_2**	**CH_4**	**N_2O**
Units	TJ/Gg	kg/tonne	Kg/TJ	kg/TJ		
Diesel oil	43	3186.3	74100	74100	3.9	3.9
Motor Gasoline	44.3	3069.99	69300	69300	33	3.2

- **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%.

4.2 Input Data and Mitigation Scenario Assumptions in LEAP

In addition to the data and assumptions listed in **Section 4.1**, to complete the modelling for the transport sector the following input data and assumptions were required.

4.2.1 Further Input Data for LEAP

- **Vehicle Lifecycle Profile**

To undertake a stock turnover analysis in LEAP the age profile of the stock of vehicles is required. The vehicle life cycle profile for the age of vehicle stock was obtained from the average age of vehicle stock for data range from 2015-2020 obtained from ABTB. **Figure 15** shows the average age profile of the vehicle stock in Antigua and Barbuda. The age profile indicates that vehicles as old as twenty-five (25) years are currently registered on the island. The majority of vehicles are within the one (1) to ten (10) years age range with the highest value being five (5) years. The full data set for transport data can be found in **Appendix 9.2 Transport Data.**

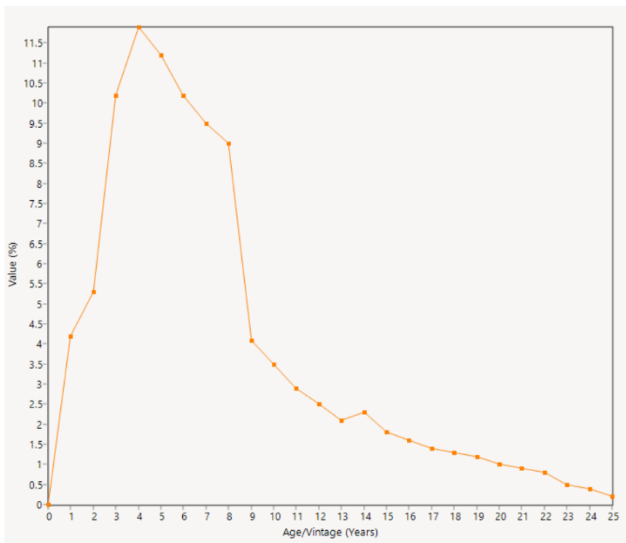


Figure 15: Antigua and Barbuda Existing Stock Profile

- **Vehicle Survival Profile**

The vehicle survival profile represents the fraction of vehicles surviving after a number of years. The survival profile for vehicles was completed based on the stock profile of vehicles and assumed that some vehicles would last for 25 years. The majority of vehicles would not survive past twelve (12) years. This lifecycle profile was used for all the vehicle categories.

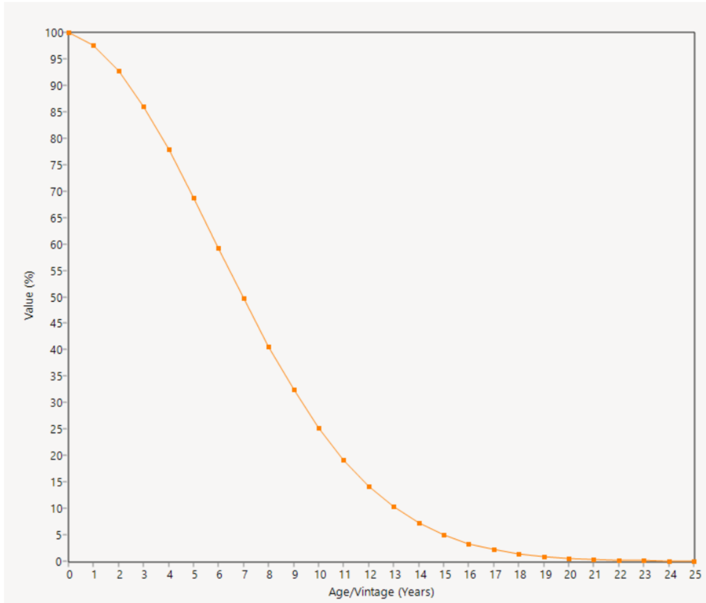


Figure 16: Antigua and Barbuda Vehicle Survival Profile [4]

❖ Additional Demographic Data

In addition to the population data, which was included in both models, the following demographic data was also added to the LEAP model:

- Population Growth Rates
- Household Size
- Number of Households
- Number of males
- Number of females
- Male population by age
- Female population by age

It should be noted that this data was not used in the modelling for the transport sector but was included in the LEAP model for data storage and possible drivers when the model is revised. The complete demographic data sets can be found in **Section 9.1**

❖ Additional Economic Data

In addition to the GDP data which was described in **Section 4.1.2**, the following data was included in the model:

- GDP Growth rate
- GDP per Capita
- Sectoral Contributions to GDP
- Sectoral GDP

This additional data was not used in the modelling for the transport sector but was included in the LEAP model for data storage and possible drivers when the model is revised. The complete economic data sets can be found in **Section 9.1.**

❖ Power Sector Data

The transport sector for Antigua and Barbuda is currently fossil fuel-based. In an effort to reduce GHG emissions, Antigua and Barbuda has introduced targets for the increased penetration of EVs. EVs use electricity and it was assumed that these vehicles' main source of power would be the main electricity grid. 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 7** shows the input variables for the power sector used in the LEAP model.

Table 7: Power plant data entered for LEAP.

<table>
<tr><th>Plant Type</th><th>Feedstock</th><th>Generating Capacity (MW) (2022)</th><th>Efficiency (%)</th><th>Merit Order</th><th>Maximum Availability (%)</th></tr>
<tr><td>Thermal Plant APUA Wadadli</td><td>Residual Fuel Oil</td><td>0</td><td>40</td><td>2</td><td>100</td></tr>
<tr><td>Thermal Plant APC Crabbs</td><td>Residual Fuel Oil</td><td>60.3</td><td>40</td><td>2</td><td>100</td></tr>
<tr><td>Thermal Plants APC Black Pine</td><td>Residual Fuel Oil</td><td>30.4</td><td>40</td><td>2</td><td>100</td></tr>
<tr><td>Utility Solar airport</td><td>solar</td><td>3</td><td>100</td><td>1</td><td rowspan="5">Based on the yearly shape of solar availability for Antigua and Barbuda</td></tr>
<tr><td>Utility Solar Bethesda</td><td>solar</td><td>4</td><td>100</td><td>1</td></tr>
<tr><td>Barbuda Plant</td><td>solar</td><td>1</td><td>100</td><td>1</td></tr>
<tr><td>Distributed Solar</td><td>solar</td><td>2.5</td><td>100</td><td>1</td></tr>
<tr><td>Additional Solar Plants</td><td>solar</td><td>0</td><td>100</td><td>1</td></tr>
<tr><td>Liquified Natural Gas (LNG) Plant</td><td>Natural Gas</td><td>0</td><td>40</td><td>2</td><td>100</td></tr>
<tr><td>Wind farms</td><td>wind</td><td>0</td><td>100</td><td>1</td><td>100</td></tr>
</table>

❖ Baseline Projection

The baseline projections for the key assumptions are described in **Section 4.1.** The projections in the transport sector were separated by categories and vehicle type and different drivers were used to project the increase in the vehicle stock for future years. For cars and SUVs in personal transportation, there is expected to be a decline in the sale of diesel vehicles and hybrid vehicles are expected to increase in numbers. This trend is based on global patterns and expert judgment. For commercial vehicles, the growth in vehicle sales is expected to increase with GDP growth with an elasticity of 0.1 and Government vehicle sales are expected to increase with an elasticity of 1.5 of the GDP growth. An elasticity of less than one (1) indicates that the growth is slower than the current growth rate and an elasticity of more than one (1) indicates that the growth is faster than the current rate.

Table 8: Baseline Projection Drivers

Vehicle Category	Driver
Personal Transportations	Population
Commercial Transportation	GDP
Government Transportation	GDP

For the power sector, an additional 30 MW of LNG is added by 2030 to meet the expected demand. However, the electricity requirements are expected to remain unchanged in the baseline with production from some renewables but mainly from fossil fuels. In the model, solar power is given priority for distribution and the EV penetration is very small, then, it is assumed that EVs introduced in the baseline would be mainly powered by renewables and not fossil fuel production.

❖ **Mitigation Scenarios**

In LEAP scenarios were developed under two NDC targets.

Target: Ban on the importation of new internal combustion engine vehicles

The following scenarios were developed:

1. The complete ban on sales of all ICE vehicles with the power sector operating with the current grid (mainly fossil fuels).
2. The complete ban on sales of all ICE vehicles with the power sector operating on 100% renewables.
3. 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).
4. The complete ban on sales of ICE cars and Sports Utility Vehicles (SUVs) only with the power sector operating on 100% renewables.
5. The complete ban on sales of ICE commercial buses only, with the power sector operating with the current grid (mainly fossil fuels).
6. The complete ban on sales of ICE commercial buses only, with the power sector operating on 100% renewables.
7. The complete ban on sales of all ICE private/personal vehicles only, with the power sector operating with the current grid (mainly fossil fuels)
8. The complete ban on sales of all ICE private/personal vehicles only, with the power sector operating on 100% renewables.
9. The complete ban on sales of all ICE commercial vehicles only, with the power sector operating with the current electricity grid (mainly fossil fuels)
10. The complete ban on sales of all ICE commercial vehicles only, with the power sector operating on 100% renewables.

In these scenarios the following assumptions were made:

1. 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.
2. The ban on sales of ICE vehicles is implemented for both new and used vehicles.
3. The ICE vehicles would be proportionally replaced with a suitable EV of the same type.
4. 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.
5. The model will indicate when the stock of ICE vehicles will be depleted based on the survival profile.
6. The current grid situation assumes a renewable energy penetration of 12.3% in 2022 with the operationalization of a 30MW Liquified Natural Gas (LNG) plant in the year 2030.
7. 100% renewables involve the use of only solar for operations with the addition of a 100MW solar plant in 2030 and a growth of 4% of distributed solar. All the fossil fuel plants will be decommissioned by 2030. Therefore, vehicles can only be charged during the period when the solar plants are operational. No LNG plants are installed in these scenarios.
8. All fossil-fueled vehicles including hybrid vehicles are transitioned to electric vehicles.

Target: 100% of government vehicles will be electric vehicles by 2035

The following scenarios were developed:

1. The complete ban on sales of all ICE Government vehicles with the power sector operating with the current grid situation (mainly fossil fuels).
2. The complete ban on sales of all ICE Government vehicles with the power sector operating on 100% renewables.

In these scenarios the following assumptions were made:

1. 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.
2. The ICE vehicles would be proportionally replaced with a suitable EV of the same type.
3. 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.
4. The survival profile 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.
5. The survival profile is also applicable to electric vehicles, once 7 years are achieved, they would need to be placed or sold.
6. The current grid situation assumes a renewable energy penetration of 12.3% in 2022 with the operationalization of a 30 MW Liquified Natural Gas (LNG) plant in the year 2030.
7. 100% renewables involve the use of only solar for operations with the addition of a 100MW solar plant in 2035 and a growth of 4% of distributed solar. All the fossil fuel plants will be decommissioned by 2030. Therefore, vehicles can only be charged during the period when the solar plants are operational. No LNG plants are installed in these scenarios.
8. All fossil-fueled vehicles including hybrid vehicles are transitioned to electric vehicles.

4.3 Input Data and Mitigation Scenario Assumptions in TraCAD

The TraCAD software utilizes various methodologies to calculate emissions reduction, such as from the UNFCCC under the Clean Development Mechanism (CDM) and ICAT.

Based on the methodologies chosen, the specific data requirements varied by climate action. They are as follows:

- ❖ **Climate Action: 3A – Change fiscal policies on fossil fuel by 2025 to enable the transition to 100% renewable energy generation in the transportation sector.**

Methodology: ICAT Methodology for Vehicle Purchase Incentives for More Efficient Vehicles

Input Data & Sources:

Table 9: Input data and sources for climate action 3a

Input Data	**Source**
Emission Factors (Petrol, Diesel)	See **Section 4.1**
Vehicle Occupancy Rate	SLIM Project Data and Expert Judgement
Net Calorific Value (Petrol, Diesel)	See **Section 4.1**
Fuel Densities (Petrol, Diesel)	Engineering Toolbox [15]
Specific Fuel Consumption	See **Section 4.1**
Vehicle Stock & Mileage Data (2022)	See **Section 4.1**
Vehicle Cost and Tax Data	See **Section 4.1**

Assumptions:

- The model assumes that there will be a 15% increase in import levies for used vehicles older than 1 year old at the end of 2025 (the impact of this policy assessed in 2026).
- The model assumes that there is no price difference for disposal when comparing newer and older vehicles.
- The model also assumes that all newly registered cars in the transport data are equal to used imported vehicles for this analysis.
- This policy incentive was modelled on data of the most common vehicle type, passenger cars. This was a result of the limitation of the methodology used and it was assumed that the data obtained would be reflective of the effectiveness of the policy for other vehicle types.
- Number of used cars imported for 2022.
    - 33126 gasoline cars
    - 37 diesel cars

- ❖ **Climate Action: 3B – Ban on ICE vehicle sales.**

Methodology: AMS-iii-C – Emissions reductions by electric and hybrid vehicles

Input Data & Sources:

Table 10: Input Data Sources for 3B & 3C

Input Data	Source
Emission Factors (Petrol, Diesel)	See **Section 4.1**
Emission Factor (Electricity)	Standardized baseline: Grid emission factor for Antigua and Barbuda [16]
Net Calorific Value (Petrol, Diesel)	See **Section 4.1**
Transmission and Distribution Losses	See **Section 4.1**
Specific Fuel Consumption	See **Section 4.1**
Vehicle Stock (2022)	See **Section 4.1**

Assumptions:

- In this scenario, it is assumed that the importation ban on the sale of new ICE vehicles will take place from the year 2022 and that all vehicles will be converted to electric vehicles by 2045. It is assumed that the ban on ICE vehicle sales by 2030 will be a key policy driver for the full transformation of the transportation sector by 2045.
- It is assumed that any pre-existing hybrid or electric vehicles within the vehicle fleet in 2022 have a negligible impact on the results.
- The annual distance travelled by all vehicles is assumed to be 14,125 km for all vehicles based on the weighted average calculated from Table 3 above.

Climate Action: 3C – 100% Government Vehicles to Electric

Methodology: AMS-iii-C – Emissions reductions by electric and hybrid vehicles

Input Data & Sources:

See **Table 10** above.

Assumptions:

- In this scenario, it is assumed that all government vehicles will be converted to EVs from the year 2022, and complete conversion will be attained in the year 2035.

Climate Action: 3D – Establish efficiency standards for the importation of all vehicles by 2020.

The analysis of NDC target 3D has not been included in this report due to incompatibilities identified during an evaluation of available methodologies. The methodology "UNFCCC_AMS_III_BC – Emission reductions through improved efficiency of vehicle fleets", which primarily involves the implementation of standards was evaluated for this NDC action. This methodology, however, diverges focus on activities geared towards enhancing energy efficiency, particularly emphasizing retrofits, and the integration of hybrid vehicles. Moreover, it proposes a centralized ownership and management structure for the vehicle fleet under a single entity which is geared towards a project approach as opposed to the rollout of national policy on efficiency standards.

As a result, based on these considerations, this NDC target 3D was not modelled in TraCAD as the available methodologies do not align with the NDC action. Additional efforts and consultation are required and underway to understand the limitations and potential options for modelling this action.

5 Results and Analysis of Modelling Impacts

In this section, the results and analysis of the modelling using the LEAP and TraCAD tools are presented in a graphical and tabular format and a brief description is given. In addition, a comparison of the results using the two modelling software tools is presented and the impact of the results on policies and strategies. Finally, in this section, a brief discussion of just transition for the transportation sector is presented.

5.1 LEAP

In this section, the modelling results using the LEAP modelling software tool are presented and analysed. The full LEAP model and results can be found in **Section 9.3.**

5.1.1 Baseline Scenario

This projection analyses the effect of the continued trend for EV transition in Antigua and Barbuda assuming no new policies or actions are implemented. LEAP analysis was done at yearly intervals, but the results are presented in graphical format and tabular format in five (5) year increments with 2019 and 2022 values shown. **Figure 17** shows the GHG emissions by vehicle category and the electricity sector in the baseline scenario assessment and **Figure 18** shows the corresponding stock of vehicles for the emissions. The corresponding values for **Figure 17** and **Figure 18** are shown in **Table 11** and **Table 15** respectively. It should be noted that the vehicles in the baseline scenario are mainly fossil fuel-driven vehicles as a result, there is little use of electricity in the transport sector and the emissions in the electricity generation branch are fairly small.

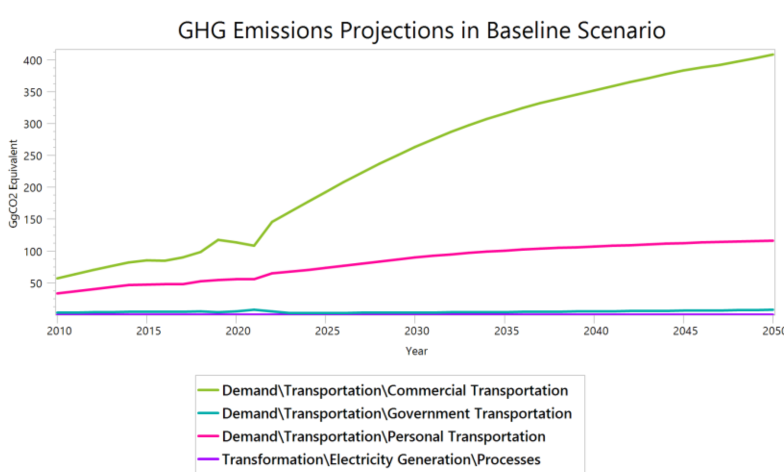


Figure 17:GHG Emissions Projects by Category in Baseline Scenario

Table 11: GHG Emissions Historical and Projected Values in the Baseline Scenario

GHG Emissions projections in the Baseline Scenario/ $GgCO_2e$											
Categories	**2010**	**2015**	**2019**	**2020**	**2022**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Commercial Transportation	57.2	85.3	117.6	113.3	145.9	192.6	263.1	316.0	351.8	383.1	408.0
Government Transportation	3.1	4.6	4.1	5.3	5.5	2.7	3.5	4.2	5.2	6.3	7.7
Personal Transportation	33.7	47.5	54.6	55.5	65.2	73.4	89.7	100.6	107.0	112.5	116.0
Electricity Generation	-	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.1
Total	94.0	137.3	176.2	174.1	216.6	268.8	356.3	420.9	464.0	502.0	531.8

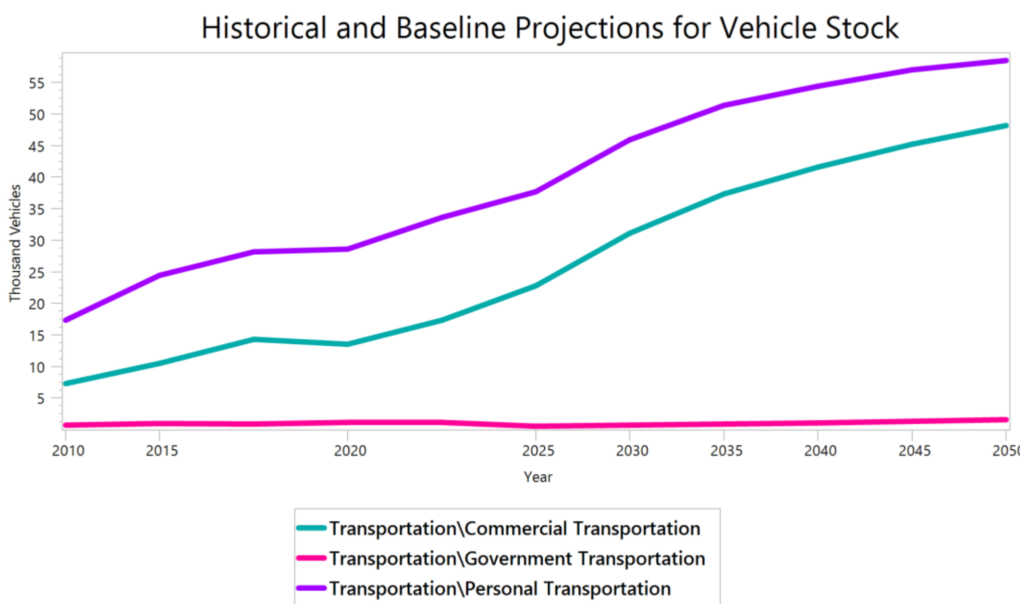


Figure 18: Historical and Baseline projections of Vehicle Stock

Table 12: Historical and Projected vehicle stock values

Vehicle Category	Number of vehicles/ 000's										
	2010	2015	2019	2020	2022	2025	2030	2035	2040	2045	2050
Commercial Transportation	7.3	10.5	14.3	13.5	17.3	22.8	31.1	37.3	41.6	45.3	48.2
Government Transportation	0.7	1.0	0.9	1.1	1.1	0.5	0.7	0.8	1.0	1.3	1.5
Personal Transportation	17.4	24.4	28.1	28.6	33.6	37.7	46.0	51.4	54.4	57.0	58.5
Total	25.3	35.9	43.3	43.2	52.1	61.0	77.8	89.6	97.0	103.5	108.3

5.1.2 Mitigation Scenario

The results of the mitigation scenarios as described in **Section 4.2.1** are given below.

5.1.2.1 Mitigation Scenario developed under Climate Action 3B.

Figure 19 shows the projected emissions for the ten (10) modelled scenarios under Climate Action 3B on the ban on sales of new and used ICE by 2030. The ban on the sales of ICE vehicles was modelled with the transition of sales to EVs beginning in the year 2025 and with a full transition to sales of EVs by 2030. In the scenarios reflecting the transition of all EVs, the government vehicles are assumed to have transitioned to EVs by 2035, therefore this scenario includes the results for the scenarios developed under climate action 3C for the transition of 100% of all Government to EV vehicles by 2035. **Table 13** shows the corresponding GHG emissions values for the scenarios developed.

The results demonstrate that if the transition of all-electric vehicles occurs without the transition to renewables of the electricity grid, then this would increase emissions until the full transition occurs. Based on the model the full transition of the stock of vehicles with a ban on the sales of ICE vehicles in 2030 does not occur until 2045 with the current survival rate of vehicles. The results also demonstrate that reductions in emissions can be achieved in the transition of the following vehicle categories without the transition to renewables in the electric grid.

- Transition to EVs for all Private/Personal Vehicles
- Transition to EVs for all cars and SUVs.
- Transition to EVs for all commercial buses.

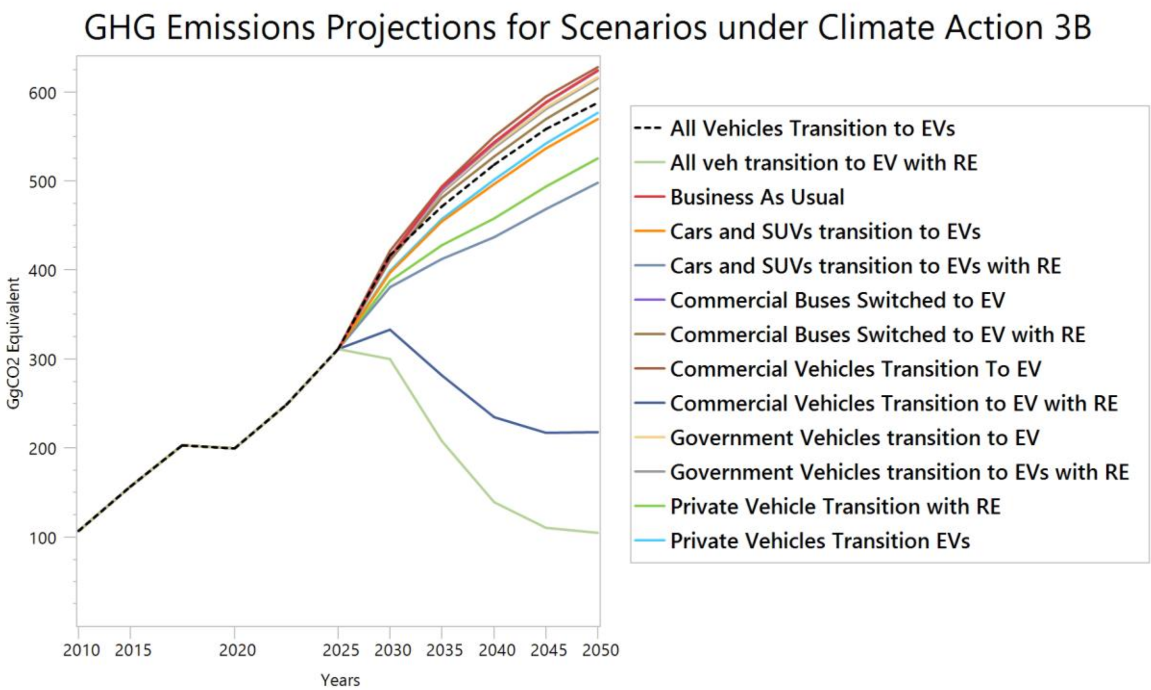


Figure 19: Mitigation Scenarios in LEAP developed under Climate Action 3B.

Table 13: GHG Emissions Projections for Mitigation Scenarios in LEAP developed under Climate Action 3B.

	GHG Emissions projections / $GgCO_2e$										
Scenario	**2010**	**2015**	**2019**	**2020**	**2022**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Business As Usual	107	156.7	202.8	199.1	248.7	311.1	415.1	492	543.5	588.7	624.4
All Vehicles Transition to EVs	107	156.7	202.8	199.1	248.7	311.1	416.1	471.5	518.5	558.6	588.1
All Vehicles transition to EV with RE	107	156.7	202.8	199.1	248.7	311.1	299.9	208.0	138.9	110.0	104.9
Cars and SUVs transition to EVs	107	156.7	202.8	199.1	248.7	311.1	396.6	454.2	496.6	536.7	569.8
Cars and SUVs transition to EVs with RE	107	156.7	202.8	199.1	248.7	311.1	380.7	412.2	436.8	468.4	497.6
Commercial Buses Switched to EVs	107	156.7	202.8	199.1	248.7	311.1	414.6	490.0	542.1	587.7	623.6
Commercial Buses Switched to EVs with RE	107	156.7	202.8	199.1	248.7	311.1	410.6	480.8	527.5	569.8	603.7
Commercial Vehicles Transition To EVs	107	156.7	202.8	199.1	248.7	311.1	421.4	493.8	549.6	595.0	627.9
Commercial Vehicles Transition to EVs with RE	107	156.7	202.8	199.1	248.7	311.1	332.8	281.4	234.8	217.2	217.9

Scenario	GHG Emissions projections / $GgCO_2e$ 2010	2015	2019	2020	2022	2025	2030	2035	2040	2045	2050
Private Vehicles Transition to EVs	107	156.7	202.8	199.1	248.7	311.1	398.5	457.3	501.1	542.4	576.4
Private Vehicle Transition Switched to EVs with RE	107	156.7	202.8	199.1	248.7	311.1	387.5	427.5	458.0	493.4	525.0

5.1.2.2 Mitigation Scenario developed under Climate Action 3C.

Figure 20 shows the projected emissions for the modelled scenarios under Climate Action 3C on the 100% transition of Government vehicles to EVs by 2035. This modelled scenario incorporates the ban on the sales of ICE vehicles with the transition of sales to EVs beginning in the year 2025 and with a full transition to sales of EVs by 2030. To ensure a full transition of Government vehicles by 2035, a policy was modelled on the survival rate of Government vehicles, ensuring that vehicles older than seven (7) years were not within the Government system. **Table 14** shows the corresponding GHG emissions values for the scenarios developed.

The results demonstrate that the transition of all government vehicles to electric vehicles would result in emissions reduction and further reductions can be achieved if the grid is transitioned completely to renewables. The electricity demand for Government vehicles is not high during the transition and therefore the electricity is provided mainly from the renewables already installed in the system. This results in minimal changes when comparing the transition of Government vehicles using the current electricity grid when compared to the transition of Government vehicles supplied with electricity from renewables. This is a limitation in the LEAP model developed, as these renewables are not separated from the supply of electricity from fossil fuels.

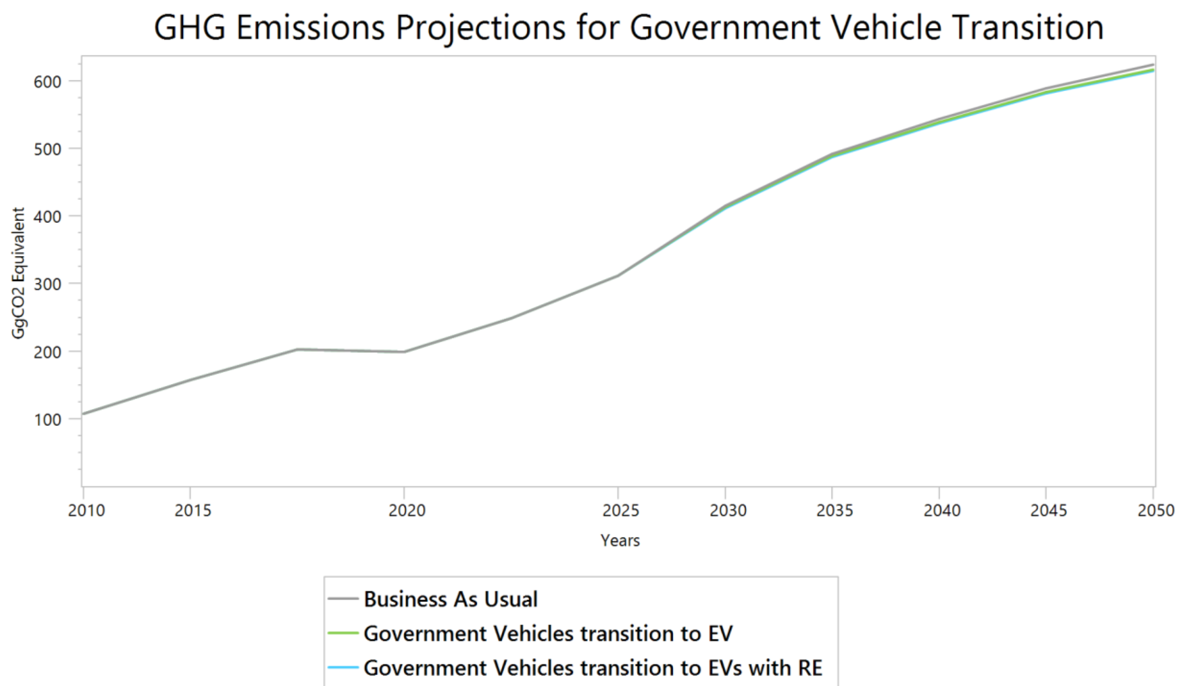


Figure 20: Mitigation Scenarios in LEAP developed under Climate Action 3C.

Table 14: GHG Emissions Projections for Mitigation Scenarios in LEAP developed under Climate Action 3C.

								GHG Emissions projections / $GgCO_2e$		
Scenario	**2010**	2019	2020	2022	**2025**	2030	2035	2040	2045	2050
Business As Usual	107	202.8	199.1	248.7	311.1	415.1	492.1	543.5	588.7	624.4
Government Vehicles transition to EV	107	202.8	199.1	248.7	311.1	413.5	488.8	539.1	582.9	616.9
Government Vehicles EV Transition with RE	107	202.8	199.1	248.7	311.1	411.8	486.9	537.2	581.0	614.9

5.2 Results of analysis in TraCAD

This section presents the results obtained from the analysis of the climate actions using the TraCAD modelling software. Each scenario developed is analysed separately. The full modelling assessment results can be found in **Section 9.4** in the **Appendix.**

5.2.1 Climate Action: 3A – Change fiscal policies on fossil fuel by 2025 to enable the transition to 100% renewable energy generation in the transportation sector.

This policy intervention aims to communicate the impacts of transport policies to ensure that they are effective in mitigating GHG emissions through consumer fiscal incentives to import more efficient vehicles.

- Baseline Year: 2010
- Project/Assessment Year: 2022
- Projection Year: 2026
- Baseline emissions in assessment year (2022): 4 tCO_2e

This climate impact assessment focused on the implementation of increased vehicle tax/levies. The environment levy imposed on vehicles in Antigua and Barbuda was established to provide the Government with a revenue method for the upfront cost of solid waste disposal for the vehicles. The environmental levy as described in **Section 4.1.3** is:

- XCD 1,000 or USD 370 for vehicles up to one (1) year and
- XCD 4,000 or USD 1480 for used vehicles over one (1)year.

Used vehicles have a higher environmental levy, noting that these vehicles are more than likely to have an earlier disposal rate than newer vehicles. This assessment analyses the impact of a fifteen per cent (15%) increase in the environmental levy on the importation of used ICE vehicles resulting in a new environmental levy of

- XCD 4,600 or USD 1702 for used vehicles over one (1)year.

The results of this modelled scenario are described in **Table 15**.

Table 15: Projection Results for Climate Action 3A in TraCAD

Projection Results – 2026	tCO_2e
Baseline emissions	4
Project Results	-97
Leakage Results	0
Total emissions reductions	101

Very high vehicle ownership fees, in addition to increasing import levy, reduce total vehicle ownership and use. This methodology does not account for the emissions from the remaining stock of fossil fuel vehicles beyond the year 2026. Based on these results of price-driven consumer incentives of environmental levies, further emissions reductions on imports of new vehicles are achievable through expansion to modified vehicle taxes and fees that could subsidize importation of low-carbon-fuel vehicles as a means to further encourage motorists to choose lower carbon-fueled vehicles.

5.2.2 Climate Action: 3B – Ban on ICE vehicle sales.

In this assessment, the full transition of the vehicles stock in 2045 is assessed, due to the limitation of the modelling in the assessment of vehicles and the impact of these sales on the stock of vehicles.

- Base Year: 2010
- Assessment Year: 2022
- Projection Year: 2045
- Baseline emissions in assessment year (2022): 516,025 tCO_2e

Estimation of projected GHG impacts of this action in 2045 was done by using the GHG Impact module in the tool and applying the methodology "AMS-III.C Small-scale Methodology: Emission reductions by electric and hybrid vehicles" developed by the UNFCCC for assessing CDM mitigation actions where fuel switch to electric and hybrid vehicles, and displacement of more-GHG-intensive vehicles.

The results of this modelled scenario are described in **Table 16**.

Table 16: Projection Results for Climate Action 3B in TraCAD

Projection Results – 2045	tCO_2e
Baseline emissions	571826
Project Results	100623
Leakage Results	0
Total emissions reductions	471202

In summary, the ban on the importation of ICE vehicles and the shift to all-electric vehicle sales by 2045 has yielded substantial benefits in terms of GHG emissions reduction. The analysis for the transition period reveals a decrease in emissions, with a reduction of **471,202 tCO2e** from 2022 to 2045. This achievement is reflected across all vehicle types in the national fleet contributing to an **overall decrease in emissions of 82.4%** from the baseline emissions. The results demonstrate that even with the present electricity grid which is mainly fossil fuel based and a grid emission factor of 0.62 $kgCO_2/kWh$ there is a huge potential for emission reductions when switching to electric vehicles. Nevertheless, further emission reductions can be achieved through increased penetration of renewables into the grid.

5.2.3 Climate Action: 3C – 100% Government Vehicles to Electric

In this assessment, the full transition of the government vehicle stock in 2035 is assessed.

- Government electric vehicles = 100% in 2035
- Base Year: 2010
- Assessment Year: 2022
- Projection Year: 2035
- Baseline emissions in assessment year (2022): 15,677 tCO_2e

Estimation of projected GHG impacts of this action in 2035 was done by using the same methodology as climate action 3B above and the results are shown in **Table 17.**

Table 17: Projection Results for Climate Action 3C in TraCAD

Projection Results – 2035	tCO_2e
Baseline emissions	17239
Project Results	3024
Leakage Results	0
Total emissions reductions	14215

In summary, the switch to 100% electric vehicles in 2035 is projected to reduce GHG emissions across all vehicle types, contributing to an overall decrease in emissions by 82.5% from the baseline emissions for Government vehicles. This analysis suggests that the transition to electric vehicles can have a meaningful impact on mitigating climate change by reducing emissions associated with fossil fuel-based transportation. In this model, the biggest emission reduction by vehicle type occurs from the transition to electric buses and trucks, due to their relatively higher usage (compared to personal vehicles) and therefore aggregate fuel consumption. This impact is seen due to the complete switch from diesel fuel, which is the main fuel type for these vehicle types, to completely electric fleets.

5.3 Comparison of results of both models

Antigua and Barbuda 2019 GHG Inventory data obtained from West Indies Oil Company (WIOC) and Antigua Power Utility Authority (APUA) indicates that the total GHG emissions level in road transportation is approximately 190 $GgCO_2e$. These results correspond well with the values obtained in the LEAP model but not with the values obtained in the TraCAD model, with TraCAD estimating emissions of 571.8 GgCO2e in 2022 and LEAP estimating emissions of 202.8 GgCO2e in 2019. Several factors can be attributed to the discrepancies found in the values these include but are not limited to the following:

1. LEAP uses vehicle data, fuel economy, mileage, and fuel type to estimate emissions in the transport sector. The mileage data was assumed based on several factors and expert judgement to include in the model.
2. TraCAD – for the modelling of emissions, a common annual distance travelled of 14, 125km was used for all vehicle types. This was also based on the mileage data used in the LEAP model, but a weighted average was used for all vehicle types.
3. Data from WIOC and APUA – Road transport was assumed to consume all gasoline and diesel oil sold on the island in 2019. Due to insufficient data on domestic marine transportation, consumption in that subsector was not considered in the calculations.

Therefore, further work is required to investigate this discrepancy and to calibrate the historical baseline emissions with the fuel used in the country and the reported data from WIOC and APUA.

The comparison of results between LEAP and TraCAD is otherwise difficult as LEAP emissions reductions are measured per year based on the baseline scenario and the emissions reductions for

TraCAD are accumulated emissions over the time frame of the project period. Noting this, some comparison is made on the results for two models for climate action 3B and 3C as shown in **Table 18** and **Table 19**.

- **Climate Action 3B**

Table 18: Comparison of Results for Climate Action 3B with LEAP and TraCAD

GHG Emissions /GgCO$_2$e				
	2022		2045	
	TraCAD	**LEAP**	**TraCAD**	**LEAP**
Baseline Emissions	516.025	248.688	571.826	588.727
Emissions Reductions			471.202	30.158

In this scenario, the baseline emissions from LEAP and TraCAD are significantly different in 2022 but the project emissions for the year 2045 are similar. This indicates that LEAP estimates a much higher increase in vehicle stocks from 2022 to 2045. The emission reduction potential for TraCAD indicates an 82% reduction in emissions while LEAP estimates only a 1.6% reduction in emissions with a transition to EV using the current grid structure.

- **Climate Action 3C**

Table 19: Comparison of Results for Climate Action 3C with LEAP and TraCAD

GHG Emissions /GgCO$_2$e				
	2022		2035	
	TraCAD	**LEAP**	**TraCAD**	**LEAP**
Baseline Emissions	15.677	248.688	17.239	492.050
Emissions Reductions			14.215	3.263

In this scenario, the baseline emissions for the two models should not be compared as LEAP baseline emissions consider all vehicles in the country while TraCAD calculates the baseline emissions for only Government vehicles. TraCAD estimates an emission reduction of 82% while LEAP estimates an emission reduction of 0.66% of the total vehicle fleet emissions.

5.4 Implications of Electric Mobility Transition

The modelling of the transport sector using TraCAD and LEAP has demonstrated clearly to Antigua and Barbuda that emissions reductions are possible with the transition to electric vehicles however there are some policy implications to meet the NDC targets as defined in the models.

- **Government vehicle age limit policy**

In the LEAP model to meet the target of 100% transition of Government vehicles by 2035. A seven (7) year policy was introduced for all vehicles. Indicating that Government vehicles once they reach the age of seven (7) should either be sold or disposed of. This policy is applied to all vehicles in the model and would also implicate EVs after 2035. To implement this policy careful consideration should be given to procurement and disposal guidelines of Government vehicles.
This also has implications for the island-wide transition to EVs, as the sale of these vehicles to the public will help the transition of Government vehicles but will introduce used vehicles to the island fleet. In addition, the disposal of these vehicles will require a solid waste management strategy for the Government.

- **Increased penetration of Renewable Energy to the grid**

The TraCAD model indicates that there are significant reductions in emissions with the introduction of EVs based on the current grid emission factors. The LEAP model indicates that these emission reductions are small and significant emissions reductions are not achieved in the transport sector unless the EVs are powered by renewable energy sources. This suggests that the transport transition to EVs should occur simultaneously with the power sector transition to renewables and one should not be done without the other as this just shifts the emissions from one area to the next.

- **Energy Storage**

The models developed do not consider a very important aspect of renewables, which is storage. The use of renewables such as solar is not possible to power an island system without the consideration of suitable storage technologies such as batteries. Therefore, it is important to consider the costs of storage as well as renewables when considering the transition of the transport sector.

- **Increased Taxes and Political Will**

In Antigua and Barbuda, political will is extremely important to the implementation of policies. In the TraCAD model for the introduction of fiscal policies on fossil fuel by 2025, to support the transition of 100% renewable energy generation in the transport sector, an increase in the environmental levy on used vehicles is proposed. This increase in taxes will need to be communicated to the public to reduce the negative impact of increased taxes. Therefore, a communication strategy will be recommended to ensure that the right message is displayed to the public and the benefits are articulated.

- **Costs**

EVs are generally more expensive than ICE vehicles and there the cost implication to society should be considered when transitioning the transport sector. In LEAP the capital costs of the vehicles were entered in the model, and it indicates that the additional social costs of switching to electric vehicles in 2030 from the starting value of 351 million USD is approximately 94 million USD when compared to the additional costs in the business-as-usual scenario of 22 million USD as demonstrated in **Figure 21**. This cost will have implications on the GDP of the country, on the available spending power of the people and Government and other financial implications that should be taken into account.

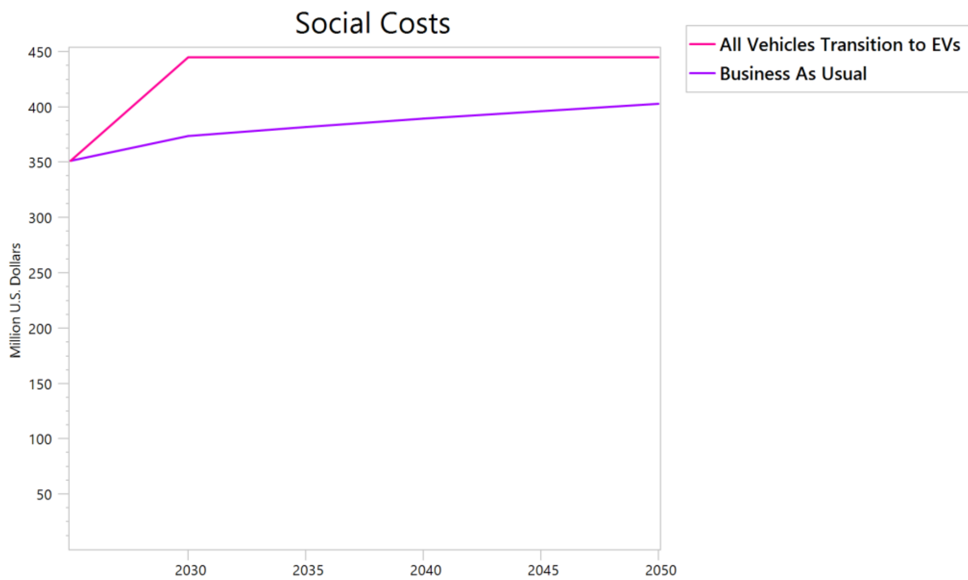


Figure 21: Social Costs of Switching to Electric Vehicles

- **Waste Disposal**

A critical component of the transition to EVs is the disposal of the ICE vehicles and the disposal of batteries. One method to evaluate the impact on the waste disposal and recycling business for the country is to estimate the number of vehicles that need to be decommissioned as the transition to EV occurs. In the LEAP model, it is estimated that sixty-one thousand (61,000) vehicles will be in the country in 2025. Assuming that there will be a gradual decline in the stock of vehicles with all vehicles transitioned by 2045, then approximately three thousand (3,000) ICE vehicles would need to be decommissioned per year from 2025. This number is significant for an island with limited land space and therefore considerations should be made for recycling the materials, and waste disposal strategy to ensure that old vehicles are not improperly disposed of, and the waste facility is properly equipped to handle the volumes of waste anticipated.

5.5 Just transition considerations for the Transport sector

The rapid and worldwide evolution of the transport sector poses significant societal challenges. Central to this transformation is the shift from fossil-fueled to zero-emission mobility systems, a crucial step in addressing climate change. The complexity lies in advancing toward low-carbon urban transport systems that enhance people's lives simultaneously. It is imperative to guarantee that this transition generates equitable and dignified employment while fostering widespread social and economic opportunities for all, irrespective of location.

The shift to a sustainable transport sector in Antigua and Barbuda demands careful consideration of just transition principles, where economic and social factors are pivotal. This shift toward cleaner transportation, crucial for environmental reasons, requires addressing potential job losses while creating new opportunities within the sector. Effective management of job dynamics, coupled with investments in skill development, facilitates a smooth transition from traditional roles in the internal combustion engine sector to emerging roles in electric vehicles and associated infrastructure.

The just transition approach should extend to vulnerable populations and remote areas, emphasizing the importance of accessible charging infrastructure. Widespread availability of charging stations not only ensures the success of the transition but also addresses equity concerns. In remote and low-income areas, efforts should be intensified to bridge the infrastructure gap, promoting inclusivity.

Success in this transition relies on a multi-faceted strategy, encompassing not only the technological shift to electric vehicles but also public awareness campaigns, regulatory frameworks, and financial incentives. Together, these elements create a supportive environment for the adoption of electric transportation.

In conclusion, achieving a just transition in Antigua and Barbuda's transport sector requires a holistic strategy considering economic, social, and environmental dimensions. Balancing job dynamics, enhancing skills, and addressing infrastructure disparities, particularly in remote and low-income areas, are crucial for a sustainable and equitable shift towards a cleaner transport sector.

6 Suggestions for Model Improvements

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

- Use of additional methodologies for the NDC scenarios in TraCAD
- Additional vehicles are to be included in the modelling for climate action 3A in TraCAD.
- Adjusted Methodologies for the Antigua and Barbuda in TRACAD
- Improved costing data to be included in the TraCAD for marginal abatement cost modelling.
- Improved country-specific data for emissions and fuel type
- Improved data on vehicle mileage and fuel economy
- Inclusion of storage option in the transformation sector for LEAP

7 Conclusion

Through the support of ICAT, Antigua and Barbuda has fully documented transport models with the TraCAD and LEAP Tools. By building the model for Antigua and Barbuda within these tools, the models are 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 and TraCAD to ensure that the government retains the capacity to use the models.

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9 Appendix

9.1 Demographic and Economic Data

The full data set of Demographic and Economic Data can be obtained via this link.

9.2 Transport Data

The full data set of Transport Data can be obtained via this link.

9.3 LEAP Modelling Results

The LEAP model can be obtained via this link

9.4 TraCAD Modelling Results

The full results for the TraCAD model can be obtained via this link.

ANNEX 1

Transport Tool Selection Justification Report

ANNEX 2

Transport Alignment Workshop Report