Republic of Seychelles

TECHNOLOGY NEEDS ASSESSMENT REPORT - MITIGATION

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SEYCHELLES TECHNOLOGY NEEDS ASSESSMENT REPORT – MITIGATION

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List of Acronyms

AC	Air conditioning
AFD	Agence Française de Développement
BEMS	Building Energy Management System
CAGR	Compound Annual Growth Rate
CC	Climate Change
CCGT	Combined Cycle Gas Turbine
CCM	Climate change mitigation
CDM	Clean Development Mechanism
CH_4	Methane
CIF	Cost, Insurance and Freight
COP	Conference of Parties
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DBS	Development Bank of Seychelles
DECC	Department of Energy and Climate Change
DoT	Department of Transport
EE	Energy Efficiency
EIA	Environmental Impact Assessment
EST	Environmentally Sound Technologies
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GWP	Global Warming Potential
GPS	Geospatial Positioning System
HFO	Heavy Fuel Oil
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPP	Independent Power Producer
JICA	Japan International Cooperation Agency
$ktCO_2$	Kilotonne carbon dioxide
ktoe	Kiloton of oil equivalent
LED	Light Emitting Diode
LULUCF	Land Use, Land Use Change and Forestry
LWMA	Landscape Waste Management Agency
MAED	Model for Analysis of Energy Demand
MCA	Multi Criteria Analysis
N_2O	Nitrous Oxide
NDS	National Development Strategy
MCA	Multi-criteria Analysis

MEECC	Ministry of Environment, Energy and Climate Change
MFTBE	Ministry of Finance, Trade and The Blue Economy
MLUH	Ministry of Land Use and Habitat
MWh	Megawatt hour
NCCC	National Climate Change Committee
NCCS	National Climate Change Strategy
NGO	Non-Government Organisation
NISTI	National Institute of Science, Technology and Innovation
NSB	National Statistics Bureau
PM	Particulate Matter
PSC	Project Steering Committee
PTC	Praslin Transport Company
PUC	Public Utilities Corporation
PV	Photovoltaics
RE	Renewable Energy
RTC	Road Transport Commission
SBS	Seychelles Bureau of Standards
SEC	Seychelles Energy Commission
SEEREP	Seychelles Energy Efficiency and Renewable Energy Program
SEYPEC	Seychelles Petroleum Company
SIDS	Small Island Developing States
SLA	Seychelles Licensing Authority
SLTA	Seychelles Land Transport Agency
SME	Small and Medium Enterprises
SMS	Seychelles Meteorological Services
SNC	Second National Communication
SPTC	Seychelles Public Transport Corporation
SR	Seychelles Rupee
SSDS	Seychelles Sustainable Development Strategy
SSP	Seychelles Strategic Plan
SWOT	Strengths-Weaknesses-Opportunities-Threats
t	tonne
TAP	Technology Action Plan
tCO_2	Tonne carbon dioxide
tCH_4	Tonne methane
TFS	Technology Fact Sheet
TNA	Technology Needs Assessment
TNC	Third National Communication
TWG	Technical or Technology Working Group
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States Dollar
VAT	Value Added Tax

VTMP	Victoria Traffic Management Plan
WTE	Waste-to-Energy

Executive Summary

The Seychelles prioritised the energy industries (or power sector) and land transport as priority sectors deserving technical assistance under the Technology Needs Assessment (TNA) project. The choice of these sectors is squarely aligned with several factors, including among others: their importance to society and economy; their significant contributions in the national greenhouse gas (GHG) inventory; alignment with government policies and strategies, including the mitigation contribution in the Seychelles Nationally Determined Contributions that was submitted in light of the Paris Agreement. Only two priority sectors were chosen because of constraints of financial and time resources. While noting that other sectors also deserve technology transfer to support the low-carbon development of Seychelles, it is proposed that the TNA process be extended to additional GHG emitting sectors during the implementation of the Third National Communication (TNC).

Technology working groups (TWG) were set up bearing in mind local expertise in technologies to address electricity supply side diversification using renewable energy sources, and end-use energy efficiency in the power sector, and a combination of spatial planning to ease congestion and modal shifts towards low-carbon transport options for both the public transport system and the private fleet of vehicles, especially cars. The members of the TWG were drawn from government, civil society, academia and the private sector. Different types of stakeholder engagement approaches were utilised, including: a national workshop to introduce the entire TNA process to stakeholder and to initiate the process of technology identification and prioritisation using MCA; working sessions of the TWGs; bilateral meetings; and communications by email. The last two approaches were particularly useful given the fact that not all stakeholders were able to attend working sessions of the TWG.

The participative and inclusive approach adopted by the TNA project ensured that members of the TWGs were regularly updated on the progress of the technology identification and prioritisation process. The technology fact sheets (TFS) were also developed in close consultations with the members of the TWG. The TFS were used to score technology options in multi-criteria analysis (MCA).

MCA calculators were customised for the TNA project, and the open source tools were made available to all stakeholders. The criteria and indicators used for the MCA exercise for both sectors were customised using the MCA4Climate framework as the starting point. In order to minimise bias in MCA, five out of the seven indicators retained by stakeholders were objective indicators. The sensitivity of technology ranking on weights was carried out for three different sets of weights. The weights were assigned by the members of the TWGs, and were found to have no bearing on the rankings of the top three prioritised technologies (for both sectors), implying that the MCA results were robust.

The top three ranked mitigation technologies for the power sector are:

1. Waste heat recovery at Roche Caiman thermal power plant for electricity generation;
2. Waste-to-energy (centralised anaerobic digester); and
3. Centralised utility-scale PV (with some battery storage).

The prioritised mitigation technologies for land transport are:

1. Low-carbon private car fleet consisting of a combination of hybrid and electric cars;
2. Victoria Traffic Management Plan (VTMP); and
3. Electric scooters.

Chapter 1 Introduction

1.1 About the TNA project

Technology transfer has been under focus since the Rio Summit in 1992, where issues related to technology transfer were included in Agenda 21 as well as in Articles 4.3, 4.5 and 4.7 of the United Nations Framework Convention on Climate Change (UNFCCC). These were subsequently discussed in Conference of Parties 1 (COP 1) in Berlin and COP 4 in Buenos Aires with Decision 2/ CP4 requiring the Global Environment Facility (GEF) to provide funding to developing country Parties to enable them identify and submit to the COP, their prioritised technology needs, especially as concerns key technologies needed in particular sectors of their national economies conducive to addressing climate change and minimising its adverse effects. Following this, GEF provided funding to 92 countries between 2000 and 2004 for the first round of Technology Needs Assessments (TNAs) through its enabling activities phase II (also known as "top-ups") programme. The processes followed by various countries in the first round of TNA were diverse and, for the most part, the end results lacked implementable actions. In response to COP 13 request, GEF proposed the Poznan Strategic Program on Technology Transfer, which was endorsed by COP 14. It consists of three funding windows; (i) technology needs assessments (TNAs); (ii) piloting priority technology projects; and (iii) dissemination of successfully demonstrated technologies.

In 2009, a new round of TNAs (TNA Phase I) commenced in 36 developing countries and was successfully concluded in April 2013. The current Global TNA project (TNA Phase II), deriving from window (i) of the Strategic Program on Technology Transfer, is designed to support 25 more countries to carry out new or improved Technology Needs Assessments within the framework of the UNFCCC. The assessments involve amongst others, in-depth analysis and prioritisation of technologies, analysis of potential barriers hindering the transfer of prioritised technologies as well as issues related to potential market opportunities at the national level. National Technology Action Plans (TAPs) agreed by all stakeholders at the country level will be prepared consistent with both the domestic and global objectives. Each TAP, which will outline essential elements of an enabling framework for technology transfer consisting of market development measures, institutional, regulatory and financial measures, and human and institutional capacity development requirements, will also include a detailed plan of action to implement the proposed policy measures and estimate the need for external assistance to cover additional implementation costs. Thus, the detailed plan of action will serve as the base for the subsequent preparation of fundable project ideas.

Targeted training and supporting materials related to methodology for prioritisation of technologies, market assessment, access and links to data on technologies developed and tested and made available to all participant countries. Experiences gained during the project implementation will be shared amongst participating countries to enhance cross-country learning. The main objectives of the project are:

1. To identify and prioritise through country-driven participatory processes, technologies that can contribute to mitigation and adaptation goals of the participant countries, while meeting their national sustainable development goals and priorities (TNA).
2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritised technologies.

3. To develop Technology Action Plans (TAP) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participant countries.

The ultimate aim of the TNA project is to use a robust process and methodology to enhance the preparedness of Seychelles to leverage international climate finance for adopting or scaling up environmentally sound technologies (ESTs) to increase its resilience in the face of the impacts of climate change. Further, the TNA process will serve as a means to support the implementation of Seychelles Intended Nationally Determined Contribution (INDC) (Republic of Seychelles, 2015a).

1.2 Existing national policies on climate change mitigation and development priorities

The Seychelles consists of over 115 islands of which some 40 are granitic and the rest coral with a total human population of about 84,600 (NSB, 2007 – '2006 population estimates'). The four main inhabited granitic islands in order of size are Mahe, Praslin, Silhouette and La Digue, and vary in age from some 650 to 750 million years old. The Seychelles islands are located within 4^{o} and 9^{o} South of the equator, and with a total area of 455.3 km^2. All the islands put together result in a coastline of about 491 km (The World Fact Book, 2008). The majority of the islands are surrounded by coral reefs with an area of about 1,690 km^2 (Payet, 2004), many of which were affected by the mass coral bleaching event of 1998 which was caused by abnormally warm waters (Linden et al., 1999). More than 90% of the population and all economic activities are located on the narrow coastal plateau of Mahe Island, at an average elevation of 2 m above sea level.

The Seychelles is categorised as a small island developing States (SIDS) that are recognised as a special case for both environment and development in Chapter 17(G) of Agenda 21 (UN, 1992). The grounds for this special consideration relates to the inherent vulnerabilities to which SIDS are exposed, including their small size, limited and narrow resource bases, geographic dispersion, isolation from markets, susceptibility to climate change and natural disasters, and exposure to external shocks from such sources as energy, financial and economic crises. Although, it is classified as an upper middle-income country, the Seychelles has the same inherent vulnerabilities resulting in key weaknesses in human, scientific, financial, technical, technological and institutional capacity.

There are several national policies and strategies that deal with climate change from the perspective of increasing the resilience of Seychelles. These are discussed below with emphasis placed on the mitigation component of climate change – i.e. the policies and strategies for reducing the emissions of greenhouse gases (GHGs).

The ***Seychelles National Climate Change Strategy*** (NCCS) 2009 (Government of Seychelles, 2009) was formulated to provide a coherent and consolidated response to climate change. The NCCS covers both climate change mitigation and adaptation. Central to the strategy is the mainstreaming of climate change into sustainable development as a national cross-sectoral programme addressing matters of policy, institutions, capacity building and civil society involvement. The NCCS formulated a vision for addressing climate change in the Seychelles (Government of Seychelles, 2009):

> "*To minimise the impacts of climate change through concerted and proactive action at all levels of society*"

Five strategic objectives have been proposed to achieve this vision:

1. To advance our understanding of climate change, its impacts and appropriate responses.
2. To put in place measures to adapt, build resilience and minimise our vulnerability to the impacts of climate change.
3. To achieve sustainable energy security through reduction of greenhouse gas emissions.
4. To mainstream climate change considerations into national policies, strategies and plans.
5. To build capacity and social empowerment at all levels to adequately respond to climate change.

The third strategic objective deals exclusively with climate change mitigation (CCM), which in the case of Seychelles is intricately linked with energy security because of the heavy reliance on imported fossil fuels. A SWOT analysis of the mitigation capacity of the Seychelles was carried out in order to inform the development of an action plan to achieve the strategic objectives of the NCCS.[1] The results of the analysis are shown in **Figure 1**. The mitigation and adaptation action plan of the NCCS is summarised in **Annex I**.

Strengths	**Weaknesses**
• High level of commitment among agencies & NGO to move towards renewable energy options • Moderate level of awareness on mitigation • Availability of an educated workforce • Private sector initiatives to reduce greenhouse gas emissions • High reliability from small scale technologies • International financing can have an immediate and positive impact. • High level of conservation and management of major sinks.	• No capacity for national energy management • Lack of financial incentives for industry to implement mitigation • Poor access to technologies appropriate for mitigation in small island context • Lack of awareness at policy level • Resistance to adopt other technologies by industry • Archaic legal framework for energy • No incentives to stimulate early adaptors • Incomplete data on energy • Poor awareness programmes on mitigation
Opportunities	**Threats**
• Availability and affordability of alternative energy technologies on the international market • Gain from the extensive experience of other small island states • Improvements in public transport • Earn from a suitably development Carbon finance framework • Standards for conservation of energy and associated infrastructure	• Persistence or recurrence of financial and oil crisis • Maintain reliance on fossil fuel only • Poorly implemented renewable energy technologies • Inappropriate energy conservation technologies and practices • Lack of financial resources to implement mitigation activities

Source: National Climate Change Strategy, 2009

Figure 1. SWOT matrix on the adaptation capacity of the Seychelles.

The matrix reaffirms the threat posed by a very high reliance on imported fossil fuels, and it highlights opportunities for mitigation in public transport and energy conservation. The threats related to poorly implemented renewable energy technologies and inappropriate energy conservation technologies and practices provide policy-informed entry points for promoting mitigation technology transfer under the TNA project. Further, the weaknesses may be viewed as the underlying barriers that maintain these threats in place. The opportunities provide a glimpse of the institutional capacities that can be tapped to promote mitigation technology transfer and diffusion.

[1] A similar exercise was carried out on the adaptation capacity of the Seychelles, which is discussed in the Seychelles Technology Needs Assessment Report – Adaptation.

Strategic objective 3 of the NCCS proposes "To achieve sustainable energy security through reduction of greenhouse gas (GHG) emissions". Four strategies have been proposed to achieve this objective (**Annex I**):

Strategy 3.1: Diversify the energy portfolio of Seychelles towards renewable forms of energy;
Strategy 3.2: Modernise the energy legislation and institutional framework to encourage innovation and transfer of technology in the energy sector;
Strategy 3.3: Improve monitoring and assessment of energy use and emissions; and
Strategy 3.4: Technology transfer in the energy production and transport sector.

It is worthwhile to point out that strategies 3.2 and 3.4 make explicit reference to technology transfer and provide guidance regarding the priority sectors that should benefit from such support (please see section 1.3.2 for more details).

The ***Energy Policy 2010*** (Van Vreden et al., 2010) has also concentrated its interventions mainly on public transport, and electricity generation and consumption. It provides targets for the penetration of renewable energy (RE) and energy efficiency (EE) that were used to inform the emission reduction targets proposed in the Seychelles INDC (Government of Seychelles, 2015a). The energy use scenarios in the power sector (electricity production and consumption) and transport to 2030 are summarised in **Table 1** (Van Vreden et al., 2010). It can be seen from **Table 1** that the Energy Policy provides guidance regarding technology options in the power and land transport sectors.

Table 1. Renewable energy and energy efficiency targets in the power and transport sectors.

Sector	Targets
Power (electricity generation)	*It is estimated, that the renewable energy sources, together with the necessary legislation, can contribute about 15% - 20% renewable energy in the supply matrix in 2030. Wind power and, in the longer term, PV, are expected to contribute substantially.*
Power (electricity consumption)	*It is estimated that implementation of the policies has the potential to save 15% - 30% of electricity consumption towards 2030 compared to the baseline.*
Transport (land)	*Keeping a high penetration of public transport, targeting fuel efficiency and biofuels in import regulation, and moving towards electric vehicles and two-wheelers, have the potential to reduce oil imports for transport purposes by 15% to 30% (or perhaps more) by 2030 compared to the baseline (2010).*

Source: Van Vreden et al., 2010

The Seychelles ***Intended Nationally Determined Contribution*** (INDC) (Government of Seychelles, 2015a) makes an implicit link with several UNFCCC-related initiatives including the TNA project regarding the transfer and diffusion of environmentally sound technologies for both climate change mitigation and adaptation. While the sectoral GHG emission baseline and mitigation scenarios are discussed in section 1.3.1, it is timely here to discuss the underlying electricity demand model that has been developed by the Seychelles Energy Commission (SEC) giving insights into the types of EE measures that are expected to be implemented in Seychelles to 2035. Projections of electricity demand to 2035 under different gross domestic product (GDP) growth rates and EE scenarios were made using Model for Analysis of Energy Demand (MAED). The implementation of a National Energy Efficiency Programme has been proposed to include the following activities:

- Promotion of energy-efficient appliances: target of10% energy savings in 2035
- Promotion of solar water heating: target of 80% of needs in Households, and 80% in Services by 2035,
- New Regulations on the use of air-conditioning (AC), target of 20% energy savings in the service sector,
- New Building Code for Household dwellings (features natural ventilation, roof insulation,..), target of 50% energy savings on fans & AC in households by 2035,
- Promotion of cogeneration (production of hot water from waste heat from electricity generation) in hotels, target to cover 20% of hot water needs by 2035.

The ***Seychelles Strategic Plan (SSP) 2015 - 2040*** (Government of Seychelles, 2015b) sets out the long term spatial planning framework for the country up to 2040. It includes spatial policies relating to:

- priorities for economic growth and development;
- scale and distribution of new housing;
- protection of the marine and terrestrial environment and biodiversity;
- protection of the built and historic environment;
- tackling climate change and safeguarding natural resources; and
- priorities for infrastructure provision.

The Strategic Plan has been aligned with the main development agenda set out in the National Development Strategy (NDS) 2015 - 2019 (Government of Seychelles, 2015c) and the Seychelles Sustainable Development Strategy (SSDS) 2012-2020 (Government of Seychelles, 2011a). Consequently, the NDS and the SSDS are not reviewed here. The development of a sustainable blue economy[2] will be of critical importance to the development of the Seychelles Strategic Plan and the achievement of the objectives set out in the National Development Strategy. In establishing the policy foundations for the Strategic Plan, it is mentioned that the projected doubling of GDP between 2007 and 2017 will require innovation in the development of the 'blue economy' (in particular the exploitation of natural resources) and of the 'green economy', maintaining a pristine natural environment and increasing the use of renewable energy. The Strategic Plan notes that innovation in particular is needed in the energy arena for finding economically feasible approaches to delivery of energy through solar, wind, tidal or other renewable resources. Conservation and demand management initiatives are intended to reduce total resource use and defer the need for costly infrastructure upgrades (Government of Seychelles, 2015b, pg.9).

The three strategic orientations and relevant components of the Strategic Plan having a link (either directly or through better energy and waste management) to climate change mitigation are summarised in **Table 2**. The accompanying measures are discussed in section 1.3.2.

[2] The concept of the 'blue economy' originates from the 2012 UN Conference on Sustainable Development and seeks to utilise the opportunities for development provided by maritime and coastal assets in a sustainable way to reduce carbon emissions, pollution and environmental degradation; promote greater energy efficiency; and protect biodiversity, whilst achieving economic growth through enhanced employment opportunities and improved social welfare.

Table 2. Strategic orientations of the SSP and components relevant to mitigation.

Strategic orientation	Components relevant to climate change mitigation
Responding to climate change and improving resilience	• Promote sustainable use of resources • Encourage distributed, localised networks of utilities, including water and energy storage, to improve resilience of provision • Introduce a waste management hierarchy with priority given to waste reduction followed by reuse, recycling and energy recovery • Address pollution issues arising from lack of appropriate sewerage treatment systems • Develop renewable energy sources and reduce dependence on imported oil
Supporting provision of efficient and resilient utilities	• The emphasis is placed on low cost interventions to achieve modern connected systems that meet typical international standards in terms of efficiency and quality of provision
Promoting multi-modal transport solutions	The components relevant to land transport are: • Close integration of land use, transport planning and development • Development of an integrated multi-modal transport system providing choice with a high degree of integration within the transportation system • Highway improvements to address issues of congestion • Measures to reduce dependence on car, promote use of sustainable transport modes and increase the proportion of trips made by public transport • Reduced air pollution, noise and carbon emissions from transport • Provision of connected, comfortable and safe pedestrian and cycling infrastructure • A range of practical Travel Demand Management strategies

Source: Government of Seychelles, 2015b

1.3 Sector selection

The selection of priority sectors for CC mitigation is based on the relative contributions of different sectors to GHG emissions in Seychelles. This section therefore provides a discussion of the sectoral GHG emissions in Seychelles based on the inventory reported in the Second National Communication, SNC (Government of Seychelles, 2011b). It also provides expected GHG emission trends in the different sectors, as well as mitigation scenarios based on the more recent analyses in the Seychelles INDC (Government of Seychelles, 2015a). The process for selecting the priority mitigation sectors for the TNA project is also discussed.

1.3.1 An overview of sectors, projected climate change, and GHG emissions status and trends of the different sectors

The current and projected climate change in Seychelles and sectors vulnerabilities are discussed in detail in the Seychelles Technology Needs Assessment Report – Adaptation (Government of Seychelles, 2016), and are not covered here. The discussion covers only sectoral GHG emissions status and trends, as well as mitigation scenarios, while bearing in mind that the national GHG inventory is yet to be updated under the Third National Communication (TNC). Further, the National Bureau of Statistics does not publish energy and environmental statistics that would allow emissions trends to be calculated. Consequently, the analyses of GHG emissions provided here have relied on the results reported in the SNC, and, where applicable, using the scenarios developed for the INDC.

The Seychelles is an insignificant emitter of GHGs by world standards as it accounted for only 0.001% of the global emissions of GHGs in 2000, and less than 0.003% of world emissions in 2011. Further, excluding the offsetting capacity of ocean biomass and marine ecosystems (or blue carbon), the Seychelles was a net sink of GHGs in 2000 at -564,232 tCO_{2e} (Government of Seychelles, 2011b). According to data provided in the SNC, the Seychelles is not expected to become a net emitter of GHGs before 2025. Voluntary emission reductions will only postpone the time when the Seychelles will become a net emitter.

Between 1995 and 2000 overall CO_2 emissions increased by 43 % and the removal capacity decreased by 1 % only. The changes in the emissions of the three main GHGs and sinks over this period are shown in **Table 3**. The data also reveals that CO_2, CH_4 and N_2O represented 77.5%, 19.5% and 3.0% of all emissions in 2000.[3]

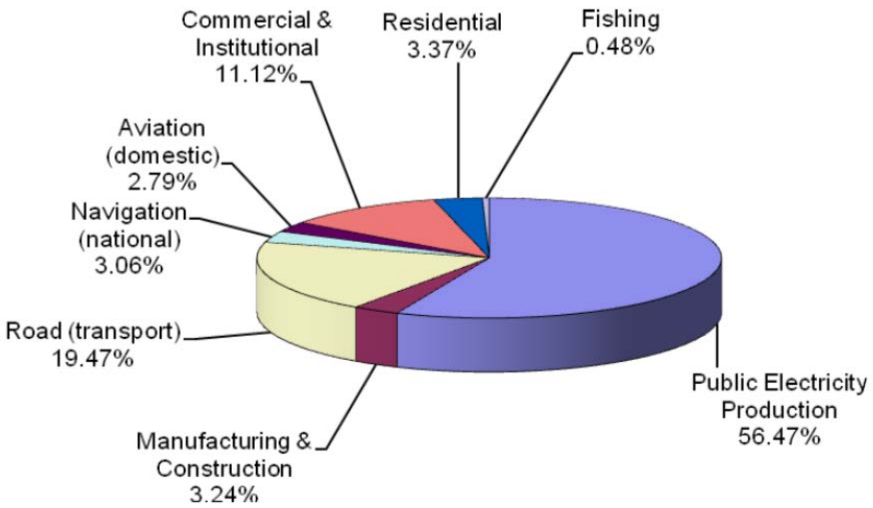
Table 3. Emissions of main GHGs and removal of carbon dioxide in 1995 and 2000 (tonnes).

GHG	1995	2000	% change
CO_2 emission	191,378	273,148	+43
CO_2 sequestration	-845,310	-837,380	-1
CH_4	2,563	2,743	+7
N_2O	77	36	-53

Source: Government of Seychelles, 2011b

Approximately 95% of all national emissions in 2000 took place in the energy sector. The remaining 5% of national emissions was accounted by forestry (Government of Seychelles, 2011b). The breakdown of CO_2 emissions in 2000 is shown in **Figure 2**. The main emitting sub-sector was the production of public electricity (~56.5% or 147,151 tCO_2) followed by transport (~25.3%), of which ~77% (or 50,732 tCO_2) emanated from road transport.

[3] Assuming the following global warming potentials (GWP): CH_4 – 25, N_2O – 298. The CO_2:CH_4:N_2O ratio is 79.9%:16.8%:3.3% when GWPs of 21 and 310 are used for CH_4 and N_2O, respectively.



Source: Government of Seychelles, 2011b

Figure 2. CO_2 emissions by sector in 2000.

Emissions from industrial processes and agriculture are insignificant in the Seychelles (Government of Seychelles, 2011b). The emissions from agriculture were deemed to be so insignificant that the SNC mentions that it might not be necessary to calculate emissions from agriculture in the future. Concerning forestry, it was estimated that 8,000 m^3 of biomass was harvested annually amounting to an annual emission of 12,540 tCO_2. In contrast, the sink capacity of forests was 837,380 tCO_2 with an expected loss in sink capacity of 1% every 5 years. Solid waste generated some 2,510 tCH_4 in 2000 (Government of Seychelles, 2011b), making it the third largest source of GHG emissions. In 2000, emissions related to fuel combustion in cooking represented 6% of national emissions.

Emissions projections and mitigation measures

Public electricity (or power generation)

The SNC also presented some emissions results for the year 2007. The generation of public electricity and transport accounted for 82.0% and 82.8% of all emissions in 2000 and 2007, respectively (Government of Seychelles, 2011b).

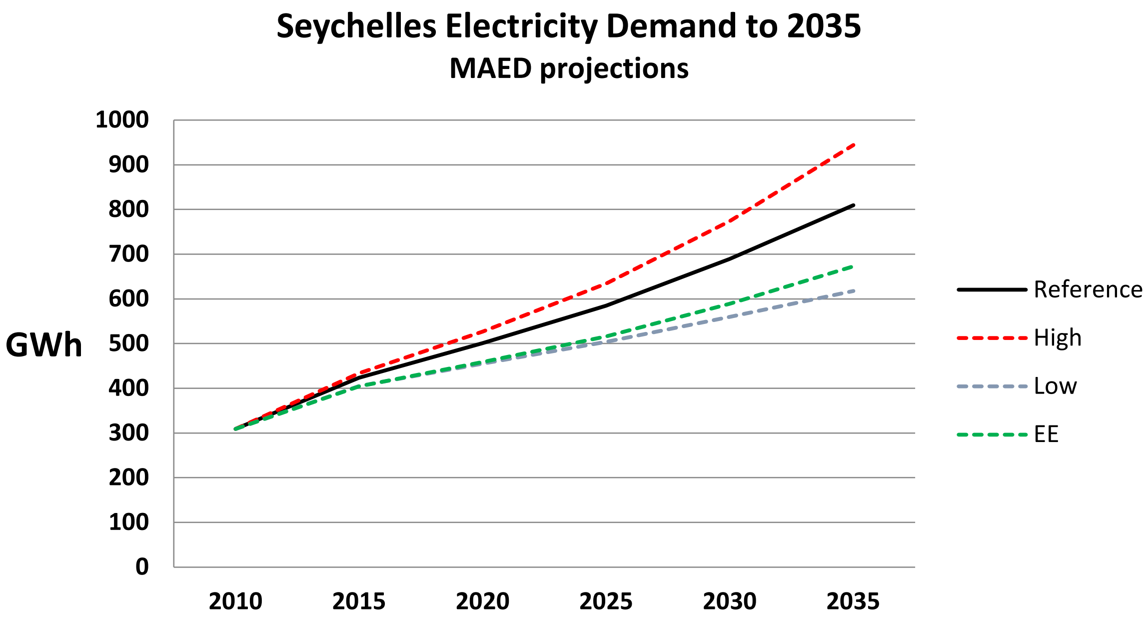
Emissions scenarios were developed for all sectors under the SNC. The baseline scenario for the generation of public electricity reported in the SNC assumed an exponential growth of electricity demand as the economy would grow at a rate of 2.6% per annum. The projected change in CO_2 emissions assuming a status quo in technology usage is shown in **Table 4**. The table also shows the results from analysis carried out during the formulation of the Seychelles INDC that is discussed below.

Table 4. Projected CO_2 emissions from electricity generation.

Year	2006	2010	2015	2020	2025	2030
CO_2 (tonne) - SNC	172,655	203,851	258,045	332,355	431,996	564,226
CO2 (tonne) - INDC	not calculated	204,040	279,410	330,250	385,710	454,400

Source: Government of Seychelles, 2011b and MWH and Expertise France, 2015

More recently (as introduced in section 1.2), MAED modeling has been used to develop electricity demand scenarios. These scenarios were used to develop the potential GHG mitigation contribution of the Seychelles INDC. **Figure 3** shows the projected demand of electricity under different scenarios. The Reference (Ref), Low and High scenarios refer to annual GDP growth rates of 5%, 3%[4] and 6%, respectively. The Energy Efficiency (EE) scenario is one where the annual energy intensity drops by 20% compared to 10% in the Reference scenario. This scenario is based on the Reference scenario (scenario 1) with a GDP growth rate of 5% per year, except that in Industry the *energy intensity decreases* ***by 20% per year*** in all the sub-sectors of industry for motor fuel uses, electricity specific uses and thermal uses except in Agriculture and in Manufacturing (MWH and Expertise France, 2015). It is assumed that for the period of the study 2010-2035, the population will grow at a constant rate of 1% per year, corresponding to the annual average growth rate for the preceding 10 years. It is also assumed that the structure of the GDP is the same as for 2010 throughout the study period.The EE interventions are listed in section 1.2.



Source: MWH and Expertise France, 2015

Figure 3. Electricity demand to 2035 under different scenarios.

During the process of developing the Seychelles INDC, the SEC revealed that the realistic non-GHG targets that have been proposed in the Energy Policy 2010 should be 15% for diversification of electricity generation using renewables by 2030, and to achieve the energy efficiency scenario given in the figure above.[5]

In order to calculate the emission reduction potentials of these non-GHG targets applied to the MAED scenario projections shown in **Figure 3**, the grid emission factor of the Seychelles was calculated

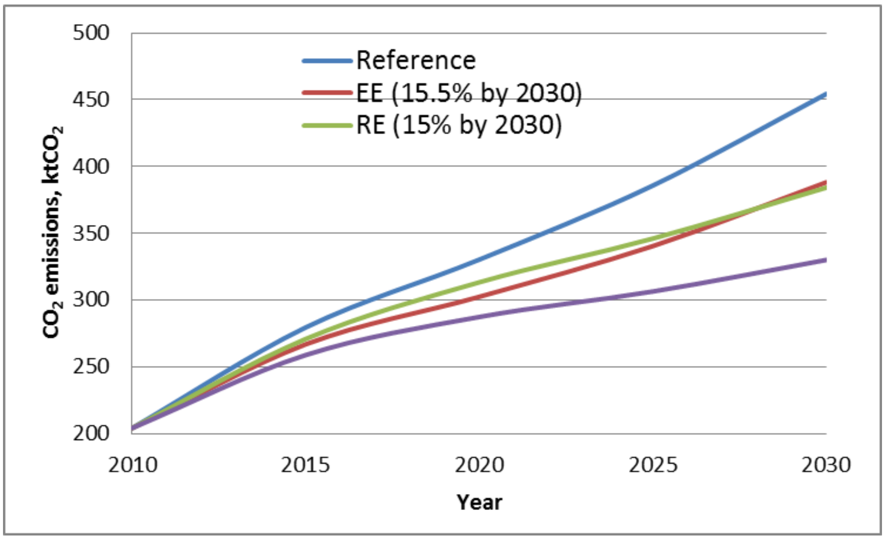
[4] The 3% growth rate in the Low scenario is close to the GDP growth rate of 2.6% used in the SNC.

[5] The Energy efficiency (EE) scenario results in a 14.56% reduction in energy efficiency in 2030. The efficiency is 4.52% in 2015 and reaching 16.91% in 2035.

using the Clean Development Mechanism (CDM) Methodological Tool 07 – i.e. “Tool to calculate the emission factor for an electricity system (Version 04.0)”.[6] Generation data was provided by the Public Utilities Corporation (PUC). The calculations are shown in **Annex II**. The combined margin grid emission factor was calculated for Mahe and Praslin that are not interconnected grids. In order to calculate the GHG emission reductions associated with the non-GHG targets discussed above, the weighted average of the Mahe and Praslin emission factors was calculated based on their respective share of electricity generation. For electricity supply diversification from renewable energy sources that are intermittent such as wind and solar PV, the combined margin emission factor has been calculated as 0.67887 tCO_2/MWh. For all other renewable energy sources and end use energy efficiency, the combined margin emission factor has been calculated as 0.65936 tCO_2/MWh.

Since the supply side diversification in the Seychelles is expected to be primarily from solar PV and wind energy (as per the Energy Policy 2010), the combined margin emission factor (0.67887 tCO_2/MWh) has been applied to convert the non-GHG target of 15% renewables in the electricity mix in 2030 into the equivalent amount of GHG emissions. Similarly, the emission factor of 0.65936 tCO_2/MWh has been applied to obtain the emission reductions associated with demand side energy efficiency gains.

The GHG emission scenarios were calculated using a combination of the Reference scenario and the targets of 15% RE and 15.5% EE in 2030. The results are shown in the **Figure 4**. In the calculations, it has been assumed that EE is carried out first and then the diversification of energy supply using RE. As shown in **Table 4**, the projections developed during the INDC process are fairly close to those reported in the SNC up to the year 2020 (difference of ~0.6%). However, the exponential growth in electricity demand assumed in the SNC generates a large difference of ~24% in 2030 when compared with the INDC results.

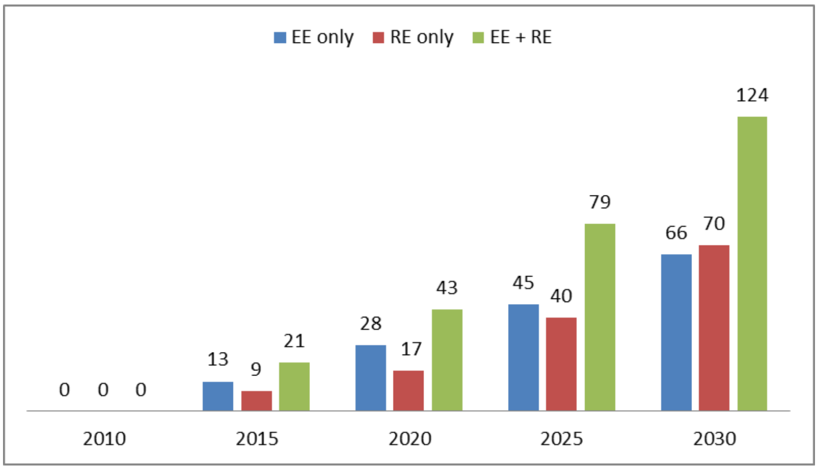


Source: MWH and Expertise France, 2015

Figure 4. CO_2 emission reductions from EE and RE targets in the power sector.

[6] http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v4.0.pdf - accessed 12 December 2013.

The GHG emission reductions ($ktCO_2$) related to the scenarios given above are shown in the bar chart below (**Figure 5**). The SNC proposed a combination of mitigation measures, including cogeneration at Victoria C power station, 3 MW of wind energy, 5000 m^2 of solar PV, 50% of all power generation from combined cycle gas turbine (CCGT), and reduction of transmission and distribution losses through the implementation of a new 33 kV line along the East coast of Mahe, which was expected to result in 77.6 $ktCO_2$ emission reductions.



Source: MWH and Expertise France, 2015

Figure 5. CO_2 emission reductions ($ktCO_2$) from EE and RE targets relative to the Reference scenario.

Transport

According to the Energy Policy 2010 (Van Vreden et al., 2010) energy use in the transport sub-sector can be reduced by 15-30% (or even more) by 2030 (**Table 1**). Projections have been made in the SNC regarding the increase in baseline emissions from road transport sector from 66,525 tCO_2 in 2005 to 167,087 tCO_2 in 2030. The projections correspond to an increase in the number of vehicles from 10,622 in 2005 to 20,000 in 2030. Fossil fuel consumption is expected to increase from 21,324 t (2005) to 53,620 t in 2030. **Table 5** summarises the baseline emissions and emission reductions up to 2030 for transport taken from the SNC and INDC. The numbers in brackets show the equivalent percentage reduction relative to the baseline emissions.

Table 5. Emission reduction in the transport sector, tCO_2.

Year	2010	2015	2020	2025	2030
Baseline emissions (tCO_2)	80,754	96,390	117,310	139,998	167,087
Emission reductions (SNC)	4,038 (5%)	9,639 (10%)	23,462 (20%)	34,999 (25%)	41,772 (25%)
Emission reductions (INDC)	0 (0%)	0 (0%)	5,865 (5%)	25,200 (18%)	50,126 (30%)

Source: Government of Seychelles, 2011b and MWH and Expertise France, 2015

The revised emission reductions used in the INDC reveals the difficulties in mitigating emissions in the transport sector. The mitigation actions proposed in the SNC for the transport are listed in **Table 6**. Some of the proposed actions are still relevant and have been shortlisted for prioritisation in chapter 4.

Table 6. Mitigation measures for the transport sub-sector proposed in the SNC.

Mitigation technology options Switch to lower-carbon fuels (e.g. LPG); solar powered buggies (for hotels); operation of electric light rail / tram system; road improvement programme; integrated land-use and transport planning; traffic management in Victoria; vehicle maintenance programme; use of solar street lights
Mitigation measures modeled Measures for light duty vehicles (e.g. fuel economy standards, fuel taxes, incentives for alternative fuel use, measures to reduce vehicle use); maintaining high fuel prices; encourage and promote use of public transport; road taxes; lower taxes for fuel efficient vehicles; carbon / CO_2 tax; emission standards and mandatory vehicle inspection/testing; import restriction for used vehicles; control of movement of Heavy Duty Vehicles

Source: Government of Seychelles, 2011b

Residential, Commercial and Institutional (RCI) sub-sectors

The projected direct (stationary combustion of fossil fuels) and indirect (use of electricity) CO_2 emissions in the RCI sub-sectors are summarised in **Table 7**. Since the same electricity tariff was used for the commercial and institutional sub-sectors, the SNC assumed a 65%:35% share of electricity use by the commercial and institutional sub-sectors, respectively.

Table 7. Projected direct and indirect CO_2 emissions in the RCI sub-sectors.

Year	**2010**	**2015**	**2020**	**2025**	**2030**
Direct CO_2 emissions					
Residential	11,016	14,153	17,290	20,427	23,564
Commercial & Institutional	54,955	67,814	80,674	93,533	106,393
Sub-total	65,971	81,967	97,964	113,960	129,957
Indirect CO_2 emissions					
Residential	115,210	138,423	161,636	184,849	208,062
Commercial & Institutional	195,527	234,947	274,367	313,787	353,207
Sub-total	310,737	373,370	436,003	498,636	561,269
Total (BAU)	**376,708**	**455,337**	**533,967**	**612,596**	**691,226**
Total (mitigation)[7]	***376,708***	***409,174 (15%)***	***427,174 (20%)***	***459,447 (25%)***	***518,420 (25%)***

Source: Government of Seychelles, 2011b

Table 7 also shows the projected reduction in overall emissions from the RCI sub-sectors by applying the mitigation actions listed in **Table 8** (and their accompanying regulatory and financial/economic instruments).

Table 8. Mitigation actions proposed for the RCI sub-sectors.

[7] The numbers in brackets show the percentage reductions in GHG emissions relative to the BAU scenario.

Residential	Commercial and Institutional
• Replace electric water heater with solar water heater • Replace incandescent bulb with CFL • Use most energy efficient appliances where appropriate • Use gas cooker instead electric cooker	Use of: • solar water heater • compact fluorescent lamp • energy efficient appliances • photovoltaic system for lighting • efficient air-conditioning system

Source: Government of Seychelles, 2011b

Industrial sub-sector

The industrial sector consists mainly of light and medium industries involved in manufacturing and construction. According to the SNC (Government of Seychelles, 2011b), it was the second largest consumer of energy in the country. The SNC adopted a linear model to forecast the energy consumption in the industrial sub-sector. GHG emissions emanate from the stationary combustion of fuel oil and gas oil, and the use of electricity, and the results are summarised in **Table 9**.

Table 9. Industrial energy use and GHG emissions: 2010-2030.

Year	2010	2015	2020	2025	2030
Electricity (ktoe)	2.65	2.90	3.19	3.45	3.72
Fuel (ktoe)	9.34	11.03	12.72	14.41	16.1
Total GHG emissions (tCO_2)	47,921	55,064	62,208	69,351	76,494

Source: Government of Seychelles, 2011b

A mitigation scenario was developed based on the implementation of the mitigation options listed in **Table 10**. This table also summarises the measures and instruments that were proposed in the SNC in order to implement the mitigation technologies.

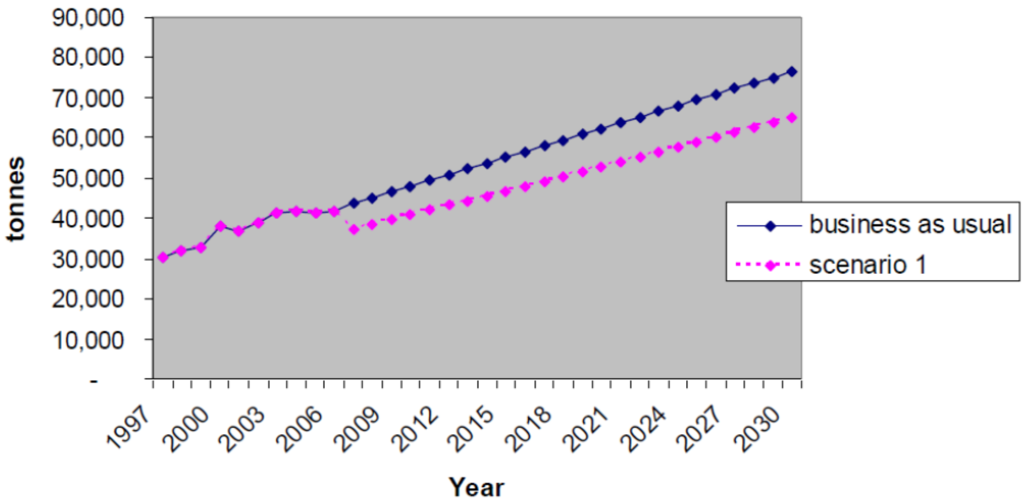
Table 10. Description of mitigation technologies and accompanying measures for the industrial sub-sector.

Mitigation technology or measure	Description
Mitigation technologies	
Fuel switch	Shift from fuel and gas oil to natural gas (less carbon intensive fuels).
Co-generation	Through the utilisation of the heat, the efficiency of a co-generation plant can reach 90% or more. Co-generation therefore offers energy savings ranging between 15-40% when compared to the separate supply of electricity and heat from conventional power stations and boilers. This option has been proposed for auto-producers of electricity.
Renewable energies	Seychelles has good solar radiation for the application of solar technologies (photovoltaic). Many industries in the Seychelles are encouraged to use solar water heaters for producing hot water or to pre-heat water in boilers. The use of PV-generated renewable electricity would help to help minimise CO_2 emissions from thermal power generation.
Instruments or measures for implementing technologies	
Incentives	***Monetary incentives***: Grants for the purpose of conducting comprehensive energy audits and implementing corresponding measures to improve efficiency or to conserve energy or purchase replacement or retrofit equipment that is more energy

	efficient; ***Tax incentives:*** Refundable tax credit provided for the purchase of equipment or other capital expenditures that will result in quantifiable energy savings; ***Loan programme:*** Creation of an energy efficiency loan programme to offer low-interest loans for large capital expenditures to reduce energy consumption.
Tariff structure	Tariff charges for the industrial sector are divided into two categories: the single-phase (tariff 210-220) and the three-phase (tariff 310-320). This was revised in 2008 due to the increase in the oil market prices. Government took the decision to revise the tariff every six months and the value of the new tariff is determined by international oil prices. The revision can be made every 3 months, which is the interval at which SEYPEC procures fuels. This makes energy prices more cost reflective.
Carbon tax	Seychelles has not implemented any carbon taxes but in the future when this would be well implemented it could play a significant role in the reduction of the total carbon dioxide emission annually.
Emission Standard and offset	Emission standards and offset have to be determined by the Seychelles' Bureau of Standards in collaboration with the Department of Environment to suit the current situation.
Voluntary agreement	Voluntary agreement is suitable to achieve a reduction in CO_2 in industries. This can be implemented by each entrepreneur by developing an energy conservation plan or better known as an energy management programme.
Energy auditing	Energy auditing can be used to identify areas where there are energy wastages and losses in the industrial sector. Energy auditing can be performed by any industry at least every 2-3 years.
Research, development and demonstration programme	Industries invest in research, development and demonstration programmes to improve their productivity and product quality. Increasing energy productivity would lead to a decrease in GHG emissions.

Source: Government of Seychelles, 2011b

It was assumed that technologies and measures listed in **Table 10** could produce a 15% reduction in GHG emissions relative to the baseline scenario in 2015, as well as a similar year-on-year emissions reductions. The baseline and mitigation scenarios are shown in **Figure 6**.

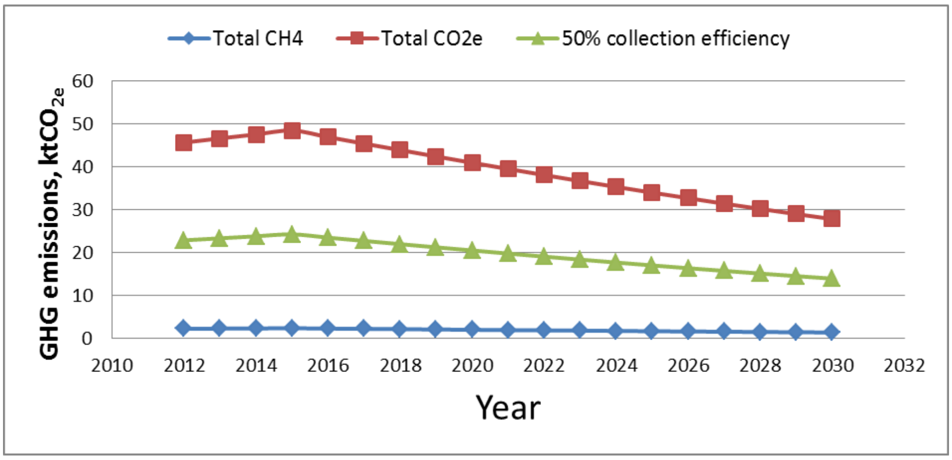


Source: Government of Seychelles, 2011b, pg.160

Figure 6. Trend and projections in GHG emissions (tCO_{2e}) in the industrial sub-sector for the baseline and mitigation scenarios.

Solid Waste

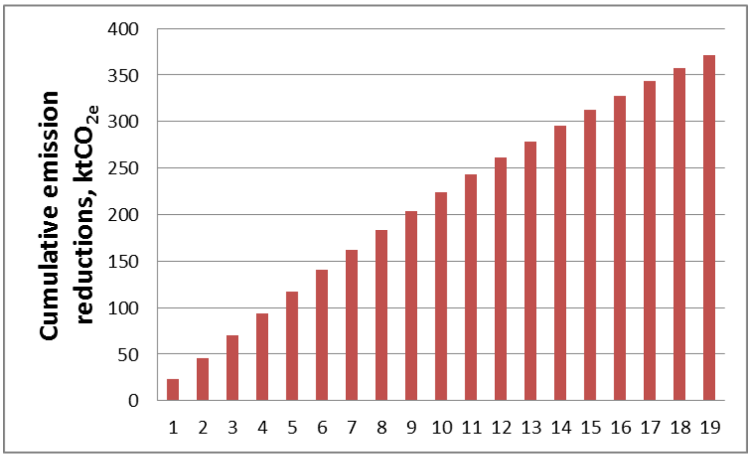
Emission reductions from solid waste management were included in the Seychelles INDC (Government of Seychelles, 2015a). Currently, the emissions of CH_4 at landfills are not captured for flaring, nor used for electricity generation. The projected emissions profile of CH_4 is shown in **Figure 7** for the period covering 2012 and 2030.[8] The projections are for a daily volume of 96 tonnes of solid waste, and a lifetime of landfill spanning 1995 and 2015.[9] The profile for the equivalent CO_2 emissions is also shown **Figure 7** below,[10] and a conservative scenario where only 50% of the emissions are captured for flaring is also shown. There is currently no provision for power generation using the captured emissions.



Source: MWH and Expertise France, 2015

Figure 7. Emission of methane from the old landfill.

The cumulative emission reductions are shown in **Figure 8**.



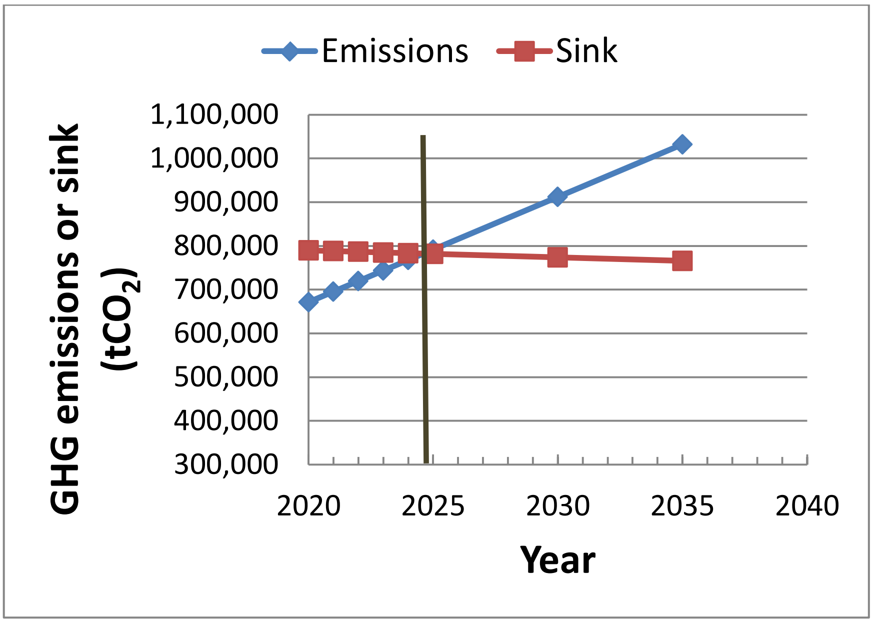
Source: MWH and Expertise France, 2015

[8] The projections were made using the US EPA exponential decay model.
[9] 2015 is the year when the old landfill was expected to be closed.
[10] A Global Warming Potential of 21 was used for CH_4.

Figure 8. Cumulative emission reductions from landfill gas capture: 2012-2030.

Land Use, Land Use Change and Forestry (LULUCF)

The forestry sector remains the greatest national asset for the removal of CO_2. According to the SNC (Government of Seychelles, 2011b), the Seychelles is currently a net sink. With GHG emissions projected to increase from 310,816 tCO_2 in 2005 to 911, 985 tCO_2 in 2030, and its removal capacity decrease from 813,780 tCO_2 in 2005 to 773,896 tCO_2 in 2030, the Seychelles is not expected to become a net emitter until 2024-2025. The cross over point is shown in **Figure 9** assuming linear changes in the GHG emissions and sink profiles. The reduction in sink capacity is projected to take place by 1% every 5 years, and it is assumed that this could not be avoided since reclaiming land for built-up areas (to protect forests) has proved to be too costly (Government of Seychelles, 2011b).

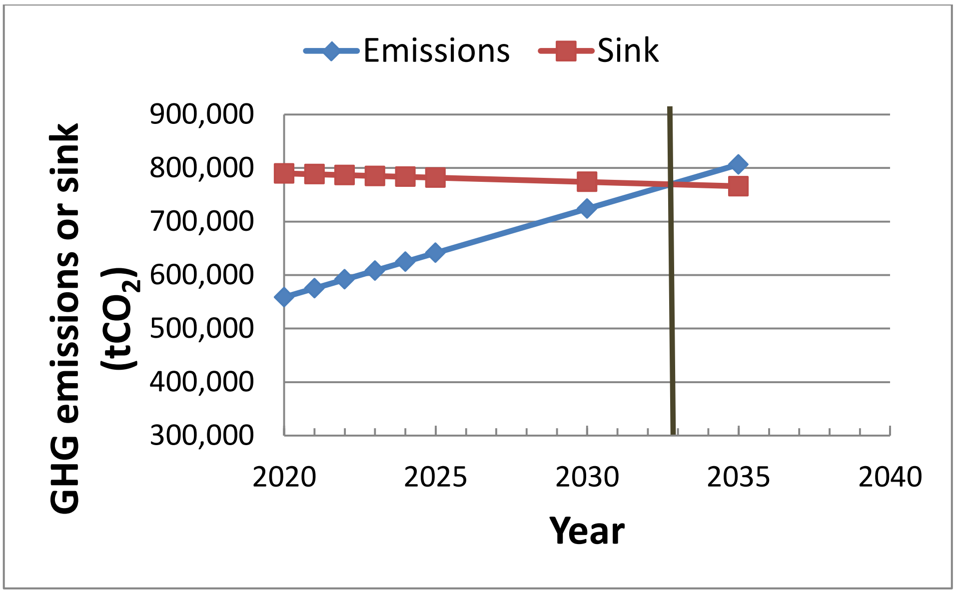


Source: MWH and Expertise France, 2015

Figure 9. Projected GHG emissions and sink under business as usual scenarios.

It is worth noting that, all else being equal; achieving the GHG emission reductions of 188 $ktCO_2$ proposed in the Seychelles INDC[11] (Government of Seychelles, 2015a) will shift the cross-over point close to 2033 (see **Figure 10**) – i.e. prolonging the time period during which Seychelles remains a net sink of GHGs. It is pointed out that prolonging the cross-over point into the future is expected to take place without any additional enhancements of carbon sinks – i.e. without any deliberate interventions to increase carbon stocks.

[11] Assuming a linear reduction in emissions.



Source: MWH and Expertise France, 2015

Figure 10. Impact of the Seychelles INDC on its net emissions profile.

The mitigation options proposed in the SNC in relation to LULUCF are summarised in Table 11.

Table 11. Mitigation options in the LULUCF sector.

Mitigation option	Description
Prevention of soil degradation	Land degradation is a major form of forest depletion. Hence, there is a need to put in place policies and legislation to prevent soil degradation. This is a cross-sectoral issue that has to be addressed together with the ministries responsible for agriculture and land use.
Prevention and control of forest fire	Fires pose a serious threat to forests. The damage caused by forest fires is still visible on the islands of Praslin and Curieuse, where the vegetation regeneration has been very slow. This measure also protects biodiversity, since forest fire favours the propagation of invasive alien species.
Maintaining, enforcing and updating legislations	The Department of Environment should be better equipped, both in term of human resources and equipment, to enforce existing regulations for forest management and conservation. There is also the need to review all existing regulations and to declare other regulations to ensure proper and effective protection of the forest areas.
Development of a Sustainable Development Masterplan	Such a plan will help reduce the risk of uncontrolled development and will provide government with a tool to facilitate the process of development, and at the same time protect the forests.
Proper spatial planning capabilities	Special emphasis should be placed on spatial planning to ensure that all infrastructural development projects fall within the Planning Authority's purview.
Reclamation	Land reclamation is an effective way to mitigate GHGs, and in the Seychelles it has effectively reduced the pressure to develop forest areas for infrastructure. There is the need, however, for a stronger emphasis on the application of a sustainable development strategy to develop current and future land reclamation projects, while taking into account SLR.
Sustainable lifestyles	Promoting sustainable lifestyles can minimise the ecological footprint of every household, organisation and district.

Mitigation option	Description
Forest management and conservation	There needs to be a reinforcement of the Forestry Division with additional human resources and necessary equipment so as to ensure the effective implementation of the Forest Management Plan.
Data collection, storage and dissemination	The lack of high quality and timely forestry and land use data has been a significant problem in tracking the changes in carbon sinks related to LULUCF. A mechanism should be put in place to collect, process, store and disseminate such data.

Source: Government of Seychelles, 2011b

1.3.2 Process and results of sector selection

The process for prioritising mitigation sectors has been aligned with the approach adopted in the Seychelles INDC (Government of Seychelles, 2015a) – i.e. focusing on sectors that contribute most to the generation of GHGs. The national emissions profile discussed in the previous section clearly shows that the priority sector for mitigation in Seychelles is the energy sector. In particular, the generation of electricity and transport are significant emitting sub-sectors. The Seychelles Nationally Determined Contribution proposes to reduce GHG emissions in 2030 by 188 $ktCO_{2e}$ relative to baseline emissions. In 2030, the emission reductions from the generation and use of electricity (~124 $ktCO_{2e}$ in **Figure 5**), and land transport (~50 $ktCO_{2e}$ in **Table 5**) are expected to be around 174 $ktCO_{2e}$ in 2030 – i.e. ~93% of the total quantity of emission reductions.

In the Seychelles, climate change mitigation to stabilise the climate system is not a primary objective. Mitigation is rather seen as an important outcome or by-product of decreasing the country's dependence on imported fossil fuels (i.e. increase in energy security), and to enhance its balance of trade profile (through a reduction in its energy bill) (Government of Seychelles, 2009). The energy bill of the Seychelles represented 25.15% of its total import bill in 2014.[12] Except for the generation of 2.15% of renewable electricity in 2014,[13] all the other energy needs of the Seychelles were met from imported fossil fuels. Again, the generation of public electricity and fossil fuel use in transport are two significant energy end use sectors.

Further, the discussions in section 1.2 (please see **Table 2**) showed that the CCM components of the SSP 2015-2040 (Government of Seychelles, 2015b) are squarely focused on: (1) the promotion of RE to reduce dependence on imported oil, (2) supporting the provision of efficient and resilient utilities, including power generation, and (3) promoting multi-modal transport solutions. To further highlight the focus of the SSP 2015 – 2040 on the power sector and transport, its policy measures are detailed in **Table 12**.

Table 12. Measures proposed in the Seychelles Strategic Plan related to climate change mitigation.

Policy CC6 Establish an Energy Hierarchy This is achieved by applying the following energy hierarchy: • **Mean**: reduce demand for energy through a (national) programme of education and introduction of

[12] According to the 2014 provisional data provided by the National Bureau of Statistics, the total cost of all imports was Rs 14.5 billion, of which the imports of fossil fuels were Rs 3.7 billion.

[13] Data provided by the PUC shows that the total grid electricity generated on Mahe and Praslin was 362.7 GWh in 2014. In the same year, the generation for solar PV and wind was 7.8 GWh.

measures such as energy efficient appliances and appropriate environmental performance in building design. Developments should comply with the standards for sustainable design and construction in accordance with Policy CC10.

- **Lean**: reduce losses by encouraging the upgrading of transmission lines and supporting energy generation from low carbon sources. Investigate measures for increasing energy storage at the local and national level.
- **Green**: increase the share of energy generated from renewable sources. Optimise opportunities for the provision of energy from renewable sources both on-site and off-site.

Policy CC10 Promote Sustainable Design and Construction

The design and construction of all new development, and the redevelopment and refurbishment of existing building stock will adopt and incorporate sustainable construction standards and techniques. This will include (among others):

- Considering how all aspects of development can contribute to securing high standards of sustainable development including aspects such as energy, water efficiency and biodiversity gain.
- Designing to optimise the use of natural lighting, heat and ventilation to minimise demand for artificial heating and cooling. Energy supplies should be provided in accordance with the requirements of Policy CC6.

Policy CC11 Develop a Sustainable Buildings Rating System

- New building developments will be assessed against a Sustainable Buildings Rating System.

Policy U1 Deliver Resilient and Efficient Utilities Systems

GoS will work with partners, developers and investors to achieve and promote the development of modern, sustainable, effective and resource-efficient utilities systems.

- GoS and infrastructure providers will promote good practice in efficient resource use.

Policy TR1 Integrate Land Use Planning and Transport

An integrated approach to land use and transport planning will be adopted to minimise impacts of new developments on the transport system.

New developments will be required to:

- Make appropriate connections to roads, public realm, and public transport networks.
- Promote and facilitate the use of sustainable modes of travel, including walking, cycling and public transport.

Policy TR2 Promote an Multi-modal Approach to Transport Assessment

Any new development that increases traffic volume will be required to promote sustainable modes of travel. Any such development will also need to demonstrate that it will not give rise to traffic impacts on the transport network, which would exceed design capacity. Mitigation measures, such as travel demand management measures, should be provided where necessary.

Policy TR5 Improve Strategic Road Network

This policy seeks to undertake a programme of improvements to the strategic road network including but not limited to:

- A package of short term measures to address problems of congestion caused by through traffic in Victoria as identified in the Victoria Masterplan;
- The intra-island connector road between Bois du Rose Avenue and Ile Aurore including a new road

between Bois de Rose Avenue and Ile du Port;
- Western Victoria bypass between Beau Vallon and Saint Louis which includes a new stretch of road and highway improvement works;
- The link road between Bois de Rose Avenue and Mont Fleuri/Forêt Noire;
- Dualling of the Bois de Rose Avenue/Providence Highway/East Coast Road between Victoria and Anse Royale;
- Upgrade La Gogue Road between Glacis and Anse Etoile;
- Extension of Port Launay Road to Cap Ternay; and
- Provision of a restricted access connection between Grand Anse and north coast in Praslin.

Policy TR7 Promote Public Transport

This policy is for promoting and strengthening the use of public transport by:
- working with all stakeholders to improve the bus network and deliver related infrastructure;
- allocating and managing highway space to encourage bus transport; and
- providing an integrated and comprehensive travel planning advice service.

New developments should make suitable provision for public transport and, where appropriate, for improved interchange between different modes of transport. Provision may include new interchanges, bus stops, shelters, passenger seating, signage, and timetable information.

Policy TR8 Promote Walking and Cycling

This policy promotes walking and cycling and creation of high quality, safe streets and public spaces, pedestrian links and facilities for cyclists. New developments will be required to make suitable provision for pedestrians and cyclists.

Policy TR9 Maintain a Sustainable Transport Network on La Digue

This aims to maintain a sustainable non-motorised transport network on La Digue. Provision for motorised transport will be subject to strict controls to protect the distinctive character of the island and its natural environment.

Policy MTR1 Ensure Public Transport Provision

Land identified in Public Transport Framework Plan for the following public transport schemes will be safeguarded for these uses in the Land Use Plans:
- Safe and secure bus stops along the upgraded eastern corridor;
- Convenience parking at existing and proposed secondary transport hubs;
- Relocation of the existing bus terminal to two new facilities at Roche Caiman and Ile du Port; and
- Infrastructure necessary to deliver a loop bus service around Victoria including new bus stops and signage.

Parking management measures will be encouraged in Victoria to reduce congestion and promote more sustainable methods of travel. This could include re-provision of parking outside central Victoria and at public transport hubs.

Policy MTR2 Support Cycling and Pedestrian Facilities

Land identified in Public Transport Framework Plan will be safeguarded in the Land Use Plans for the provision of segregated walking and cycling links along the waterfront from Ile Aurore to south of Seychelles International Airport. Land will also be safeguarded for the provision of a segregated cycling route in Beau Vallon as illustrated in Public Transport Framework Plan.

Source: Government of Seychelles, 2015b

Using the above rationale, and faced with financial and time constraints, the two priority mitigation sectors retained for the TNA process are:

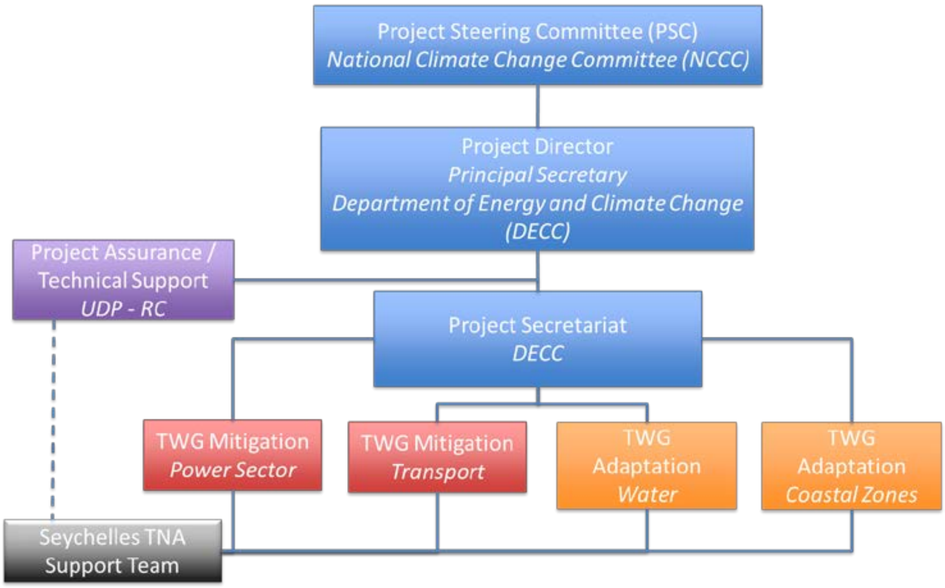
1. Power sector (energy industries), and
2. Land transport.

Chapter 2 Institutional arrangement for the TNA and the stakeholder involvement

The institutional arrangement has been set up taking in account two considerations, namely: (1) the guidance note on the institutional arrangement proposed for the TNA project (Dhar, 2014), and (2) the existing institutional structures already in place in Seychelles for managing and coordinating CC activities. The latter is particularly important given the fact that Seychelles suffers from limited human resources due to its smallness. This constraint means that the multiplication of institutions has to be minimised. The small pool of human resources also imposes constraints on the stakeholder engagement process that can be carried out in terms of both the type and the number of working sessions. In contrast, smallness bestows the advantage of close proximity between project stakeholders and the relative ease of bilateral interactions.

2.1 National TNA team

Figure 11 shows the institutional arrangement that has been set up to manage the TNA project in Seychelles. The essential elements of the institutional arrangement include a Project Steering Committee (PSC), Project Director (or TNA Coordinator), Project Secretariat, Sectoral Technology Working Groups (TWG), Seychelles TNA Support Team (i.e. National Consultants/Experts) and Project Assurance. The roles and responsibilities of these different elements of the institutional structure are discussed in the next section.



Source: TNA project

Figure 11. Institutional arrangement for the TNA project in Seychelles.

The PSC provides political support for the outcomes of the TNA project. In particular, it provides guidance for acceptance and final recommendations for consideration and/or approval at Ministry and Governmental level to the TNA outcome. The PSC is comprised of high-level representatives from the institutions responsible for policy making related to the selected technologies with regard to both adaptation and mitigation. The National Climate Change Committee (NCCC) will serve as the PSC. The TNA project will serve as an opportunity to revamp the NCCC so that it becomes the national institutional structure providing the cross-sectoral coordination of all CC-related initiatives in

Seychelles. Ultimately, the NCCC will provide oversight and political support for the mainstreaming of CC at all levels for the efficient and effective implementation, monitoring and evaluation of the NDC.

The PSC is chaired by the Principal Secretary, or representative (Head of the Seychelles National Meteorological Services), of the Department of Energy and Climate Change (DECC), Ministry of Environment, Energy and Climate Change (MEECC). The Principal Secretary is also the Project Director, a position equivalent to the National TNA Coordinator, who has the responsibility of ensuring the smooth implementation of the TNA project on a day-to-day basis. The Project Director is also the National Climate Change Focal Point.

A Secretariat for implementing the TNA project is provided by the DECC. The main role of the Secretariat is to provide administrative support for coordinating the TNA project stakeholders who constitute the sectoral Technology Working Groups (TWGs), and to facilitate the working sessions of the TWGs. The TWGs are the stakeholder platforms through which the project is implemented. There are four TWGs each representing one priority sector in the TNA project as discussed in Section 1.4 above for adaptation (i.e. coastal zones and water) and as discussed in Section 1.3 of the TNA Report for Mitigation (i.e. energy industries and transport). The members of the TWGs for the mitigation priority sectors are summarised in **Annex III**.

The Seychelles TNA Support Team is comprised of one international consultant and three national consultants. The responsibility of the international consultant is to provide technical assistance in implementing the TNA project, and to provide capacity building of project stakeholders and national consultants regarding the TNA process, methodologies and tools. The international consultant acting as Team Leader of the TNA Support Team also has the responsibility to ensure the first level of quality assurance for project deliveries. The main task of the national consultants is to provide technical support to the TWGs with the support of the Team Leader. Each adaptation priority sector is assigned a CC adaptation expert (and there is one national consultant supporting both mitigation priority sectors). The TNA Support Team also liaises with the UNEP DTU Partnership (UDP) and the Regional Centre (Energy Research Centre, University of Cape Town) to ensure that the TNA project and its deliverables are completed to the highest quality and standard. Finally, the TNA Support Team is tasked to represent the Seychelles in TNA Regional Capacity Building and knowledge sharing workshops.

2.2 Stakeholder Engagement Process followed in the TNA – Overall assessment

The members of the TNA Support Team were closely involved in the process of formulating the Seychelles INDC that took place between May and October 2015. The development of the Seychelles INDC necessitated multi-stakeholder engagements across different sectors. Given the back-to-back implementation of the INDC and the TNA project, the latter has benefitted from the prior multi-stakeholder process.

A combination of bilateral and technical working group meetings was used to accomplish the process of technology identification and prioritisation. **Annex III** summarises the institutions and persons who have participated in the TNA process, including the topics towards which individuals contributed and the consultation approach.

Chapter 3 Technology prioritisation for the Power Sector

This section is primarily focused on the mitigation options in the power sector (or energy industries) by considering government priorities regarding both power supply diversification and efficient use of electricity (i.e. demand side management). As indicated in the INDC report submitted to COP 21 in Paris in 2015, the Seychelles emitted less than 0.003% of the global GHG emissions per year in 2011 (Government of Seychelles, 2015a). While emission reductions will have positive national benefits in terms of increasing energy security, improving balance of trade in terms of reduced energy bill, and green job creation, these reductions cannot be expected to have strong global environmental benefits.

Currently, the Seychelles is almost 100% dependent on imported oil to meet its energy needs, including electricity production, with imports of fuel for electricity generation alone accounting for 12% of the total government budget (NBS, 2015). This heavy reliance on imported fossil fuels places heavy pressure on the country’s foreign exchange reserves, exacerbates state budget deficits (section 1.3.2), and poses major energy security concerns, both in terms of access to supplies and pricing. Thus, as discussed in sections 1.2 and 1.3, there are opportunities for alternatives to fossil energy in the power sector.

The economies of scale are absent in such a small market to really push implementation of projects that can make significant differences with reasonable returns on investment. Due to the smallness of the market, cost competitiveness of certain new and emerging technologies may not attract investments, since the payback maybe too long to fit in a commercial enterprise budget. The government has gone one step further to remove all duties and taxes on energy efficiency and renewable energy products. One example of a simple technology is light emitting diode (LED) lamps. The cost is so high (even by regional standard) that the market for LED is still at its infancy.

The analysis carried out in the TNA process for the prioritisation of mitigation technologies has adopted the same timeline (i.e. 2030 horizon) for technology penetration targets as the emission reduction targets proposed in the Seychelles INDC (Government of Seychelles, 2015a). Recalling from section 1.2, the Seychelles INDC made the explicit case for using the TNA project as a means of implementation, or at least enhancing preparedness for its implementation. Since only two priority mitigation sectors could be addressed under the TNA project because of limited financial and time resources, it is recommended that the TNA process is adopted to support the TNC project (Mitigation Chapter & Section on Technology Transfer and Development). Technologies that are considered for prioritization have been chosen because they support government policies, strategies and action plans.

3.1 GHG emissions and existing technologies of the power sector

As discussed in section 1.3.1, almost 95% of all GHG emission stems from fossil fuel related activities, mainly the power and transport sectors. The power sector alone contributes an estimated 56% of this amount (Government of Seychelles, 2011b). The Public Utilities Corporation (PUC) has the mandate to produce and distribute public electricity in the country. It owns and operates two power stations on Mahé and one on Praslin. The distribution systems on Mahé feed some of the inner islands via sub-marine cable, and that of Praslin feeds La Digue via sub-marine cable. Two types of fuels, namely diesel (or gas oil) (auto producers and Praslin) and heavy fuel oil (HFO) are used to produce electricity.

The 2015 consumption of fuel oil was 74,509 tonnes and that of gas oil was 309 tonnes.[14] The thermal generation capacity on Mahé and Praslin are given in **Annex II**. On the outer islands, there are small diesel generators that supply these islands with electricity. Fuel is shipped from Mahé in drums to these islands by boats. There is no readily available data on the overall installed capacity on the other islands.

The examples regarding the diffusion of renewable energy sources in the power sector are scant, and it is even more so regarding the promotion of energy efficiency (EE). The notable examples are:

- A 6 MW wind farm commissioned in 2012, contributes about 2% of the country's electricity needs with an estimated 1100 full load hours of wind resource available (please see generation data given in **Annex II**);
- There are also about 1.5MW of roof top PV systems installed in both the residential and commercial sectors;[15] and
- There is also experience at the main power station on Mahé regarding the recovery of waste heat from thermal generators to produce electricity. Currently, waste heat is recovered for preheating fuel oil used for power generation (please see **Table 14** below).

3.2 Decision context

There have been a number of steps in the past few years in the Seychelles to consolidate its national energy laws, policies and programs, and to establish and support EE and RE technologies as national priorities. The national CCM policies, strategies and action plans discussed in section 1.2 support EE and RE as national priorities. The most important achievements of this effort are discussed below:

The ***Seychelles Energy Commission (SEC)*** was established in 2010. The SEC is a statutory body established by the Seychelles Energy Commission Act of 2009, which was replaced by the Energy Act in 2012 (see below). The object of the SEC is to regulate electricity related activities for adequate, reliable, cost effective and affordable electricity while protecting and conserving the environment. It regulates the generation, transmission, distribution, supply and use of electricity. In addition, the SEC promotes the use of energy efficient technologies and renewable resources.[16]

The ***Seychelles Energy Policy 2010-2030*** was developed in 2010, and it sets a national target of 15% of energy demand met by renewable energy by 2030. The objectives of the Energy Policy are discussed in section 1.2, and the sector specific EE and RE targets are listed in **Table 1**. It is the main guiding policy document for the energy sector in the Seychelles. The Energy Policy includes significant analyses of historical, existing and projected energy demand and supply, and proposes key changes to the institutional and regulatory framework for energy in the country, including strengthening the SEC, creation of an independent Energy Regulator (that was implemented as per previous discussion), and defining independent power producer (IPP) regulations to promote RE development. The Energy Policy calls for the sustainable development of the energy sector focusing on EE and RE and reduced dependence on oil to improve energy security. The five pillars of the Energy Policy are:

[14] Data obtained from PUC.
[15] Estimate provided by PUC. Data for 2014 is given in Annex II.
[16] Please see: http://www.sec.sc/index.php/about-us - accessed 25 October 2016.

- Setting up a vision for the sustainable development of the energy sector;
- Improving the Government's knowledge base for developing long-term energy strategies and guide stakeholders in decision-making;
- Changing the regulatory framework to improve both public and private investments in the energy sector;
- Focusing on increased energy efficiency and thereby reduce waste of energy; and
- Launching programs for increasing the contribution from renewable energy in the energy matrix in Seychelles.

A diversification of the energy supply is prioritised, with a minimum share of 5% for renewable energy stipulated by 2020 and 15% by 2030. The Policy places emphasis on maximising the use of locally available renewable energy resources and improving energy efficiency, with an estimate that energy savings of up to 30% may be possible through the adoption of energy efficient technologies supported by robust systems for standards, labels, and energy audits, among others. The Energy Policy does not provide detailed targets, methods, or timeframes for implementing changes to the energy sector in the Seychelles, but the Government is already considering an update to the policy to include such details and to bring it more closely into alignment with more recent policy, legal and regulatory changes. The SEC has received approval to initiate the development of the Energy Efficiency Strategy and the Energy Efficiency Implementation Plan. In order to support the implementation of the Energy Policy, and in line with the establishment of incentives to promote RE and EE (**Table 10**), the Value Added Tax (VAT) has been removed on selected energy efficient appliances and on equipment for the production of renewable energy.

The ***Energy Act***, establishing the SEC as the electricity regulator, was enacted in 2012. The Energy Act makes provisions for the SEC to oversee electricity related activities, renewable energy sources, energy efficiency, Clean Development Mechanism (CDM), tariffs and charges; consumer protection rights, issuance of licenses and permits, and any other related matters.[17]

The functions pertaining to the energy sector and their institutional responsibility are summarised in **Table 13**.

Table 13. Functions related to the energy sector and their institutional responsibility.

Functions related to Energy Sector	Institutional Responsibility
Develop energy policies, strategies and action plans	MEECC
Approve energy policies and strategies	Cabinet
Import and domestic sale of petroleum products	SEYPEC
Transmission and distribution of water and electricity	PUC
Production of electricity	PUC/IPPs/Auto producers
Update information and statistics on energy imports, energy production and energy consumption	SEC/PUC/SEYPEC/ NSB

[17] Please see: http://www.sec.sc/images/archives/policies&regulations/acts/EnergyAct2012.pdf - accessed 25 October 2016.

Update knowledge relevant to energy research, information and training programs; liaise with international agencies	SEC/PUC/SEYPEC
Provide guidance / strategies for energy efficiency and renewable energy programs, including incentives	MEECC/SEC/PUC
Fiscal incentives on EE appliances	MFTBE
Develop standards for EE appliances	SBS
Approve prices and tariffs	Cabinet
Propose and monitor overall health and safety regulations in energy sector	PUC/SEYPEC

Source : TNA project

3.3 An overview of possible mitigation technology options in Power Sector and their mitigation potential and other co-benefits

In order to identify potential mitigation technologies, a baseline assessment of ongoing related projects and initiatives was carried out first. A list of technology options relevant to Seychelles was then drafted by consulting the views of stakeholders comprising the Power Sector TWG (see **Annex III**). The identification of potential technologies was facilitated using the indicative lists of mitigation technologies provided in Annex A7-1 of the TNA Handbook (UNDP, 2010), and in the TNA Guidebook Series – Building Sector (Cam, 2012). The choice of mitigation technologies in buildings also drew from lessons learned from international experience (UNDP & GEF, 2010). Prior to discussing the potential of various mitigation technologies, the focus is first turned to national programmes or initiatives that underscore technology development.

Programmes supporting mitigation technologies

In 2013, the Government of Seychelles started implementation of a GEF-funded project, "***Promoting Grid connected Rooftop Photovoltaic systems in Seychelles***" – also called the 'PV Project'. The main objective of this project is to increase the use of grid-connected PV as a sustainable means of generating electricity in selected main islands and smaller islands of the Seychelles, with a focus on small-scale producers who are already connected to the national electricity grid. An important aspect of the PV Project is the funding of a rebate scheme to further motivate potential investors.

The main components of the PV Project are:

1. Strengthening policy, institutional, regulatory and financial framework for grid-connected solar PV;
2. Technology support and delivery system for solar PV technology; and
3. Solar PV demonstration projects.

Under this project, legislation and regulatory framework have been reviewed, and about 1.5 MW of roof-top PV have already been installed. Over 2,000,000 SR has already been paid in the form of rebates for an installed capacity of 800 kWp.

In June 2014, the Government of Seychelles implemented another UNDP–GEF project, "***Promotion and up-scaling of climate-resilient, resource efficient technologies in a Tropical Island Context***"- also known as the 'RE Project'. The main objectives of this project were: (1) to have the governance systems; (2) use of technologies and practices; and (3) financing mechanisms that promote environmental, energy and climate adaptation mainstreamed into national development plans by 2016.

The main components of the RE Project were:

1. Improved policy, institutional, legal/regulatory and financial framework for resource efficient technologies;
2. Awareness-raising and educational campaign on resource efficient technologies;
3. Training schemes to support market for resource efficient technologies; and
4. Financing Mechanisms to support adoption of resource efficient technologies.

The RE Project and the SEC have initiated the process of developing standards and labelling for energy efficient equipment, establish building codes for new buildings, and e-waste management.

The SEC, with technical and financial support from Agence Française de Développement (AFD), has carried out an ***energy mapping study*** for identifying and quantifying energy saving potential in different commercial sectors targeting industry and tourism. Data were collected from high energy consumers like Seybrew, UCPS, CCCL, STC, FOODPRO, and hotels of different sizes and ratings. A draft report was presented to the SEC at the end of November 2015.[18]

With support from the Japan International Cooperation Agency (JICA), a project for formulating the ***Master Plan for Development of Micro Grids*** was been initiated in April 2015. A report on the studies done so far on increasing the RE integration capacity, review on maximum amount of RE deployable, and deployment of batteries is being finalised. In addition, the project will provide critical catalytic support to several programs designed to provide concessionary financing for energy and water efficient appliances, including the Seychelles Energy Efficiency and Renewable Energy Program (SEEREP), a financing scheme for the residential sector to purchase EE appliances; a credit facility of the Development Bank of Seychelles (DBS) to provide concessionary finance for the adoption of EE technologies in the Small and Medium Scale Enterprises (SME loan); and the Neptune Program of the PUC, which will provide concessionary financing for the purchase of water saving devices, including rainwater harvesting installations and other source substitution solutions. The project will play a critical facilitating role for all of these financing programs, through developing the necessary evidence-based policy frameworks, providing capacity building for financial institutions, banks and other participants to enable their participation in the programs, and increasing public awareness about the programs and the opportunities and options for end users to purchase EE technologies with concessionary financing.

<u>Potential of mitigation technologies</u>

Very few studies have investigated the potential of mitigation technologies in the Seychelles. Where they exist, focus has been primarily on mitigation technologies that serve to diversify the supply of electricity away from the heavy reliance on thermal generation using fuel oil. The most recent study was carried out in order to investigate the limits to the integration of solar PV in the national grid (Brown et al., 2016). In order to calculate the technical potential for grid PV, the installed capacities

[18] The report is not publicly available.

for wind, biomass, hydroelectricity and waste-to-energy were agreed in advance with the electric utility (i.e. PUC) and regulator (i.e. SEC) based on the potentials that are listed in **Table 14**.

Table 14. Renewable energy potential on Mahé.

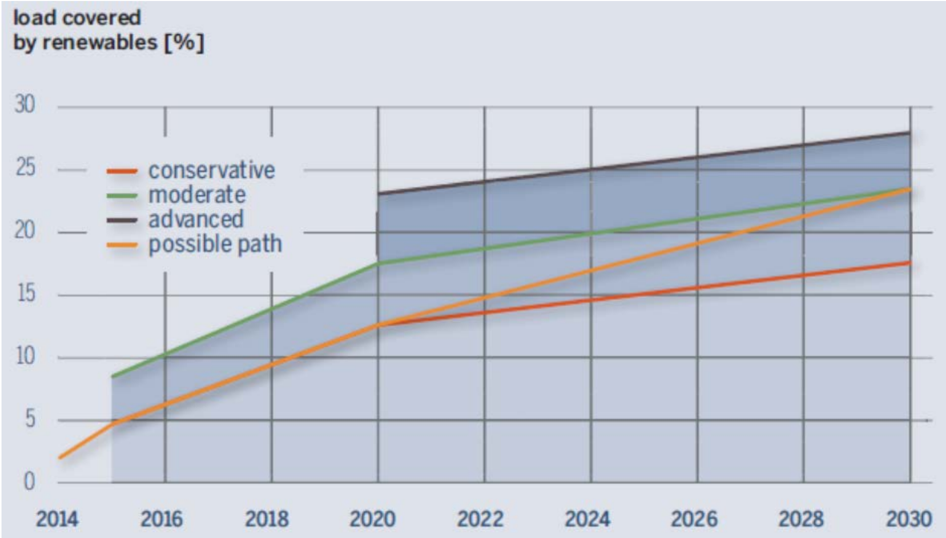
RE source (MW)	2015	2020	2030	Capacity factor (%)
Wind (harbour)	6	6	6	12.6
Wind (South)			10	16.8
Biomass			5	90.0
Hydroelectric			2	44.4
Waste-to-energy		5	7	82.2

Source: Brown et al., 2016

As mentioned in section 3.1, 6 MW of wind energy are already installed on artificial islands in the harbour. According to wind speed measurements made in 2011 (Masdar and Lahmeyer International, 2011), sites in the South that better exploit the Monsoon winds could add an additional 10 MW installed wind capacity by 2030. Further, these sites are expected to have higher annual energy yields (~1,470 full-load hours) than the current site (~1,100 full-load hours).

The biomass potential is based on a feasibility study (Moustache, 2011), which concluded that there was enough biomass from woody invasive species to last 15 years, after which energy crops could be planted (Knopp, 2012). The hydroelectric potential and the factor by which it can substitute conventional generation capacity were drawn from a report on hydro potential for Mahé (Lambeau, 2008). Based on the volume and characteristic of municipal solid waste generated on Mahé, it was estimated that a waste-to-energy plant generating 7 MW of power could be located at the refuse site between Victoria and the airport (Brown et al., 2016). The waste-to-energy mitigation option is further discussed below.

Based on the data given in **Table 14**, the load that can be covered by renewable sources of energy was computed for different scenarios as shown in **Figure 12**. The bottom line is that the penetration of 15% renewables by 2030 would be easily achieved even in the conservation scenario. The study concluded that by using innovative technologies such as demand side management and allowing the diesel generators to operate for short periods of time at lower turn-down rates, the Seychelles could cover up to 28% of its electrical demand from clean energy sources. The installed capacity of PV in 2030 for the conservative, moderate and advanced scenarios is 21.5 MW, 57.2 MW, and 85.8 MW, respectively (Brown et al., 2016).



Source: Brown et al., 2016

Figure 12. Coverage of load by all renewables for the whole of Seychelles according to different scenarios.

Technology options for the TNA project

Based on the above considerations and given the small size of the market in the Seychelles, three criteria have been used to assess the potential mitigation technology options in the power sector. These are:

1. Technologies must be proven and commercially available – i.e. technologies that require large upfront R&D are not considered;
2. The mitigation technology must be adaptable for the Seychelles; and
3. Technology options should support Government policies, strategies and action plans.

The potential technologies are shown in **Table 15** below. They were discussed by members of the Power Sector TWG during the first national TNA training workshop that was held on 28 and 29 April 2016. In the renewable energy category, the focus is on greater diffusion of solar technologies with or without storage systems, and the generation of electricity from waste (either municipal solid waste or agricultural residues). Another mitigation option is the use of RE for space cooling. The energy efficiency category focuses on technologies that will make the electricity system more efficient by either using less electricity for same outputs or recovery of heat from thermal power plants for increased electricity production. The EE technologies span different applications including buildings insulation and cold storage.

The benefits to society, environment and economy of adopting these mitigation technologies are many fold. In order to capture these benefits, appropriate indicators were selected within the multi-criteria analysis (MCA) framework to quantify them. The MCA framework used for prioritising the mitigation technologies given in **Table 15** is discussed in the next section. The social, environmental and economic benefits of the technologies are discussed below, while the results of the calculations are given in section 3.5:

1. Enhancing energy security (economic benefit): The mitigation technologies either diversify the supply of electricity using renewable energy sources or reduce the use of electricity. In

both cases, the result is a reduction in the amount of thermally-generated electricity using fuel oil. The overall impact is less dependence on imported fossil fuels, and a decrease in the country's energy bill. The contribution of the short-listed mitigation technologies towards improving the energy security of Seychelles is quantified in the next section using '*decrease in energy bill*' as indicator. The decrease in energy bill is calculated using the product of quantity of fuel oil (tonne/yr) avoided by making use of RE and EE technologies and the average price of fuel oil (US$/tonne). The quantity of fuel oil reduced or avoided is obtained by multiplying the quantity of electricity reduced (MWh/yr) and the average specific fuel use for generation of power plants [tonne (fuel)/MWh (electricity generated)]. Equations (1) and (2) summarise the calculations for quantifying '*decrease in energy bill*';

$$decrease\ in\ energy\ bill\ \left(\frac{US\$}{yr}\right) = fuel\ oil\ avoided\ \left(\frac{tonne}{yr}\right) \times\ average\ price\ of\ fuel\ oil\ \left(\frac{US\$}{tonne}\right), \quad \text{Eq(1)}$$

and,

$$fuel\ oil\ avoided\ \left(\frac{tonne}{yr}\right) = electricity\ reduced\ \left(\frac{MWh}{yr}\right) \times average\ specific\ electricity\ generation\ of\ power\ plants\ \left(\frac{tonne}{MWh}\right). \quad \text{Eq(2)}$$

2. Global environmental benefit (environmental benefit): As mentioned in section 1.2, the reduction in GHG emissions is not necessarily a primary objective of Seychelles, but it is rather a co-benefit of increasing its energy security by decreasing reliance on imported fossil fuels in favour of EE and RE. Hence, each one of the technologies listed in **Table 15** will reduce GHG emissions, and absolute emission reductions will depend on the targets or penetration levels of each technology. In brief, the GHG emission reduction is calculated as a product of either the quantity (e.g. MWh) of renewable electricity generated or the quantity (MWh) of grid electricity saved due to more efficient end uses and the grid emission factor (tCO_2/MWh) that is given in **Annex II**. Equation (3) shows the calculation.

$$GHG\ emission\ reduction\ \left(\frac{tCO_2}{yr}\right) = grid\ electricity\ avoided\ \left(\frac{MWh}{yr}\right) \times grid\ emission\ factor\ \left(\frac{tCO_2}{MWh}\right). \quad \text{Eq(3)}$$

3. Job creation (social benefit): Another benefit of diffusing or scaling up EE and RE technologies is the creation of green jobs. Seychelles is committed to the green economy as an integral part of its vision for a Blue Economy (Seychelles Ministry of Foreign Affairs, 2014). The methodology to calculate green job creation is aligned with that used in UNEP's Green Economy Report (2011a). The number of jobs generated by diversifying the supply of electricity using RE sources is calculated using Equation (4).

$$Jobs_{RE}(jobs/yr) = Installed\ capacity\ (MW)[Coefficient_{C\&I} + Coefficient_{O\&M}](\frac{jobs}{MW/yr}) \quad \text{Eq(4)}$$

Where, $Coefficient_{C\&I}$ is the job creation coefficient for the construction and implementation stage of the RE project, and $Coefficient_{O\&M}$ is the job creation coefficient during the operation and maintenance phase of the project. The job creation coefficients are derived from Rutovitz and Atherton (2009).

The number of jobs created from energy efficiency interventions is calculated using Equation (5).

$$Jobs_{EE}(jobs/yr) = Electricity\ avoided\ (\frac{MWh}{yr}) \times Coefficient_{EE}(\frac{jobs}{MWh}) \quad \text{Eq(5)}$$

Where, $Coefficient_{EE}$ is the number of jobs created per unit (MWh) of electricity avoided by EE technology. This coefficient was calculated using data given in Kammen (2009) and Wei, Patadia and Kammen (2010). The EE job creation coefficient for Seychelles was obtained by normalising the source data by the ratio of labour intensity (i.e. total number of jobs per unit of GDP) in Seychelles and the United States.

Table 15 also gives the baseline status of the mitigation technologies, as well as their targets to 2030, which is the timeframe used for the Seychelles INDC. Intermediate targets are also given in the 'Pathway' column. The second column lists the issues that were considered or suggested by stakeholders regarding the technologies. The penetration targets have been used to calculate the benefits discussed earlier, and to carry out technology prioritisation using MCA.

Table 15. Technology options and penetration targets for the power sector.

Technology Option	Description	Baseline (2015)	Pathway	Target 2030	Estimated cost (US$)
Utility-scale PV (MW scale) system with storage	It is clear from the technology options discussed in section 1.3.2 that there is a sizeable scope for the scaling up of utility-scale PV in Seychelles. As per the results shown in **Figure 12**, the realistic potential for utility-scale PV is between 21.5 MW and 57.2 MW by 2030 – i.e. the range of options between the conservative and moderate scenarios discussed in section 1.3.2. Given that the generation of electricity from PV may not be limited to the three most populated islands where the existing thermal generation can be used to back up the intermittency of PV, battery storage is proposed on the islands of Romainville and Praslin.	0 MW installed	• 5MW PV (no storage) to be installed 2017 • 4MW PV (no storage) to be installed 2018 • 2MW PV plant on Romainville Island in 2018 • 1MW PV plant on Praslin in 2018 • 4MW battery storage installed on Romainville in 2020 • 1MW battery on Praslin in 2025	• 12 MW PV • 5MW storage	• $24m (PV) • $500,000
Building Energy Management System (BEMS)	BEMS is a computer-based control system installed in buildings that controls and monitors the energy-using hardware in the building – i.e. a building's mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems. BEMS is relatively new in Seychelles as it has not been integrated in the design of existing buildings. However, new buildings are integrating BEMS in their design, especially targeting mainly space cooling in	0 system installed	• Legislation to be drafted in 2017 • 1st BEMS pilot system 2018 • 10% of building stock with BEMS by 2025	10GWh	$100,000 per building

Technology Option	Description	Baseline (2015)	Pathway	Target 2030	Estimated cost (US$)
	commercial and industrial buildings. Currently, there is no regulation that mandates the use of BEMS to enhance the energy efficiency in commercial and industrial buildings.				
Insulation in buildings	Being a tropical country, thermal comfort inside buildings is a real concern. Air conditioning is the primary option for maintaining thermal comfort inside buildings. Most building are built in concrete walls with either corrugated iron or concrete roofs, making them have high thermal mass. There is no practice of designing and building solar passive buildings that make use of adequate natural ventilation and/or building envelope insulation. Hence, energy used for space cooling is lost by convection and radiation. There is, therefore, the potential for energy savings in buildings that make use of space cooling. This can be achieved through retrofitting existing buildings and implementing roof insulation in all new buildings. In the baseline, there is no regulation than mandates the application of building thermal insulation. It is proposed that the application of thermal insulation would start as a voluntary scheme supported with appropriate incentives. Some aspects of thermal insulation can be made mandatory in 2018.	0 (Some buildings use reflective film in the roof space)	• Insulation in buildings with cooling system compulsory in 2018 • All new buildings built with roof space insulation	15GWh	$15,000 per bldg
Efficient cold storage	There are several large commercial operations that	0	• Incentive program for	5 GWh	Up to $150,000 per cold

Technology Option	Description	Baseline (2015)	Pathway	Target 2030	Estimated cost (US$)
(food processing industries)	drive the demand for cooling. In particular, there is a large demand for refrigeration in the food processing industry, and the best example is the tune processing and canning industry (Indian Ocean Tuna Ltd). Other applications of cold storage are in hotels and supermarkets		migrating to highly efficient cold storage technology in place by 2020 • All cold storage systems to have migrated to the new system by 2025		storage rooms
Agro forestry (food and energy crops)	As mentioned in section 1.3.2, there is a potential for generating electricity from agricultural residues, and agro-forestry through the generation of biomass or energy crops. According to a feasibility study (Moustache, 2011), there should be sufficient biomass for base load power generation.	0	• Full techno economic feasibility study in 2018 • First agro forest plantation in 2020 • First harvest scheduled in 2025/2026 • One harvest every year after (2027, 2028, 2029, 2030) • 5MW biomass powered plant operational by 2025	5MW	• $20m for plant • $5m feedstock prod.
Alternative space cooling technologies	As mentioned earlier, there is justified need for building space cooling in Seychelles. While it is anticipated that building envelope insulation will reduce the energy demand for cooling, there will still be a need for space cooling. Hence, it is appropriate to analyse alternative cooling technology options that do not require electricity, such as (1) geothermal; and (2) solar. While project	0	• Pilot project in 2018 • Final mechanism and legislative framework in 2019 • Market penetration in 2020	5 GWh	$5m for financial incentives (include setting up operating framework)

Technology Option	Description	Baseline (2015)	Pathway	Target 2030	Estimated cost (US$)
	stakeholders deemed these options as viable, they also pointed out that there was a lacking regulatory framework or supporting strategy to promote these alternative cooling technologies.				
Fuel cells application (utility-scale or decentralized applications)	This option was proposed for large-scale electricity generation. Nevertheless, stakeholders acknowledged that the technology was still expensive. It was judged that utility-scale application would be better than small-scale application, since the former will have the added advantage of allowing higher penetration of RE of intermittent sources into the grid. Adopting utility-scale fuel cells could potentially reduce generation costs through scale of economies.	0	• Feasibility studies completed in 2020 • Pilot project of 1 MW in 2024 • 4MW plant operational in 2025	5MW	$5m
Waste-to-energy	Centralised anaerobic digestion option chosen to be built very close to the current land fill. GHG emission reduction will accrue from landfill waste diversion and savings on grid electricity generated using fuel oil.	0	Launch project for a 4MW WtE project in 2017. Operation scheduled for 2019	4MW	$15m
Waste heat recovery at the Roche Caiman power station for power generation	The PUC has experience with the recovery of waste heat for pre-heating HFO used in thermal generation. This experience will be extended to the recovery of waste heat during thermal combustion of fuel oil for power generation using steam cycle generation.	2MW (for pre heating HFO)	• Carry out feasibility study in 2017 • 5MW heat recovered for power generation in 2020 • 7MW recovered in 2028	12MW	$5m

Source: TNA project

3.4 Criteria and process of technology prioritisation for the power sector

During the first national workshop,[19] stakeholders agreed on the criteria and indicators listed in **Table 16** for prioritising the mitigation technologies listed in **Table 15**. The MCA framework developed by the MCA4Climate project (UNEP, 2011b) was used as the starting point for discussions. The criteria and indicators shown in **Table 16** are the result of customising the MCA4Climate framework for Seychelles.

As with the adaptation sectors (Government of Seychelles, 2016), this part of the process depended heavily on the participation of the members of the technical working groups, representing various organisations with a stake in the process. Three different combinations of weightings for the indicators were agreed by stakeholders during the first national workshop and follow up bilateral meetings held with members of the Power Sector TWG in July 2016.

The Power Sector TWG comprised of the following organisations (please also see **Annex III**);

- Seychelles Energy Commission (SEC)
- Department of Energy and Climate Change (DECC)
- Public Utilities Corporation (PUC)
- PV project of the Programme Coordination Unit of the MEECC
- Private Sector representative for PV/EE business

The criteria and indicators were chosen by the members of the TWG in the plenary sessions. The TWG also assigned weights to the indicators as presented in **Table 15**.

Table 16. Criteria and indicators for prioritising mitigation technologies in the power sector.

Criteria	Indicators	Weights 1	Weights 2	Weights 3	Units
Climate-related	• GHG reduction per rupee investment	0.1	0.05	0.2	Tonne CO_{2e}/SR investment
Financing needs	• Direct costs capital investment, operation and maintenance	0.25	0.15	0.15	SR/$
Implementation Barriers	• Ease of implementation	0.2	0.2	0.15	Likert scale
Economic	• Decrease in energy bill	0.2	0.27	0.3	$/SR
Environmental	• Impact on land use	0.05	0.03	0.1	Ha
Social	• Local job creation • Potential for local content	• 0.15 • 0.05	• 0.2 • 0.1	• 0.05 • 0.05	• No. Jobs • Likert scale

Source: TNA project

The choice of the indicators is explained in **Table 17** to highlight the thought process of the stakeholders in the energy sector (covering both the power and transport sub-sectors).

[19] The first national capacity building workshop was carried out 28 and 29 April 2016. Stakeholders were introduced to the TNA process, including technology identification and prioritisation, barriers analysis, and development of technology actions plans. Stakeholders initiated the process of technology identification, and identified criteria and indicators for prioritising technologies.

Table 17. Rationale underlying the choice of MCA indicators.

Criteria	Indicators	Rationale for choice
Climate-related	GHG reduction per rupee investment	Since this is a CCM project, one of the main objectives of technology transfer is to achieve GHG emission reductions. It was decided to use an intensity indicator – i.e. GHG reduction per unit of direct investment, since this would be a more meaningful indicator for discriminating the mitigation technologies. The calculation of GHG emission reductions is discussed in the previous section.
Financing needs	Direct costs capital investment, operation and maintenance	The upfront capital cost, especially for RE technologies, is known to be a barrier for technology uptake. This is linked to the fact that the risks in investing in EE and RE in developing countries can be high, leading to relatively higher cost of capital. Hence, the direct costs associated with capital investment, operation and maintenance of technologies has been selected as a stand-alone indicators. This indicator will also be used to carry out benefit cost analysis for the prioritised technologies during the next stages of the TNA project.
Implementation Barriers	Ease of implementation (bearing in mind several factors like how complex it is, technical capacity of workers, institutional arrangements/governance, regulatory)	This indicator captures the compound effect of all non-financial barriers on technology transfer and diffusion. As mentioned earlier, underlying non-financial barriers increase the risk environment, and therefore the cost of capital. The barriers include, among others, technical capacity (e.g. for technology deployment and operation, grid interconnection, etc..), institutional capacity to promote mitigation technologies, regulatory/legal barriers to mainstream CCM, social acceptance (especially of variable REs); awareness , and administrative (e.g. protracted processes to obtaining permits and licenses). These barriers are enumerated in the technology fact sheets.
Economic	Decrease in energy bill	As discussed in chapter 2, increasing energy security is a very high priority for Seychelles. Consequently, a macroeconomic indicator has been selected to capture the economic impact of reducing dependence on imported fossil fuels. The method of calculation is discussed in section 3.3.
Environmental	Impact on land use	Being a very small country with unfavourable topography for development, land is an extremely scarce commodity in Seychelles. This prompted stakeholders to favour technologies that have minimum use of land. While noting that land use is an important issue, stakeholders nevertheless thought that it was not as decisive in choice of mitigating technologies as the other indicators (gauged by the lowest weight assigned to this indicator in **Table 16**).
Social	Local job creation	As discussed in the previous section, Seychelles is committed to the green economy as an integral part of its vision for a Blue Economy. One of the objectives of the green economy is the creation of green jobs. The methodology for calculating

		jobs creation is discussed in section 3.3.
	Potential for local content	Stakeholders also concluded that a strong social benefit of a technology would be its potential to integrate higher levels of local content. While increasing local content may imply increasing local jobs, it is a broader measure of the direct and indirect impacts that the technology may have in its value chain. Hence, a technology that has a stronger value chain in Seychelles would have a higher local content than a technology that is imported off the shelf from overseas (i.e. weak local value chain). It is measured on a relative scale based on the expert evaluation of stakeholders.

Source: TNA project

3.5 Results of technology prioritisation for the power sector

The members of the Power Sector TWG met bilaterally in July 2016 to undertake the MCA exercise for prioritising mitigation technologies. As can be seen from **Table 16**, five out of the seven MCA indicators are objective indicators (i.e. except for 'ease of implementation' and 'potential for local ownership'). The objective indicators were calculated by the TNA consultants and integrated into the customised MCA Calculator that was designed for the power sector. The customised MCA Calculator (**Annex V**) was shared with the members of the TWG prior to the bilateral meetings. Clarifications were provided regarding the calculations during the meetings. Further, the Power Sector TWG scored the technologies against the two subjective indicators.

A work session took place following several bilateral stakeholder meetings and email exchanges to gather information about each one of the eight proposed technologies and their associated costs. The stakeholders made use of the technology fact sheets (TFS) that were developed for each one of the eight long-listed technologies given in **Table 15**. The TFS for the top three prioritised technologies are given in **Annex III**.

Table 18 shows the results of technology prioritisation using MCA for the cohort of weights corresponding to 'Weights 1' in **Table 16**. Prior to being weighed, the scores were normalised on a MIN-MAX scale. Therefore, the final scores given in **Table 18** are the product of the normalised scores and weights. The top three ranked technologies are: (1) waste heat recovery; (2) waste-to-energy (WTE); and (3) utility-scale PV. The top two technologies were the same for all three sets of weights showing that the MCA results are robust. The third ranked technology was different depending on the combination of weights that were used. Utility-scale PV ranked third for weight combinations 'Weights 1' and 'Weights 2' in **Table 16**, whereas the third technology was Agriculture Residues for 'Weights 3'. Based on the balance of evidence provided by the MCA results, the technologies that are prioritised for carrying out barriers analysis and developing technology action plans (TAPs) are:

1. Waste heat recovery at thermal power plant (for electricity generation);
2. Waste-to-energy; and
3. Utility-scale PV.

Table 18. Weighted normalised scores of MCA for prioritising power sector mitigation technologies.

	CRITERIA AND INDICATORS								
	Financing needs	Implementation Barriers	Climate	Economic	Environmental	Social			
TECHNOLOGY	Direct cost/tCO_2	Ease of implementation	GHG reduction	Reduction in energy bill	Land used	Potential for local content	Local job creation	**TOTAL**	**RANK**
Utility-scale PV	5.4	7.5	12.2	7.6	0.0	1.3	15.0	**48.99**	**3**
BEMS	18.6	6.0	1.6	1.3	5.0	2.5	0.2	**35.17**	**6**
Building Insulation	20.0	9.0	4.2	3.3	5.0	2.5	0.5	**44.48**	**5**
Efficient Cold Storage	19.3	5.0	0.2	0.2	5.0	2.5	0.0	**32.27**	**8**
Agricultural Residues	16.6	6.5	7.2	6.2	5.0	4.5	1.4	**47.36**	**4**
Alternative Space Cooling	19.0	6.5	0.0	0.0	5.0	3.8	0.0	**34.29**	**7**
Fuel Cells (Utility -scale)	0.0	2.5	7.8	6.4	5.0	0.3	2.5	**24.41**	**9**
Waste-to-Energy (WTE)	14.1	3.5	15.2	11.5	5.0	4.5	1.2	**54.99**	**2**
Waste Heat Recovery	11.3	8.5	25.0	20.0	5.0	2.5	1.2	**73.57**	**1**

Source: TNA project

Chapter 4 Technology prioritisation for land transport sector

Unlike the power sector that has experienced some supply diversification using RE sources, almost the entire transport system in the Seychelles is dependent on imported fossil fuels. The exception is La Digue, which is dominated by bicycles and the recent uptake of hybrid vehicles. This has been largely due to the lowering of import duties on electric and hybrid vehicles as shown in **Table 19**.

Table 19. Comparison of taxes on conventional, hybrid and electric vehicles.

Types of Vehicle	Applicable Trades Tax on CIF Value	Applicable Excise Tax on CIF Value	Applicable VAT on VAT Base (Trades Tax + Excise Tax + CIF)	Applicable Levy (SR)
Average 5-seater conventional Car (above 1600cc -2000cc)	25%	50%	15%	50,000
Average 5-seater hybrid Car (above 1600cc -2000cc)	5%	0%	15%	0%
Average 5-seater electric Car (above 1600cc -2000cc)	0%	0%	15%	0%

Source: Department of Transport, 2015

Unfortunately, there is very little information on the transport sector in the Seychelles. The Department of Transport (DoT) is in the process of structuring itself to produce statistics on the sector. The SEC has some statistics on the consumption of fuel in this sector. The vehicle population has seen a steady increase since the seventies, and in 2014, there were 19,198 registered vehicles in Seychelles (NBS, 2015). The Population & Housing Census carried out in 2010 revealed that 25% of household possessed a form of motorised transport (NBS, 2015). The number of registered vehicles on the roads has increased at a compound annual growth rate (CAGR) of 5.81% between 2010 and 2014 (NBS, 2015), and the park of motorised vehicles is expected to reach around 36,640 vehicles in 2030 (DoT, 2015). This projection is significantly higher (by ~83%) than the projection reported in the SNC as discussed in section 1.3.1. The number of registered vehicles between 2004 and 2014 is shown in **Table 20**, revealing that the projection given in the SNC may have been reached as early as 2015.

Table 20. Number of registered vehicles: 2004 - 2014.

Year	2004	2006	2008	2010	2012	2014
Number of registered vehicles	10,109	11,012	11,853	15,316	16,570	19,198

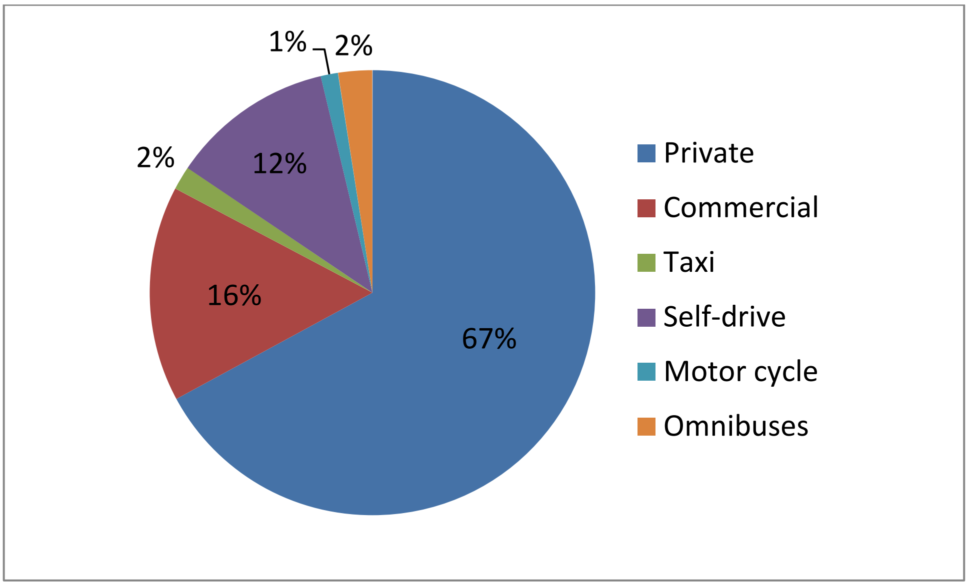
Source: National Bureau of Statistics, 2015

The main types of fuel consumed in land transport are diesel and gasoline. In 2005, 21,324 tonnes of fuel were consumed and this is expected to reach 53,620 tonnes in 2030 (section 1.3.1). The traffic density is highest on the East Coast of Mahé than in other parts of the island.

4.1 GHG emissions and existing technologies in the transport sector

As discussed in section 1.3.1 (**Figure 2**), the transport sector is the second largest emitter of CO_2 in Seychelles. Further, it was shown that ~77% of all GHG emissions from the transport sector resulted from road transport. Based on these data, and following the discussions in section 1.3.2, the TNA project focuses on mitigation in road transport.

Except for few electric vehicles, the overwhelming majority of the land-based vehicles have internal combustion engines burning gasoline and diesel. The chart shown in **Figure 13** shows the breakdown of motorised vehicles by type of vehicle for 2014. Although the road system is short,[20] it is built on a very difficult terrain consisting of steep slopes (especially for going across the island of Mahé) and bends. Also, the road surface conditions are not good in many places. All these conditions make for slow and low-gearing driving conditions that are not very efficient. The topography of the granitic islands may also explain the low penetration of motorised two-wheelers (at 1.3% of total number of motorised vehicles) and bicycles.



Source: National Bureau of Statistics, 2015

Figure 13. Breakdown of registered vehicles by type of vehicle, 2014.

It would be advisable for the DoT to run tests on the efficiency of vehicles for the different road conditions as the results would inform the possibilities to improve efficiency in the road transport sector.

All else being equal, the baseline GHG emissions emanating from road transport is expected to reach 167,067 tCO_2 in 2030. The Seychelles NDC has reported a 30% reduction in emissions relative to this baseline by 2030 (see **Table 5**).

4.2 Decision context

This section discusses the institutional arrangements and regulatory framework that support the development and implementation of policies and strategies pertaining to road transport.

The Institutional setup

The main institutional stakeholders in the land transport sector in Seychelles are:

[20] In 2014, there were 514 km of sealed roads and 12 km of unsealed roads (NBS, 2015).

- Department of Transport (DoT)
- Road Transport Commission (RTC)
- Seychelles Land Transport Agency (SLTA)
- Seychelles Public Transport Corporation (SPTC)
- Seychelles Licensing Authority (SLA)
- Seychelles Petroleum Company (SEYPEC)

The Division of Transport (DoT), Ministry of Home Affairs and Transport in collaboration with SLTA, RTC and SLA is responsible for planning, developing, implementing and managing public and private transport in Seychelles. Land Transport is regulated under the Road Act and the Road Transport Act. The DoT and RTC are in fact responsible for regulating the number of vehicles, their usage, and road worthiness standards to ensure road safety, with the collaboration of the Traffic Section of the Police and they also help Ministry of Home Affairs and Transport to control vehicular pollution.

The Commissioner of the RTC is subject to the general direction of the Minister responsible for Transport, and his role and responsibilities are guided by the Road Transport Act that is discussed below. In accordance with the Road Transport Act Chapter 206, the Road Transport Commissioner with the approval of the Minister has the following functions (Government of Seychelles, 2012a):

- Prescribe and regulate parking places for public vehicles;
- Prohibit and restrict the driving of vehicles or any specified class or description of vehicles on any specified road in order not to endanger the safety of the vehicles/person therein or other road users and also to protect the roads from being damaged;
- Specify the routes to be followed by vehicles; restrict road use during particular hours; restrict road use in a specified direction; prohibits or regulate the use of any part thereof for the hire of any vehicles;
- Restricts/prohibits road use for works of repair or reconstruction;
- Cause to be erected and maintained traffic signs on or near any roads;
- Prohibit or restrict the parking of vehicles either absolutely or during certain days or during certain hours;
- Impose on any road such limit or lower limit of speed as he considers necessary, by reason of road repairs and reconstruction or preventing damages to the road surface;
- Limit the speed on the road for the safety of the public using the roads; and
- Establish road crossings for foot passengers on the roads.

The Seychelles Public Transport Corporation (SPTC) was established in December 1977 to operate the public transport provision in Seychelles. It is today the sole public transport service provider in Seychelles. In addition to its bus operations on Mahé, SPTC is the parent company to the Praslin Transport Company (PTC) that has the specific brief of operating public transport services on Praslin. During stakeholder consultations carried out in June 2015,[21] SPTC outlined that they employed around 550 staff, of which approximately 50% were drivers. In terms of bus services, the company provides bus services along 50 routes on Mahé, issuing around 45,000 tickets daily. On Praslin there are approximately 20 buses operated by PTC along four routes and employing 35 staff.

[21] These were consultations carried out during the development of the Seychelles INDC.

The Seychelles Land Transport Agency (SLTA) was created under the Seychelles Land Transport Act, 2009. The SLTA is managed by a Chief Executive Officer under the guidance of a Board of Directors. SLTA's main responsibility is the construction and maintenance of the road networks in Seychelles. The DoT, together with the SLTA have identified a number of schemes within greater Victoria area designed to ease traffic congestion in the city centre and improve traffic management, parking and public transportation infrastructure. The SLTA has started implementing the Victoria Traffic Management Plan with the re-modelling of the 5th June Avenue. The aim is to improve the flow of traffic and ensuring the safety of road users in Victoria.

The Seychelles Petroleum Company (SEYPEC) being the main importer of fuels, has the responsibility to ensure that the type of fuels being imported at least meet the minimum required international standard with regards to pollution, which in turn has an impact on climate change.

In addition to the above, institutions can be identified based on their abilities to influence the use of energy, and hence GHG emissions, in the transport sector. **Table 21** lists the institutions and the means through which they can influence the use of energy in the transport sector.

Table 21. Influence of institutions on the use of energy in the transport sector.

Influence on energy use in road transport	Institutional Responsibility
Develop transport policies, strategies and action plans	Department of Transport
Approve transport policies, strategies and action plans	Cabinet
Import and domestic sale of motor vehicle fuels	SEYPEC
Implement policies and regulate the land transport sector	RTC
Responsible for management and implementation of government policies in the land transportation sector, including the road systems	SLTA
Public mass transportation system	SPTC
Update knowledge relevant to research, information and training programs	DoT/RTC
Fiscal incentives on hybrid and electric vehicles	MoFTBE
Emissions control for road vehicles	DoT

Source: TNA project

Legal Framework

The Road Act – Chapter 205 (Consolidated at 2012) and Road Transport Act (2009) provide the legal framework for the management and enforcement of road and traffic-related issues. The **Road Act – Chapter 205** (Government of Seychelles, 2012b) deals with the classification of public roads and highways, and provides guidance regarding the use of disused roads. It also provides guidance regarding the improvements of road infrastructure. In so doing, the Road Act clarifies the functions of the Ministry of Land Transport and the oversight responsibilities of the Minister. As mentioned briefly earlier, the **Road Transport Act** (Government of Seychelles, 2012a) provides the regulatory framework for the licensing of drivers and the registration of motorised vehicles. It also stipulates the functions of the Road Transport Commissioner as discussed above. It also provides for penalties regarding omissions that it contains regarding misuse of public roads, as well as neglect regarding the proper licensing of drivers and due registration of motorised vehicles.

The Omnibus sector was created in January 2008 with the enactment of the Licenses (Public omnibus) Regulations 2008. Currently the Omnibus sector is concentrating on contract services. To date there are about 195 active omnibus licensees on Mahé, Praslin and La Digue.

Policies, strategies and studies

Notwithstanding the Energy Policy 2010 (Van Vreden et al., 2010) that was discussed in section 1.2, there is no specific strategy dedicated to the transport sector. The transport sector is covered under umbrella strategies such as the NCCS 2009 (Government of Seychelles, 2009) or the SSP 2015-2040 (Government of Seychelles, 2015b) that have been discussed in section 1.2 and 1.3.2, respectively.

Some relevant transport studies are:

- Seychelles Land Transport Planning & Policy Study (1997): Analysis of the transport trends in Seychelles and recommendations for reducing congestion and modernizing the road infrastructure. There was also emphasis on issuing a policy where the government would continue to pursue strategies aimed at reducing the number and severity of accidents;[22] and
- Victoria Traffic Management Study (2007): Presents a report on the present traffic situation in and around Victoria and sets the target to improve the situation for the next 20 years through Traffic Management Projects.[23]

4.3 An overview of possible mitigation technology options in land transport and their mitigation potential and other co-benefits

As noted in the previous sections, there has not been any strategy dedicated to reducing GHG emissions in the transport sector, and sector statistics are scarce. A closer look at the statistics in **Table 20** shows that the number of registered vehicles grew at a CAGR of 7.17% between 2004 and 2010. This is higher that the growth of 5.81% registered between 2010 and 2014. These data may suggest a slowing down in the increase in vehicle stock that may be plausible considering the smallness of the islands and the correspondingly high incidences of traffic congestion, especially in Victoria. But this is not the case. Seychelles faced a debt crisis that was compounded by the global financial crisis in 2008 that led to International Monetary Fund (IMF) structural reforms, the most significant components of which being implemented between 2008 and 2011.[24] As expected expenditure of disposable income on capital items contracted during this period. Consequently, the increase in the number of registered vehicles dropped to 5.69% between 2008 and 2011, and reached its lowest value of 3.51% (CAGR) between 2010 and 2011. However, with strong recovery of the economy, the park of registered vehicles increased at CAGR of 7.64% between 2012 and 2014. It is worth noting that the number of private vehicles increased by 10.44% between 2012 and 2014 after seeing a contraction of 1.74% between 2010 and 2011. This simple analysis shows the status quo in land transport as far as measures to curb GHG emissions are concerned. Most of the measures proposed in the SNC to reduce GHG emissions in land transport (**Table 6**) are yet to be implemented

[22] Please see: http://www.pfsr.org/national-highlights/road-safety-a-cause-for-concern/ - accessed 7 November 2016.
[23] Please see: http://www.nation.sc/article.html?id=236534 – accessed 7 November 2016.
[24] Please see: https://www.imf.org/external/pubs/ft/survey/so/2013/car122013b.htm - accessed 8 November 2016.

and are still relevant. The strategic focus of the SSP 2015–2040 (Government of Seychelles, 2015b) regarding land transport is summarised in **Table 12**.

As was the case for the power sector, a baseline assessment of ongoing related projects and initiatives was carried out first. A list of technological options was drafted prior to the national TNA workshop that took place on 28 and 29 April 2016. The technology options were identified based on: (1) a review of existing initiatives;[25] and (2) the TNA Guidebook Series – Transport Sector (UNEP Risoe Centre, 2011). Further, the same three criteria that were used for identifying mitigation technologies in the power sector were adopted as follows:

1. Technologies must be proven and commercially available;
2. The mitigation technology must be adaptable for the Seychelles; and
3. Technology options should support Government policies, strategies and action plans.

A list of technology options relevant to Seychelles was then drafted by consulting the views of stakeholders comprising the Transport Sector TWG (see **Annex III**), starting on 29 April 2016 during the first national TNA workshop. The list of technologies is given in **Table 22**. It has the same format as similar **Table 15** in section 3.3 for the power sector. Given the description of the sector, it is possible to improve efficiency significantly, which will imply a reduction in fuel consumption. This is apparently obvious in the public transport system, where the buses used are not efficient, bus loading is not optimal and the uptake of private vehicles could be countered with an effective mass transport system. Other options include the uptake and diffusion of low-carbon motorised vehicles such as hybrid and electric buses, cars and scooters. In alignment with current Government initiatives, the list of technologies also covers the Victoria Traffic management Plan (VTMP) and making enhanced use of walking and bicycles.

[25] As discussed earlier, there have been relatively few initiatives to introduce mitigation technologies in the land transport sector.

Table 22. Technology options and penetration targets for the transport sector.

Technology	Description and benefits	Baseline	Pathway	Target 2030	Estimated cost (US$)
Victoria traffic management plan (VTMP) (all the components below will support the TMP	Congestion is a major issue across Seychelles, and particularly in Victoria, where bus journey times and reliability are significantly impacted. The central bus terminal in Victoria will be relocated to two separate facilities to assist alleviating congestion in Victoria by allowing the provision of faster more reliable services, which avoid congestion hotspots around Victoria city centre. The two new facilities, one at Roche Caiman and one at Ile du Port would provide decentralised bus transfer locations and depots, and act as an important interchange point between other modes (please see 'park and ride' below). Other measures to decrease traffic congestion in Victoria as detailed in the SSP 2015-2040 are: • Western Victoria bypass between Beau Vallon and Saint Louis which includes a new stretch of road and highway improvement works; • Dualling of the Bois de Rose venue/Providence Highway/East Coast Road between Victoria and Anse Royale;	0	• Feasibility studies carried out in 2017 (some work carried out under the SSP) • VTMP drafted and approved in 2018 • VTMP implemented in 2018 • Improve traffic flow in 2020 by 5% (reduced idle time) • It is estimated that 7ha of additional land will be needed for the hardware	5% reduction in national fuel consumption	• $100,000 for software • $55m hardware
Efficient public transport system	Almost 33% of all daily transport trips are taken by bus in Seychelles, making it the most popular mode of public transport. However, some 40% of the fleet are between 10-18years old, and therefore less fuel efficient than modern buses. Coupled with the problem of congestion, public transport is becoming a less attractive mode of travel for those having the choice between using the bus or a private vehicle. The	0	• Bus management plan drafted in 2016 • This is implemented at the end of 2018 • 2 % Savings in diesel in 2017 • Proper feasibility study and infrastructure analysis during 2016-	5% reduction in SPTC fuel consumption	• $100,000 for software • $15m for hardware

Technology	Description and benefits	Baseline	Pathway	Target 2030	Estimated cost (US$)
	SSP 2015-2040 (Government of Seychelles, 2015b) proposes to encourage modal shift to public transport by providing new public transport facilities where a need is identified, including bus stops, shelters, improved buses (comfort), signage and timetable information. Stakeholders also suggested accompanying measures such as changes in bus management & dispatch (reliability, comfort, safety, connectivity, accessibility) to cause modal shift away from private transportation. SPTC is currently implementing these measures using new scheduling software, introduction of new routes based on demand, ensuring that all new buses have more modern safety components, and by further exploring the use of GPS to share the location and severity of traffic jams. Regarding the specific case of Victoria and noting the negative impacts of traffic congestion, incentives and disincentives that can support the modal shift were identified by stakeholders, including: limiting parking space, applying parking charges, creating awareness campaigns, and providing a 'park-and-ride' service from Roche Caiman to Victoria and from Ile du Port to Victoria. These measures could be coupled with carpooling, and car sharing through differential car tolls, and electronic car pricing in the Central Business District (CBD).	0	2017 • Decongestion of Victoria		

Technology	Description and benefits	Baseline	Pathway	Target 2030	Estimated cost (US$)
	It was also noted that legislation already exists for allowing private operators in the public transport system to increase accessibility. To date there have been no proposals from the private sector.				
Public transport (mix of hybrid and electric, Euro 3 engines)	To support actions already proposed in the SSP 2015-2040, stakeholders also proposed the introduction of a mix of hybrid and electric buses, as well as buses with lower-emission Euro 3 engines. The electric buses may be used on flat areas such as between Vitoria and Perseverance, and south-bound routes to Anse Aux Pins. For other routes that consist of steep slopes and bends, buses with Euro 1 engines may be used. The overall benefits will be low exhaust emissions, including GHGs.	0	• 1st electric bus to be tested in 2018 • 1st hybrid bus to be tested in 2018 • 2 electric buses on the road in 2020 • 5 hybrid buses on the road in 2020 • 5 buses with Euro 1 engines on the road in 2018	• 5 electric buses • 10 hybrid buses • 103 buses with Euro1 engines • 171 buses with Euro2 engines • 24 buses with Euro3 engines	$25m
Low-carbon private car fleet (including government vehicles, and taxis) (mix of hybrid & electric)	The proposed mitigation technologies are analogous to those proposed for public transport – i.e. introduction or higher penetration of hybrid and electric cars. As shown in **Table 19**, financial instruments are already in place to promote hybrid and electric cars. An undesired outcome of these incentives has been the uptake of heavier, larger-bodied hybrid sports utility vehicles at the expense of smaller-sized hybrid cars that, at best, has resulted in	• 18 electric cars • 300 hydrid cars • 0 other fuels	Incentive system put in place to scale up the use of electric cars, hybrid cars and other vehicles running on other fuels. It is assumed that the average distance travelled by cars in Seychelles is 10,000 km per year.	• 10% of car fleet is electric • 70% of car fleet is hybrid • 5% of car fleet uses other fuels	$1.25m (setting up of revolving fund to speed uptake)

Technology	Description and benefits	Baseline	Pathway	Target 2030	Estimated cost (US$)
	the status quo regarding road transport energy use.[26] There is a need, therefore, to review the structure of the financial incentives in order to prevent subsidizing measures that have no net impact on fuel consumption.				
Scaling up bicycle use	The Government is committed to supporting more cycling and pedestrian links, as part of the promotion of more active, healthy and sustainable lifestyles. The concentration of development in existing settlements presents opportunities for increased levels of walking and cycling in conjunction with upgrades to existing and new infrastructure to promote a mode shift from private car use to more sustainable non-motorised modes of travel. The SSP 2015-2040 proposes to establish a multi-modal transport network across Mahé, which allows for efficient interchange between various modes of transport, with a particular emphasis on promoting the use of cycling and walking. Currently, Mahé is lacking the infrastructure required to encourage cycling and walking resulting in poor perceptions of user safety; poor quality facilities; a lack of coordination between pedestrian desire lines and crossing facilities, especially in Victoria; and an overall lack of	0 (No support in place to promote use of bicycles)	• Drafted policy in 2018 • Policy put in place in 2019 • Increase of 200 bikes on the roads per year till 2030 The land requirement for additional bike paths will be approximately 2.5ha It is also estimated that the bike will displace 300 cars on the road driving in and around Victoria to reduce congestion. Each bicycle will travel an average 900 km per year.	300 bicycles	• $50,000 for incentive program • $25,000 for safety program • $1,500,000 for infrastructure

[26] An analysis has been carried out to illustrate the undesired outcome of the tax incentives by comparing the fuel efficiencies of three different types of vehicles using data from the http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/oee/pdf/transportation/tools/fuelratings/Model_Year%202016_Vehicle_Tables.pdf – accessed 8 November 2016. The fuel intensity (for city driving) of a Toyota Prius C (1.5 L engine) is 5.4 L/100 km. A similar sized conventional car such as the Toyota Yaris (1.5 L engine) is 7.2 L/100 km. However, a Toyota RAV4 Hybrid (2.5 L engine) has a fuel intensity of 6.9 L/100 km, which under the road conditions prevailing in Seychelles would most probably not be any more fuel efficient compared to a conventional car.

Technology	Description and benefits	Baseline	Pathway	Target 2030	Estimated cost (US$)
	provision. The Public Transport Framework Plan in the SSP 2015-2040 has already identified the land for the provision of segregated walking and cycling facilities along the east and northern coasts. Competent authorities will improve walking and cycling facilities across Mahé by: way-finding and signage and improvements to existing / addition of new walkways and cycle routes to ensure safety for users, among others.				
Electric scooters	Electric scooters can be used along the flat regions of the granitic islands, for commuting in Victoria, as well as for commuting along the routes described above for electric buses. It is assumed that the electric scooters would be an alternative to motorcycles.	0	• Feasibility studies in 2018 • Financial mechanism in 2018 • Increase of 100 electric scooters on the roads per year till 2030 The scooters will travel on the same road as the cars and will displace commuting typically carried out using gasoline-powered cars on the road. Each scooter will travel approximately 3,000 km per year.	1500 electric scooters	$150,000 for incentive program (loss of tax income for gov.)

Source: TNA project

The land transport mitigation technologies provide several sustainable development benefits – i.e. to society, environment and economy. The criteria and indicators chosen to prioritise the technologies have been chosen to quantify these developmental dividends. The MCA framework used for prioritising the land transport mitigation technologies is the same as that used for technology prioritization in the power sector and is discussed in the next section. It is timely here to discuss the social, environmental and economic benefits of the land transport mitigation technologies, while noting that the detailed calculations and results are reported in section 4.5.

1. Enhancing energy security (economic benefit): The mitigation technologies result in reductions in road transport energy use through one or a combination of: decreased idling time through road decongestion, more efficient public transport system, or modal shift towards less energy intensive forms of mobility. Although the different mitigation technologies offer different energy saving potentials, the overall goal is less dependence on imported fossil fuels, and a decrease in the country's energy bill. The contribution of the short-listed mitigation technologies towards improving the energy security of Seychelles is quantified in the next section using '*decrease in energy bill*' as indicator. The decrease in energy bill is equal to the amount saved on oil imports. It is calculated using the product of quantity of fuel (tonne/yr) avoided and the average price of fuel (US$/tonne) as shown in Eq(1) above. The quantity of liquid fuel savings is estimated using different methods for different mitigation technologies as explained in **Table 23**.

Table 23. Methods used to calculate energy savings from land transport mitigation technologies.

Technology	Method used for calculating energy savings
Victoria traffic management plan (VTMP)	Top down approach using fixed target energy use reduction (5%) relative to the projected energy use baseline in 2030. The target is informed by expert knowledge in the sector.
Efficient public transport system	Top down approach using fixed target energy use reduction (5%) relative to the projected energy use baseline in 2030. The target is informed by expert knowledge at SPTC.
Public transport (mix of hybrid and electric, Euro 1,2 and 3 engines)	A bottom up, project-based approach is used to calculate the reduction in the use of diesel by electric, hybrid and buses with Euro 1, Euro 2 and Euro 3 engines. The baseline assumes that the incumbent technology – i.e. diesel-powered conventional buses – would be used in the absence of the low-carbon motorised options. Since the three low-carbon technologies will be used in different terrains, route-specific data will be used to carry out calculations in 2030, such as: Electric buses • Average annual distance travelled (43,200 km) by buses on routes where electric buses will be introduced, and • Average fuel economy of a conventional bus operating on same routes (e.g. L(diesel)/100 km) • It is assumed that batteries will be charged using grid electricity. Hence, emission reductions is calculated net of GHG emissions from the generation of electricity Hybrid buses • Average annual distance travelled (114,480 km) by buses on routes where hybrid buses will be introduced,

Technology	Method used for calculating energy savings
	• Average fuel economy of a conventional bus operating on same routes (e.g. L(diesel)/100 km); and • Average fuel economy of a hybrid bus operating on same routes Buses with Euro 1, Euro 2 and Euro 3 engines • Since Euro emission standards are not related to fuel economy, they are assumed here not to result in the reduction of carbon dioxide. As a conservative approach, the introduction of buses with Euro 1, 2 and 3 engines does not result in any GHG emission reductions
Low-carbon private car fleet (including government vehicles, and taxis) (mix of hybrid & electric)	A bottom up, project-based approach is used to calculate the reduction in the use of gasoline by electric and hybrid cars, while assuming that these low-carbon options will replace conventional gasoline-powered cars. Data used to calculate reduction in the use of gasoline are: • Projected number of cars in 2030 • Average annual distance travelled by a private car (km/yr); • Average fuel economy of a conventional car [L(gasoline)/100km]; and • Average fuel economy of a hybrid car [L(gasoline)/100km] • It is assumed that batteries will be charged using grid electricity. Hence, emission reductions is calculated net of GHG emissions from the generation of electricity
Scaling up bicycle use	A bottom up, project-based approach is used to calculate the reduction in the use of gasoline by electric scooters, while assuming that they will replace conventional gasoline-powered motorcycles. The data used are: • Number of new bicycles displacing motorcycles in 2030; • Average annual distance travelled by a motorcycle (km/yr); and • Average fuel economy of a conventional motorcycle [L(gasoline)/100km]
Electric scooters	A bottom up, project-based approach is used to calculate the reduction in the use of gasoline by electric scooters, while assuming that they will replace conventional gasoline-powered cars. The data used are: • Number of scooters in 2030; • Average annual distance travelled by a car in the region where electric scooters will be introduced (km/yr); and • Average fuel economy of a conventional car [L(gasoline)/100km] • It is assumed that batteries will be charged using grid electricity. Hence, emission reductions is calculated net of GHG emissions from the generation of electricity

Source: TNA project

2. Global environmental benefit (environmental benefit): GHG emission reductions are a co-benefit of decreasing energy use in land transport. Each technology is expected to deliver emission reductions based on the 2030 targets given in **Table 22**. Equation (6) shows the calculation of emission reductions.

$$GHG\ emission\ reduction\ \left(\frac{tCO_2}{yr}\right) = \\ quantity\ of\ diesel\ or\ gasoline\ reduced\ \left(\frac{t(fuel)}{yr}\right) \times \\ emission\ factor\ of\ diesel\ or\ gasoline\ \left(\frac{tCO_2}{t(fuel)}\right). \qquad \text{Eq(6)}$$

3. Job creation (social benefit): Another benefit of mitigation technology transfer in land transport is the creation of jobs (net relative to the baseline situation) as calculated by Eq(7). In the case of direct technology substitution (e.g. conventional car/motorcycle for hybrid or electric car/scooter or bicycles), the *Job creation coefficient* has been assumed to be zero – i.e. not net jobs are created by the technology transfer. This is especially the case since these are consumer goods in a retail market where these technologies do not have a significant value chain except for importers and concessionaries/sellers. Their maintenance has also been assumed to not create new jobs.

$$Jobs\ \left(\frac{jobs}{yr}\right) = Number\ of\ technology\ units\ (units\ of\ technology) \times \\ Job\ creation\ coefficient\left(\frac{jobs}{units\ of\ technology}\right). \qquad \text{Eq(7)}$$

Where necessary, the *Job creation coefficient* has been estimated based on the expert judgement of the Transport TWG.

4.4 Criteria and process of technology prioritisation for land transport sector

The process for selecting the criteria and indicators for technology prioritisation was the same as for that used for the power sector as discussed in section 3.4. Similarly, the Transport Sector TWG was set up to bring together available national expertise into the process and incorporate their inputs in the analysis. The Transport Sector TWG was comprised of the following organisations (please also see **Annex III**):

- Department of Transport (DoT)
- Road Transport Commission (RTC)
- Seychelles Land Transport Agency (SLTA)
- Seychelles Energy Commission (SEC)
- Seychelles Public Transport Corporation (SPTC)
- Taxi drivers Association

The criteria and indicators agreed by stakeholders, along with the weights are given in **Table 24**. They are similar to the ones used for the power sector (**Table 16**). The sector stakeholders proposed an additional indicator '*air pollution per capita*'. This indicator was not retained because it was thought to be directly correlated with the calculation of GHG emissions. Since the land transport mitigation technologies decrease energy use against a given baseline (as discussed in **Table 23**), and since the liquid fuels – i.e. diesel or gasoline – have fixed emission factors for any form of pollutant such as CO_2, NOx, CO, and PM, then the reduction in any one of these air pollutants is directly proportional to the reduction in energy use. Consequently, the reduction in GHGs and the reduction in other air pollutants will result in the same relative scores for the mitigation technologies. This will merely amount to duplication. Consequently, they cannot both be used to separate the different technologies during the prioritisation process. Since the objective of the TNA project is to support the reduction of GHGs to achieve the objectives of the UNFCCC, the capacity for the different technologies to reduce GHG emissions was chosen ahead of their respective capacities to reduce other forms of air pollution.

Table 24. Criteria and indicators for prioritising mitigation technologies in the transport sector.

Criteria	Indicators	Weights 1	Weights 2	Weights 3	Units
Climate-related	• GHG reduction per rupee investment	0.1	0.05	0.2	Tonne CO_{2e}/SR investment
Financing needs	• Direct costs capital investment, operation and maintenance	0.25	0.15	0.15	SR/$
Implementation barriers	• Ease of implementation (bearing in mind several factors like how complex it is, technical capacity of workers, institutional arrangements/governance, regulatory)	0.2	0.2	0.15	Likert Scale
Economic	• Decrease in energy bill (a proxy for balance of trade)	0.2	0.27	0.3	$/SR
Environmental	• Impact on land use (space required)	0.05	0.03	0.1	Ha
Social	• Local job creation • Potential for local content	0.15 0.05	0.2 0.1	0.05 0.05	• No. Jobs • Likert scale

Source: TNA project

4.5 Results of technology prioritisation for transport sector

The members of the Transport Sector TWG met with the consultants bilaterally in November 2016 to finalise the MCA exercise for prioritising mitigation technologies. As was the case for the power sector, **Table 24** shows that five out of the seven MCA indicators are objective indicators (i.e. except for 'ease of implementation' and 'potential for local content'). The objective indicators were calculated by the TNA consultants and integrated into the customised MCA Calculator. The customised MCA Calculator (**Annex V**) was shared with the members of the TWG prior to the bilateral meetings. Clarifications were provided regarding the calculations during the meetings. Further, the Transport Sector TWG scored the technologies against the two subjective indicators.

A work session took place following several bilateral stakeholder meetings and email exchanges to gather information about each one of the six short-listed technologies and their associated costs. The stakeholders made use of the technology fact sheets (TFS) that were developed for each one of the technologies given in **Table 22**. The TFS for the top three prioritised technologies are given in **Annex III**.

Table 25 shows the results of technology prioritisation using MCA for the cohort of weights corresponding to ‘Weights 1’ in **Table 24**. Prior to being weighed, the scores were normalised on a MIN-MAX scale. Therefore, the final scores given in **Table 25** are the product of the normalised scores and weights. The top three ranked technologies are: (1) low-carbon private car fleet; (2) Victoria Traffic Management Plan (VTMP); and (3) electric scooters. The top three prioritised technologies were the same for all three sets of weights showing that the MCA results are robust. The rankings of the 4th to 6th ranked technologies changed when the combination of weights were varied, which for the purposes of technology prioritising process is irrelevant. The technologies that are prioritised for carrying out barriers analysis and developing TAPs are:

1. Low-carbon private car fleet;
2. Victoria Traffic Management Plan (VTMP); and
3. Electric scooters.

Table 25. Weighted normalised scores of MCA for prioritising transport sector mitigation technologies.

	CRITERIA AND INDICATORS								
	Financing needs	**Implementation Barriers**	**Climate**	**Economic**	**Environmental**	**Social**			
TECHNOLOGY	Direct cost/tCO_2	Ease of implementation	GHG reduction	Reduction in energy bill	Land used	Potential for local content	Local job creation	**TOTAL**	**RANK**
VTMP	22.4	9.0	6.7	11.9	0.0	3.8	0.0	**53.79**	**2**
Efficient public transport system	0.0	15.0	0.3	0.4	5.0	4.5	0.0	**25.22**	**6**
Public Transport – low carbon	20.2	12.0	0.2	0.4	5.0	0.8	0.0	**38.63**	**4**
Low-carbon private car fleet	15.9	8.0	10.0	20.0	5.0	0.8	0.0	**59.64**	**1**
Bicycles	25.0	5.0	0.0	0.0	3.2	2.5	0.0	**35.71**	**5**
Electric scooters	21.4	10.0	0.6	1.0	5.0	1.8	0.0	**39.72**	**3**

Source: TNA project

Chapter 5 Summary and Conclusions

5.1 Power Sector

The power sector is still very reliant on import petroleum products for the production of electricity. These constitute mainly heavy fuel oil and diesel, which account for over 50% of the country's GHG emissions. In order to understand the issues within the sector and to propose and assess the technologies that could bring sustainable development benefits including the reduction of GHG emissions, a Power Sector TWG was set up. This working group was set up while noting the challenge of limited technical experts in the power sector.

A list of nine (9) mitigation technologies was drawn based on TNA resources, as well as inputs from local stakeholders. The stakeholders reviewed the list of power sector mitigation technologies during the first TNA national workshop that was held on 28 and 29 April 2016. A total of seven indicators were chosen out of which five were objective indicators and the remaining two were subjective indicators (i.e. scored on a Likert scale). The objective indicators were calculated by the TNA consultants. Members of the Power Sector TWG also identified three different sets of weights for carrying out sensitivity analyses in MCA.

Based on the balance of evidence provided by the MCA results, the top three prioritised technologies are:

1. Waste heat recovery at Roche Caiman thermal power plant for electricity generation;
2. Waste-to-energy using centralised anaerobic digester; and
3. Centralised, utility-scale PV (with some battery storage)

As shown in **Table 16**, the indicators related to technology cost, GHG emission reduction and decrease in energy bill capture between 47% (Weights 2) and 65% (Weights 3) of the total weights of indicators. Hence, they play a decisive role in technology prioritisation. All three prioritised mitigation technologies aim to diversify electricity generation away from fuel oil. Other electricity supply diversification technologies were either relatively too costly, such as utility-scale fuels cells, and/or limited in scale of application, such as power generation from agricultural residue. Limited scale of application translates into lower GHG emission reductions and lower reduction in the energy bill (i.e. cost of fuel used to generate electricity using conventional technology).

The other short-listed technologies were essentially demand side management (or energy efficiency) interventions that were also limited in scale of application thereby resulting in relatively lower GHG emission reductions and lower energy savings than the three prioritised technologies. This is despite the fact that the abatement costs (direct investment cost / tCO_2 abated) of the energy efficiency measures were lower than the supply side diversification technologies. In the case of the demand side energy efficiency technologies, their scale of implementation has been the main limiting factor in their final ranking.

The performance of the mitigation technologies relative to the local job creation also deserves discussion. It can be seen from weighted normalised scores given in **Table 18** that the first three ranked mitigation technologies, and especially utility-scale PV, have relatively higher potential for local job creation.

The quantification of the benefits of technologies, such as global environmental benefit (i.e. GHG emission reduction), reduction in energy bill and local job creation, in the MCA Calculator (**Annex V**) will be used to carry out detailed benefit-cost analysis of the prioritised technologies during the barriers analysis step of the TNA process.

The Seychelles is currently developing a Green Climate Fund (GCF) proposal for scaling-up the diffusion of solar PV. The TNA team exchanged with the GCF project development team, and the technology prioritisation for the power sector was shared with that team.

5.2 Transport Sector

The transport sector is almost entirely reliant on imported petroleum products, mainly in the form of motor gasoline and diesel that is mainly used in public transport. The sector is the second largest GHG emitting sector in Seychelles behind the power sector. This is the reason why the transport sector, and more particularly the land transport sector, has been retained as a priority sector for the TNA project.

A list of six (6) mitigation technologies was drawn based on TNA resources, as well as inputs from local stakeholders. The process of reviewing the list of technologies was the same as that used for the power sector. Further, the same set of objective and subjective indicators as for the power sector were used for carrying out MCA to prioritise the land transport mitigation technologies. The MCA results show that the top three prioritised technologies are:

1. Low-carbon private car fleet;
2. Victoria Traffic Management Plan (VTMP); and
3. Electric scooters.

As discussed above, the three indicators that play a significant role in technology ranking are financing costs per unit of GHG abated, GHG emission reduction and reduction in energy bill. The weighted normalised scores in **Table 25** reveal that the top three ranked mitigation technologies scored relatively higher than the other technologies on these three indicators. In Seychelles, land transport emission is dominated by the use of private vehicles. Each one of the top three ranked land transport mitigation technologies has a direct effect on reducing private vehicle travel needs or reducing energy use through the curtailment of traffic congestion. Nevertheless, it can be seen from the results in **Table 25** that there is a large gap between the total scores of the top two ranked technologies on the one hand and the third technology on the other.

The low-carbon private car fleet seeks to diffuse and scale up the use of hybrid (70% of all private cars) and electric (10 % of all private vehicles) cars significantly by 2030. Traffic congestion is a major concern in Victoria. The VTMP, which seeks to reduce traffic congestion, has significant positive impacts on reducing GHG emission and energy bill at a relatively attractive cost. Although electric scooters substitute for distance travelled using private cars, the scale of impacts is much lower compared to the two top ranked technologies.

The low-carbon public transport option deserves further consideration. This technology is analogous to low-carbon private car fleet as it seeks to introduce hybrid and electric public buses on dedicated routes on Mahé. The technology transfer scale is comparatively smaller than for private cars with the introduction of only 10 hybrid and 5 electric buses by 2030. Nevertheless, it is worth noting that the difference between the total score of electric scooters (3rd ranked technology) and that of low-carbon public transport (4th ranked technology) is very small. This suggests that changes in assumptions underlying the calculation parameters in the MCA Calculator (**Annex V**) may change the relative ranks of the two technologies. Of all the parameters used to quantify the objective indicators, the annual car distance travelled that is substituted by electric scooters is most decisive. In the analysis (i.e. results in **Table 25**), it has been assumed that this distance is 3,000 km/yr. In order to reverse the relative rankings of electric scooters and low-carbon public transport for all combinations of weights, the distance needs to be reduced to at least 2,200 km/yr – i.e. a reduction of ~27%, which is thought to be too low based on the best estimate of the calculation parameters used in the MCA Calculator (**Annex V**).

Increasing the efficiency of the public transport system is not an attractive mitigation option because it delivers relatively low levels of GHG emission reduction and reduction in energy use. Also, it has the highest investment cost per unit of GHG abated. The scaling up of bicycles is cheapest technology options but it suffers disproportionately from lack of scale.

In contrast with the mitigation technologies in the power sector, the land transport mitigation technologies do not create net new jobs. This is because several options involve technology substitution (e.g. bicycles, electric scooters, electric cars and hybrid cars) that will most probably make use of existing retail outlets. Where new skills will be required (e.g. maintenance of hybrid and electric vehicles), it is expected that re-skilling of existing labour will take place.

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Annex I: The NCCS Action Plan

Objective 1 - To advance our understanding of climate change, its impacts and appropriate responses		
Strategy 1.1: Identification of gaps and research priorities required to predict the impacts of climate change in Seychelles		
Action #	**Action**	**Priority**
1.1.1	Assess data needs and important gaps in knowledge that impede adaptation to CC	high
1.1.2	Establish long-term monitoring of oceanographic parameters, including sea level rise and sea surface temperature	high
1.1.3	Consolidate the existing beach and wetland monitoring programmes	moderate
1.1.4	Improve data collection and monitoring for vector distribution on the main inhabited islands, in particular mosquito species	high
1.1.5	Study and prescribe the monitoring/technical requirements required for early warning of extreme storm and wind events	high
1.1.6	Identify climate sensitivity and develop relevant ecological and socio-economic	high

	indicators for the artisanal fisheries subsector	
Strategy 1.2: Development of capacity to manage, analyse and present such data in a manner in which it can be useful for guiding policy and influencing adaptation		
1.2.1	Undertake small and basin-scale modelling using oceanographic monitoring stations and arrays	high
1.2.2	Use high resolution models in the development of CC scenarios for Seychelles	moderate
1.2.3	Assess and research trends and relationships of disease outbreaks or vector distributions within the context of climate variability and change	moderate
1.2.4	Develop health risk plans based upon CC scenarios	moderate
1.2.5	Acquire high resolution DEM data for use in mapping climate-related risks, zoning, and vulnerable areas	high
1.2.6	Incorporate sector data (e.g. agriculture, tourism, fisheries, forestry, etc.) into risk, vulnerability and distribution maps	high
1.2.7	Establish farm-level value at risk database	High
1.2.8	Develop ecosystem modeling for climate-sensitive fisheries	moderate
1.2.9	Model changes in the distribution and productivity of marine resources at a relevant spatial scale under CC scenarios	high
Strategy 1.3: Establishment of sustainable long-term monitoring programmes in strategic areas, with focus on climate scenarios, risk assessments and adaptation		
1.3.1	Access to high-resolution regional and global ocean and coastal datasets	moderate
1.3.2	Establish Sea Level Rise/Tidal Observation stations on other islands of Seychelles	high
1.3.3	Expand rainfall monitoring network for development of appropriate predictive and design tools	high
1.3.4	Establish operational network for monitoring and sharing of data at national & regional level	moderate
1.3.5	Implement mechanisms to ensure sustainability in financing and support of oceanographic research and monitoring	moderate
1.3.6	Implement fisheries-independent monitoring system for coral reef fisheries resources that incorporates resilience indicators	high
Objective 2 - To put in place measures to adapt, build resilience and minimise our vulnerability to the impacts of climate change		
Strategy 2.1: Identify priorities for adaptation, especially in critical sectors		
2.1.1	Study to identify and prioritise areas for adaptation intervention	high
2.1.2	Undertake review of policies and institutions with a view to ensure consideration of adaptation issues	moderate
2.1.3	Evaluate potential coastal risk zones, vulnerabilities and level of protection in place	moderate
2.1.4	Assess the effectiveness of existing adaptation techniques, including impediments to implementation	high
2.1.5	Assess levels of disease/pest control resistance in climate-related vectors	high
2.1.6	Determine adaptation opportunities in fisheries considering socio-economic conditions, fishing pressure, and international trade	high
Strategy 2.2 : Assess and improve ongoing management activities and their contribution to adaptation		
2.2.1	Identify key areas of management which entails consideration of adaptation	high
2.2.2	Development of legally binding coastal land-use plans (incorporating the impact of climate change and natural changes in coastal processes)	moderate
2.2.3	Improvements, awareness and further investments in waste collection and management to reduce flooding and vector/disease propagation risks	low

2.2.4	Improvements to the public health infrastructure in response to climate-driven epidemics improved	moderate
2.2.5	Adoption of coping approaches with regards to the management of protected areas for resilience to climate change	moderate
2.2.6	Establish basic design specifications, incorporating climate change considerations, into coastal drainage, coastal protection, road and other infrastructure development projects	high
2.2.7	Establish and strengthen the role of EIA and SEA in climate change adaptation and risk/impact reduction	high
2.2.8	Develop social and ecological resilience in exploited marine ecosystems through adoption of an ecosystem-approach in fisheries management plans	high
Strategy 2.3 : Implementation of adaptation activities		
2.3.1	Develop and implement on a pilot scale effective adaptation measures and tools at community level, including coastal restoration approaches	high
2.3.2	Research and develop alternative coastal designs (such as elevation of buildings) which accommodate sea level rise	high
2.3.3	Implement nation-wide rainwater harvesting programme	high
2.3.4	Demonstration of adaptation technology implementation, with focus on nature-based methods	moderate
2.3.5	Enhance the management of coral refugia and resilient areas	high
2.3.6	Evaluate and implement new plant varieties, strategies for pest and invasive control for agriculture and forestry, to cope with changed climatic conditions	
2.3.7	Reinforce approaches for sustainability in fisheries through improvements in monitoring and management of fishing zones	very high
2.3.8	Develop and implement cost-effective beach restoration techniques in support of the tourism industry	high
Strategy 2.4: Establish financing mechanisms for adaptation		
2.4.1	Dedicated financing for preventative measures and early warning of climate-related vector disease prevention established	high
2.4.2	Develop the capacity to mobilise and implement resources from international agencies to address the climate risk	high
2.4.3	Explore and develop micro-insurance, risk reduction and financing mechanism and private sector financing options for adaptation	high
2.4.4	Establishment of a National Disaster Crop Insurance scheme	high
Objective 3 - To achieve sustainable energy security through reduction of greenhouse gas emissions		
Strategy 3.1: Diversify the energy portfolio of Seychelles towards renewable forms of energy		
3.1.1	Develop a comprehensive energy policy aimed at charting a strategy to achieve energy security	high & ongoing
3.1.2	Feasibility studies for the establishment of wind, solar and waste-to-energy technologies	moderate
3.1.3	Upgrading of national grid to accommodate alternative sources of energy	moderate
Strategy 3.2: Modernise the energy legislation and institutional framework to encourage innovation and transfer of technology in the energy sector		
3.2.1	Establish legally and strengthen the Seychelles Energy Commission to oversee energy management in Seychelles	high & initiated
3.2.2	Development of new Energy Act	high
3.2.3	Develop and implement framework for enabling financial incentives, including feed-in	high

	tariffs, for technology transfer and conservation in the energy sector	
3.2.4	Implement market-based mechanisms to enhance energy efficiency in industry and other sectors	moderate
3.2.5	Develop appropriate codes and specifications for energy efficiency in the transport, building and commercial sectors	high
3.2.6	Establish a carbon market in Seychelles	moderate
Strategy 3.3: Improve monitoring and assessment of energy use and emissions		
3.3.1	Establish legal requirement for sharing of energy data	high
3.3.2	Develop and maintain energy statistics	high
3.3.3	Maintain data on other sources of GHG emissions as specified in the UNFCCC guidelines	moderate
Strategy 3.4: Technology transfer in the energy production and transport sector		
3.4.1	Establishment of a clearinghouse and advisory services platform on efficient technologies and appliances	high
3.4.2	Establish demonstration projects for various energy technologies with the participation of the private sector	high
3.4.3	Create an enabling environment for the piloting and testing of new vehicle technologies	high
Objective 4 - To mainstream climate change considerations into national policies, strategies and plans		
Strategy 4.1: Addressing institutional learning and stakeholder flows		
4.1.1	Identify and undertake a review of the main institutions involved in responding to climate change, identify conflicts or parallel efforts and explore networking and synergies	high
4.1.2	Review of key procedures, guidelines and specifications to include climate change adaptation considerations into national planning	moderate
4.1.3	Develop programme to raise awareness of the likely impacts of climate change for all identified stakeholders	moderate
Strategy 4.2: Incorporate climate risk assessment and response into Government		
4.2.1	Engagement of government (incl. the executive & legislative) with the scientific community for input of climate risk information into the development of national development strategies, policies and laws	moderate
4.2.2	Identify key stakeholders and develop policy for involvement of key stakeholders in climate change adaptation through a multi-stakeholder coordination committee	high
4.2.3	Update TCPA guidelines and modus operandi to mainstream climate change into key national risk sectors	high
4.2.4	Develop a knowledge platform on mainstreaming adaptation in small islands	high
4.2.5	Revise and implement the Fisheries Policy, Inshore Fisheries Strategy and Fisheries Development Plan to incorporate sector adaptation mechanisms to climate change	high
Strategy 4.3: Incorporate climate risk assessment into the Private Sector		
4.3.1	Development of incentive structures by reducing bureaucracy, barriers to introduction of new technologies and supporting capacity building activities	high
4.3.2	Adoption of guidelines and codes for development which take into consideration climate change issues	moderate
Objective 5 - To build capacity and social empowerment at all levels to adequately respond to climate change		
Strategy 5.1: Develop Climate Change education and communication		
5.1.1	Develop and deploy climate change curriculum and teacher support materials in	high

	Seychelles Schools	
5.1.2	Design and implement climate change educational and advocacy activities	moderate
5.1.3	Integrate climate change education in all relevant national policies and strategies	high
5.1.4	Organize awareness and educational activities for the youth	moderate
5.1.5	Promote ongoing stakeholder/community involvement in decision making regarding climate change education, awareness & training at national and district levels	moderate
5.1.6	Develop capacity for emissions trading and carbon management with focus on CDM, NAMA and other mechanisms	moderate
Strategy 5.2: Implement climate change awareness at all levels		
5.2.1	Identify gaps in communication and implement awareness raising activities within government, private sector and other organizations	moderate
5.2.2	Integrate climate change education into all sectoral policies and strategies, i.e. tourism, fisheries, energy, agriculture, education, development, disaster response, etc	high
5.2.3	Identify vulnerable groups and prioritise for capacity building activities to address climate change risk	high
5.2.4	Develop communication and awareness strategies to engage the community in responding and adapting to climate change	high
5.2.5	Identify the main gender issues in connection with climate change and implement capacity building programmes to address any specific gender-biased needs	moderate
Strategy 5.3: Strengthen formal climate change capacity building institutions		
5.3.1	Introduce climate change research and adaptation training at university level	high
5.3.2	Develop and maintain a knowledge-base and use case studies for climate risk reduction	high
5.3.3	Integrative and adaptation leadership training in "Climate change, climate variability and coastal security"	high
5.3.4	Development of appropriate modes of learning for adaptation at all levels and sectors of society, including aspects of empowerment at the local level	moderate
5.3.5	Establish a system of sustainable financing for climate change education, awareness and training programs	high
Strategy 5.4: Develop the capacity for global environment management, in particular climate change		
5.4.1	Develop capacity for negotiations at international level	high
5.4.2	Develop policy research projects focused on analysis of global policy and mechanisms in relation to the specificities and priorities of small island states	high

Annex II: Grid Emission Factor

Operating Margin Emission Factors (tCO_2/MWh)

Calculating the operating margin for Mahe

Table 1: Generation data in MWh, MAHE

Year	2012		2013		2014		3-yr average		
Fuel	**LFO**	**HFO**	**LFO**	**HFO**	**LFO**	**HFO**	**LFO**	**HFO**	
Generation	1,882.036	294,865.991	1,383.583	306,458.444	610.498	313,464.712	**1,292.039**	**304,929.716**	306,221.755
Sent out	287,399.124		297,794.853		303,653.806		296,282.594		
Total	296,748.027		307,842.027		314,075.210		306,221.755		

Table 2: Fuel used, MAHE

	LFO	HFO	LFO	HFO	LFO	HFO	LFO	HFO
litres	823,352	69,303,545	692,964	71,011,794	366,563	72,099,648	627,626	70,804,996
tonnes	690.051	64,979.004	580.773	66,580.658	307.216	67,600.630	**526.014**	**66,386.764**

Total

Density of fuels

density HFO 937.6 kg/m3

density LFO 838.1 kg/m3

Emission factor of fuels

EF = CEF x (1-FCS) x FCO x 44/12

CEF = carbon emission factor

FCS = fraction of carbon stored for fuel used = 0

FCO = fraction of carbon oxidised = 0.99

	LFO	HFO
FCS	0	0
FCO	0.99	0.99
CEF, tC/TJ	20.2	21.1
EF, tCO2/TJ	73.326	76.593
NCV, GJ/t(fuel)	42.91	40.212
EF, tCO2/t(fuel)	**3.146419**	**3.07995772**

EF(OM)-Mahe 0.695699 tCO2/MWh

Calculating the operating margin for Praslin

Table 1: Generation data in MWh, PRASLIN

Year	2012	2013	2014	3-yr avg.
	38,885.026	38,616.188	39,873.798	**39,125.004**

Table 2: Fuel used, PRASLIN

Year	2012	2013	2014	3-yr avg.
litres	10,832,969	10,796,541	10,421,404	10,683,638
tonnes	9079.1113	9048.581	8734.1787	**8953.957**

EF(OM)-Praslin 0.720074 tCO2/MWh

Build Margin Emission Factors (tCO_2/MWh)

Calculating the build margin for Mahe

Total generation in 2014 321,878.020 MWh

1. 20% of generation - SET(20%) 64,375.604 MWh

2. The 5 most recent power units - SET(5 recent)

	Power units	*Derated capacity, MW*	*Year Commissioned*	*MWh,2014*	*Source of data*
1	solar PV	0.975	2014	712.000	Mahe!
2	wind	6	2013	7,090.810	Mahe!
3	B41+B51	16	2011	99,085.940	PUC - Generation April 2015.xlsx
4	A11-A41+B11-B31	42	2000	181,098.660	PUC - Generation April 2015.xlsx
5	8B	6	1998	33,365.000	PUC - Generation April 2015.xlsx
	Total	**70.975**		**321,352.410**	

3. SET(5 recent) > SET(20%) - therefore, retain SET(5 recent)

4. Eliminating all power units older than 10 years

	Power units	*Derated capacity, MW*	*Year Commissioned*	*MWh,2014*	*Source of data*
1	solar PV	0.975	2014	712.000	Mahe!
2	wind	6	2013	7,090.810	Mahe!
3	B41+B51	16	2011	99,085.940	PUC - Generation April 2015.xlsx
	Total	**22.975**		**106,888.750**	

Since, total generation after eliminating power units older than 10 years is larger than for SET(20%),

then retain solar PV, wind farm, B41+B51 for calculating EF(BM)

5. Calculating the Build Margin Emission Factor

	MWh, 2014	Fuel, m3	Fuel, tonne	CO2, t
solar PV	712.00	-	-	-
wind	7,090.81	-	-	-
B41+B51 (HFO)	98,990.42	22460.393	21,058.864	64,860.412
B41+B51 (LFO)	95.52	24.772	20.761	65.324
Total	**106,888.75**			**64,925.736**

EF(BM) - MAHE 0.607414 tCO2/MWh

Calculating the build margin for Praslin

Total sent out in 2014 39,873.798 MWh

1. 20% of generation - SET(20%) 7,974.760 MWh

2. The 5 most recent power units - SET(5 recent)

	Power units	*Derated capacity, MW*	*Year Commissioned*	*MWh,2014*	*Source of data*
1	M6	1	2013	31.000	PUC - Generation April 2015.xlsx
2	7P+8P	5	2003	29,833.000	PUC - Generation April 2015.xlsx
3	M5	1.1	2000	354.000	PUC - Generation April 2015.xlsx
4	M4	1.2	1999	2,738.000	PUC - Generation April 2015.xlsx
5	6P	1.4	1996	4,006.000	PUC - Generation April 2015.xlsx
	Total	**9.7**		**36,962.000**	

3. SET(5 recent) > SET(20%) - therefore, retain SET(5 recent)

4. Eliminating all power units older than 10 years

	Power units	*Derated capacity, MW*	*Year Commissioned*	*MWh,2014*	*Source of data*
1	M6	1	2013	31.000	PUC - Generation April 2015.xlsx
	Total	**1**		**31**	

Since the total generation after eliminating units older than 10 years is less than for SET(20%)
need to add power units older than 10 years until total generation is at least equal to that of SET(20%)

	Power units	*Derated capacity, MW*	*Year Commissioned*	*MWh,2014*	*Source of data*
1	M6	1	2013	31.000	PUC - Generation April 2015.xlsx
2	7P+8P	5	2003	29,833.000	PUC - Generation April 2015.xlsx
	Total	**6**		**29,864.000**	

Hence, need to retain M6, and 7P&8P for calculating EF(BM)

5. Calculating the Build Margin Emission Factor

	MWh, 2014	Fuel, m3	Fuel, tonne	CO2, t
M6	31.00	8.0	6.705	21.096
7P+8P	29,833.00	8,198	6,870.744	21,618.237
Total	**29,864.00**	**8,206.0**	**6,877.449**	**21,639.333**

EF(BM) - PRASLIN 0.724596 tCO2/MWh

Combined Margin Emission Factor for the Seychelles

MAHE	EF(OM)	EF(BM)	
	0.69569893	0.607414	
	w(OM)	w(BM)	EF(CM)
1. Intermittent RE (PV, wind)	0.75	0.25	0.6736
2. all other projects	0.5	0.5	0.6516
PRASLIN	EF(OM)	EF(BM)	
	0.72007398	0.724596	
	w(OM)	w(BM)	**EF(CM)**
1. Intermittent RE (PV, wind)	0.75	0.25	**0.7212**
2. all other projects	0.5	0.5	**0.7223**
Weighted average EF(CM) for SEZ			
Total generation (SEZ)	361,751.818		
% Mahe in SEZ	88.98		
% Praslin in SEZ	11.02		
Total	100.00		
SEZ	**EF(CM)**		
1. Intermittent RE (PV, wind)	**0.67887**		
2. all other projects	**0.65936**		

Annex III: List of stakeholders involved and their contacts

POWER SECTOR

Name	Contact details	Affiliation	Approach of consultation	Topics
1. Tony Imaduwa	timaduwa@sec.sc	SEC	Bilateral	List of applicable technologies for the power sector
2. Cynthia Alexander	calexander@sec.sc	SEC	Workshop participant	Status of EE and RE in Seychelles
3. Laurent Sam	lsam@puc.sc	PUC	Workshop participant	Technologies implemented (or planned) by PUC
4. Kalsey Belle	kbelle@puc.sc	PUC	Workshop participant	Technologies implemented (or planned) by PUC
5. Anil Singh	asingh@puc.sc	PUC	Bilateral	Integration of variable RE into the grid
6. Christian Fleischer	Chris-fleischer@hotmail.com	MSc Student	Workshop participant	Large-scale energy storage for grid stabilisation
7. Theodore Marguerite	t.marguerite@gov.sc	DECC	Bilateral	Policy and technology options
8. Mamy Razanjatovo	rmazanajatovo@sec.sc	SEC	Workshop participant	Energy modeling and forecasting
9. Guilly Moustache	gmoustache@sec.sc	SEC	Bilateral	Energy information
10. Ravin Sunnassee	rsunnassee@puc.sc	PUC	Bilateral	Electricity generation options
11. Emanuele De Stefani	emanuele.destefani@gmail.com	Private sector	Workshop participant	Status of supply of PV equipment
12. Bertrand Rassool	lbmrassool@yahoo.co.uk	Private sector	consulted	Status of energy sector and technology forecasts

LAND TRANSPORT

Name	Contact details	Affiliation	Approach of consultation	Topics
1. Desire PAYET	dpayet@slta.sc	SLTA	TWG	Implementing policies and road infrastructure
2. Valentina BARRA	vbarra@gov.sc	DoT	TWG	Developing legislations and policies
3. Diane HOAREAU	dhoareau@gov.sc	DoT	TWG	Developing legislations and policies
4. Pedro EUGENIE	peugenie@gov.sc	DoT	TWG	Developing legislations and policies
5. Hans ALBERT	Hans.Albert@sptc.sc	SPTC	TWG	Public transportation
6. Dean ZELIME	dzelime@seyports.sc	SPA	Consulted by email	Maritime transportation
7. Parinda HERATH	pherath@slta.sc	SLTA	Consulted by email	Implementing policies and road infrastructure
8. Tim MARIE	tmarie@gov.sc	RTC	Consulted by email	Developing legislations and policies
9. Geffy ZIALOR	Geffy.zialor@sptc.sc	SPTC	Consulted by email	Public transportation
10. Cynthia ALEXANDER	c.alexander@sec.sc	SEC	TWG / Consulted by email	Energy efficiency expert

Annex IV: Technology Factsheets for prioritised technologies

POWER SECTOR

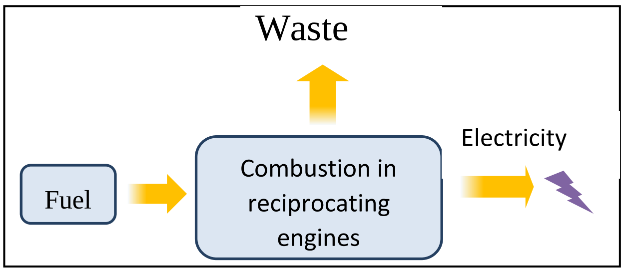
Technology:	**Central PV (MW scale) system with storage**
Technology characteristics	
Introduction	The solar power source is via photovoltaic modules that convert light directly to electricity. However, this differs from, and should not be confused with concentrated solar power, the other large-scale solar generation technology, which uses heat to drive a variety of conventional generator systems. Both approaches have their own advantages and disadvantages, but to date, for a variety of reasons, photovoltaic technology has seen much wider use in the field. A photovoltaic power station, also known as a central PV system, is a large-scale photovoltaic system (PV system) designed for the supply of merchant power into the electricity grid. They are differentiated from most building-mounted and other decentralised solar power applications because they supply power at the utility level, rather than to a local user or users. They are sometimes also referred to as solar farms or solar ranches, especially when sited in agricultural areas. The generic expression utility-scale solar is sometimes used to describe this type of project.
Technology characteristics/highlights	**PV Power Farm System** includes grid connected central inverter that connects directly to the utility grid and converts direct current (DC) output from PV arrays into alternative current (AC). The generated electricity can be sold to the utility grid according to the government's promotion policy of electricity generating from **sustainable energy.** Many storage technologies have been considered in the context of utility-scale energy storage systems. These include: • Pumped Hydro • Batteries (including conventional and advanced technologies) • Superconducting magnetic energy storage (SMES) • Flywheels • Supercapacitors / Ultracapacitors Each technology has its own particular strengths and operational characteristics. For example, pumped hydro is best suited for large-scale bulk electrical energy storage (if suitable geographic topology, geology and environmental conditions exist). Pumped hydro generating stations have been built capable of supplying 1800MW of electricity for four to six hours.

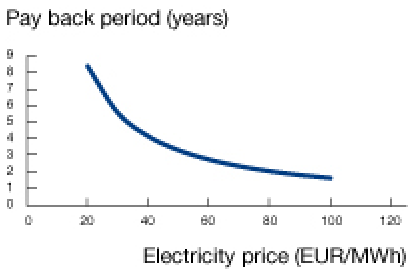
<table>
<tr><th>Technology:</th><th>Central PV (MW scale) system with storage</th></tr>
<tr><td></td><td>
<table>
<tr><th>Technology</th><th>Commercial Maturity</th><th>Cost Certainty</th></tr>
<tr><td>Lead-Acid Batteries</td><td>◆</td><td>◆</td></tr>
<tr><td>Regenesys®</td><td>■</td><td>■</td></tr>
<tr><td>Na/S Batteries</td><td>■</td><td>■</td></tr>
<tr><td>Ni/Cd Batteries</td><td>▲</td><td>■</td></tr>
<tr><td>Zn/Br Batteries</td><td>■</td><td>▲</td></tr>
<tr><td>Li-ion Batteries</td><td>■</td><td>●</td></tr>
<tr><td>Vanadium-redox Batteries</td><td>■</td><td>■</td></tr>
<tr><td>Superconducting Magnetic Energy Storage (D-SMES)</td><td>▲</td><td>▲</td></tr>
<tr><td>Flywheel (high-speed)</td><td>■</td><td>■</td></tr>
<tr><td>Flywheel (low-speed)</td><td>▲</td><td>◆</td></tr>
<tr><td>Supercapacitor</td><td>■</td><td>■</td></tr>
<tr><td>Compressed Air Energy Storage (CAES)</td><td>■</td><td>▲</td></tr>
<tr><td>Compressed Air Energy Storage in surface vessels (CAES-surface)</td><td>●</td><td>●</td></tr>
<tr><td>Pumped Hydro</td><td>◆</td><td>◆</td></tr>
<tr><td>Fuel Cells (hydrogen)</td><td>■</td><td>■</td></tr>
<tr><td>Hydrogen combustion engine</td><td>▲</td><td>◆</td></tr>
</table>
Legend for Figure 4
<table>
<tr><th>Symbol</th><th>Commercial Maturity</th><th>Cost Certainty</th></tr>
<tr><td>◆</td><td>Mature products, many sold</td><td>Price list available</td></tr>
<tr><td>▲</td><td>Commercial products, multiple units in the field</td><td>Price quotes available</td></tr>
<tr><td>■</td><td>Prototype units ordered, under construction, or in the field</td><td>Costs determined for each project</td></tr>
<tr><td>●</td><td>Designs available, nothing built</td><td>Costs estimated</td></tr>
</table>
</td></tr>
<tr><td>Country specific applicability and potential</td><td>The impact of photovoltaic (PV) power generation with energy storage on the electric utility's load shape for load leveling purposes is explored. Results show that utilities employing storage technology for peak load shaving might benefit from use of photovoltaic power, the extent of its usefulness being dependent on the specific load shapes as well as the photovoltaic array orientations.</td></tr>
<tr><td>Status of technology in country</td><td>There is no central PV system with storage technology in the country. There have been proposals made to the government for private sector to build and run such systems on an IPP basis. The government is preparing the necessary framework for this kind of project.</td></tr>
<tr><td>Benefits to economic / social and environmental development</td><td>The direct impact will be on the reduction of the fuel import bill, hence improving the balance of payment and keeping more forex in the country. This will mean that there will be more government funds for capital project.

There will be a reduction of risk of spillage due to importation of fossil fuels into the country.

New personel will have to be trained to be able work in this environment whereby creating new jobs.</td></tr>
<tr><td>Climate change mitigation benefits</td><td>There are direct CO_2 or other GHG emissions from such systems as there will reduce or eliminate the use of fossil fuels for producing electricity.</td></tr>
<tr><td>Financial Requirements and Costs</td><td>In recent years, PV technology has improved its electricity generating efficiency, reduced the installation cost per watt as well as its energy payback time, and has reached grid parity in at least 19 different markets by 2014. PV is increasingly becoming a viable source of mainstream power. However, prices for PV systems show strong</td></tr>
</table>

Technology:	Central PV (MW scale) system with storage
	regional variations, much more than solar cells and panels, which tend to be global commodities. In 2013, utility-scale system prices in highly penetrated markets such as China and Germany were significantly lower ($1.40/W) than in the United States ($3.30/W). The IEA explains these discrepancies due to differences in "soft costs", which include customer acquisition, permitting, inspection and interconnection, installation labor and financing costs. The cost of the project is estimated at USD34.7m with battery storage and O&M costs.

Technology:	Waste heat recovery at the Roche Caiman power station
Technology characteristics	
Introduction	An innovative way of generating even more power using the same number of generators within the same area is to use the waste heat in their exhaust gases to drive another generator. The waste heat can also be utilised to heat water for desalination or to produce ice directly. However, the electricity produced from this technology could be used in a wider range of activities and does not have to be consumed close to the source of generation. Recovering waste heat using compact heat exchangers is an effective way to increase energy efficiency in both new and existing plants. But not all heat is worth recovering. It all comes down to the possibilities of reusing the energy in an economical way.
Technology characteristics/highlights	At the main power station on Mahé, HFO (Heavy Fuel Oil) is burned in generators to produce electricity. In this process, heat is generated and discarded through chimney stacks into the atmosphere as shown in the figure below. Waste Heat to Power (WHP) harnesses the exhaust waste heat and uses it to drive a steam turbine generator to produce electricity. The exhaust gases are then released into the environment at a lower temperature. 
Country specific applicability and potential	Several studies have been carried out to examine the technical potential of this technology. One study was carried out by the supplier of certain components for existing power station. The results of these studies have all shown that there is a potential for these application with a very reasonable return on investment.
Status of technology in	There have been a few small scale applications of this technology,

Technology:	Waste heat recovery at the Roche Caiman power station
country	mostly capturing the waste heat from air conditioning systems and small generator sets to produce hot water. Ephilia hotel is producing most of its hot water from waste heat.
Benefits to economic / social and environmental development	The main contribution of waste heat recovery to socio-economic development and environmental protection is due to the efficiency benefits of technology compared to conventional power generation primarily through potential cost savings, lower oil import bill, CO_2 emissions reduction, and less reliance on (imported) resources.
Climate change mitigation benefits	Since waste heat recovery often leads to significant fuel savings (avoided fuel use), CO_2 emissions are often reduced. The primary benefit of lower emissions is of course the positive effects on our environment, but they can have monetary value as well.
Financial Requirements and Costs	The cycle converts waste heat to electricity with an efficiency of approximately 10%. In this case the heat recovery system converts approximately 7 MW (23.9 MMBtu/h) of waste heat into 0.7 MW of electricity, i.e. an annual production of 5,880 MWh. The project is estimated to cost a total of USD42.84m over the lifetime of the project. This cover the O&M costs as well. An initial cost estimation has been carried out by PUC with the assistance of Alfa Laval, a manufacturer of auxiliary equipment for power stations based in Sweden. 

Technology:	Waste-to-energy (anaerobic digestion)
Technology characteristics	
Introduction	The process of anaerobic digestion is decomposition of biodegradable material by micro-organisms in the absence of oxygen. This process is often used for industrial or domestic purposes to manage waste streams. As a result, the process produces a biogas, consisting mainly of CH_4 and CO_2, which can be used for energy production in a Combined Heat and Power plant. Second, the process results in a nutrient-rich digestate which is similar to compost. The compaction and burial of trash at landfill facilities creates an anaerobic environment for decomposition. As a result, landfills naturally produce large amounts of methane. Gas emitted from the

Technology:	Waste-to-energy (anaerobic digestion)
	landfill facilities is typically called landfill gas, as opposed to biogas. The primary difference between the two is the lower methane content of landfill gas relative to biogas – approximately 45-60 percent compared to 55-70 percent.
Technology characteristics/highlights	There are two basic types of anaerobic digesters: batch and continuous. Batch-type digesters are the simplest to build. Their operation consists of loading the digester with organic materials and allowing it to digest. The retention time depends on temperature and other factors. Once the digestion is complete, the effluent is removed and the process is repeated. In a continuous digester, organic material is constantly or regularly fed into the digester. The material moves through the digester either mechanically or by the force of the new feed pushing out digested material. Unlike batch-type digesters, continuous digesters produce biogas without the interruption of loading material and unloading effluent. They may be better suited for large-scale operations. Proper design, operation, and maintenance of continuous digesters produce a steady and predictable supply of usable biogas.
Country specific applicability and potential	Given the scarce land resource in the country and to use land for landfill purposes does not make sense. The last 2 landfills have been built on expensive reclaimed land right next to the sea, whereby effluents have polluted the area around the site. This technology will greatly reduce or eliminate the risks with the landfills. Recycling and composting have been identified as other opportunities of this technology.
Status of technology in country	Feasibility studies, including resource assessment, have been carried and it is determined that there is opportunity for this technology based on anaerobic digestors. Cost benefit analysis has also been carried out.
Benefits to economic / social and environmental development	**Contribution of the technology to social development :** The technology can also be applied to the agriculture sector. This sector is often an important part of the economy of developing nations, producing a considerable part of the GDP and employing a vast number of people. Projects using anaerobic digestion technology improve the viability of these farmers by producing energy and compost. The technology is therefore capable of strengthening the backbone of the economy and subsequently improves social development. The current waste stabilization technique most often used at pig farms is the open anaerobic lagoon. Next to emitting methane directly into the atmosphere, this technique has several disadvantages that would be solved by the introduction of a anaerobic digester facility. The workplace at an open lagoon system is unhealthy and unpleasant to work at. This impacts on and a strong odor is produced by the open lagoon. The implementation of an anaerobic digester facility makes the

Technology:	Waste-to-energy (anaerobic digestion)
	workplace safer and healthier. Local air quality is significantly improved, as outlined in the environmental protection section, and the strong odor is considerably reduced. **Contribution of the technology to economic development (including energy market support):** Several economic development benefits are associated with this technology. These benefits mostly arise from the energy production of the technology. National energy self-sufficiency is increased due to the local energy production. This can be a major benefit in countries which are highly dependent on fossil fuel imports for their energy. Reducing the dependence on foreign energy sources leads to an improved economic balance sheet of the country and a higher level of energy security. In some countries, the locally generated energy might provide a more reliable supply of energy than the energy supplied by the national grid. Moreover, when the technology is applied at many locations, the combined energy production might reduce the need to build new power plants at a national level and therefore preserve national resources. **Contribution of the technology to protection of the environment :** Large amounts of animal waste can create serious environmental concerns. When animal manure enters rivers, streams or groundwater supplies it can have environmentally detrimental effects. In addition, decomposing manure causes air quality concerns associated with ammonia emissions, and the contribution of methane emissions to global climate change. The implementation of an anaerobic digestion offers a number of air and water quality benefits. Differences exist among the possible variations of anaerobic digester. **Water quality benefits**. When an anaerobic digester system is properly managed, phosphorous and metals such as copper and zinc will settle out in the process cells (EPA). Therefore, the technology reduces phosphorous and metals loadings to surface waters when manure is land-applied. In addition, digester systems isolate and destroy disease causing organisms that might otherwise enter surface waters and pose a risk to animal and human health. This is especially true for heated digesters. Moreover, anaerobic digesters help protect water resources. **Reduction of landfill requirements**. Biological treatment of waste, such as composting and anaerobic digestion reduces volume of waste and therefore the lowers landfill requirements. Recycling of the residual solids as fertilizer further reduces waste volume.

Technology:	Waste-to-energy (anaerobic digestion)
Climate change mitigation benefits	Methane - The main climate related benefit of this technology is the prevention of methane emissions into the atmosphere. In order to prevent methane emissions it is essential that the anaerobic digester facility either puts the produced biogas to effective use (for instance by feeding it into a CHP unit) or that the biogas is flared.
Financial Requirements and Costs	The net-cost of anaerobic digesters and the production of biogas depend on a number of factors, including the following: • the methane production potential of the feedstock used; • digester type; • volume of waste and intended hydraulic retention time; • the amount of waste available as a feedstock; • the capital and operating costs of the digester type needed for a particular application; • the intended use of the biogas produced; and • the value of the fertilizer produced as a by-product of digestion. The type and size of the digester used will have a large impact on cost, as some digesters are more costly to construct and operate. The use of biogas will also have an effect on the net-cost of an anaerobic digester. Depending on the project and the region in which it is being developed, the type of fuel a digester is displacing will have an effect on its net-cost. For instance, substituting upgraded biogas for natural gas—as opposed to using it to produce electricity—in an area where electricity is a less expensive energy source will make a project more cost-effective. In some cases, the use of a digester will have external benefits that may not be reflected in its cost. For example, anaerobic digestion may cut down on municipal waste disposal costs by decreasing the amount of waste deposited in landfills. It may also decrease environmental regulation compliance costs, such as those associated with water protection or odour control. However, given this difficulty and using the current waste data (amounted collected only and missing calorific value), the estimated future cost of such a project is USD19.88m. This is based on the AD WtE option.
Advantages/Disadvantages	Advantages • Reduction of greenhouse gas emissions through methane recovery • Generation of biogas and fertiliser (almost complete retention of the fertiliser nutrients (N, P and K) • Combined treatment of different organic waste and wastewaters • Reduction of solids to be handled (e.g. less excess sludge)

Technology:	Waste-to-energy (anaerobic digestion)
	• Good pathogen removal depending on temperature • Process stability (high-loads can be treated but anaerobic sludge can also be preserved for prolonged periods without any feeding) Disadvantages • Small- and middle-scale anaerobic technology for the treatment of solid waste in middle- and low-income countries is still relatively new • Experts are required for the design and construction, depending on scale may also for operation and maintenance • Reuse of produced energy (e.g. transformation into, fire/light, heat and power) needs to be established • High sensitivity of methanogenic bacteria to a large number of chemical compounds • Sulphurous compounds can lead to odour

LAND TRANSPORT

<table>
<tr><th>Technology</th><th>Low-carbon private car fleet</th></tr>
<tr><td colspan="2">Technology characteristics</td></tr>
<tr><td>Introduction</td><td>At present, there is no easy and good solution to the problem of lowering CO_2 emission in the transport sector. Currently, there exist two major technical pathways to GHG emission reductions. The first pathway involves the deployment of low carbon alternative fuels like biofuels, LPG, LNG and CNG. The second technical pathway involves the improvement of the energy efficiency of the vehicles through downsizing of the engine and various levels of hybridization and electrification. These two technical pathways are complementary.
The most energy efficient vehicle available today is the electric vehicle charged with solar PV. However, commercialization of full electric vehicles is still hampered by high purchase prices (storage systems), short driving ranges and long recharging times. These facts have led to the construction of hybrid vehicles. A hybrid car combines an internal combustion engine with technologies used in full electric vehicles.</td></tr>
<tr><td>Technology characteristics/highlights</td><td>Current transport technologies are changing fastest in the passenger vehicle market, which will eventually be reflected in road-based freight vehicles. The technical options are multiplying for both engines and fuel, without any obvious winner. What appears clear is that regions will have the opportunity to influence and guide technical options in order to meet their own requirements.
All options for vehicle technology are subject to intense innovative efforts and incremental improvements. Such is the pace of innovation that most technological opportunities are nowhere near their full potential.
Selection of appropriate vehicle and fuel technologies should depend, not only on greenhouse gas impact and the matter of oil depletion, but also on a variety of other factors, including the following:
Mass movement versus flexibility
Energy infrastructure: investment needs, competition and energy security
Range versus efficiency
Maturity of underlying technologies</td></tr>
<tr><td>Country specific applicability and potential</td><td>The government is putting in place various mechanisms to promote the use of alternative technologies in the transport sector. The tax regime for hybrid and electric vehicles has changed in favour of the technologies.The physical terrain in also attractive to the use of these new technologies, especially the electric cars.

It is assumed that there is no need for direct capital injection to kick start this project, it requires a small amount of cash that will see the setting up of some sort of revolving funds amounting to USD1.25m.</td></tr>
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Technology	Low-carbon private car fleet
Status of technology in country	The market for electric and hybrid cars have opened up and the uptake of these technologies, though cautious at the beginning, has picked up significantly.The other fuels and technologies are yet to appear on the market.
Benefits to economic / social and environmental development	Judicious choice of fuels and drive train technology may have a significant impact beyond the direct benefits of more effective transport and the reduction of greenhouse gas emissions. The emissions described in the environmental benefits section below create smog and impact on population health through respiratory related diseases (asthma and infection), and through other serious health problems such as liver disease and cancer caused by noxious emissions. Fuel is a significant component in the whole-of-life cost of a vehicle. Increased efficiency reduces the burden this places on the owner and on the economy as a whole. In many cases transport fuel is an imported commodity and thus can place a significant strain on the national balance of payments. Use of more local fuel sources reduces this impact. Reductions in local pollution and greenhouse gases from the use of these fuels and technologies also have economic benefits. The adaptation of appropriate technologies to suit regional circumstances may also lead to development of new industry. Airborne transport emissions can have a detrimental environmental impact apart from climate change. They can be generated at the vehicle exhaust, at the power station or at production facilities. The technologies described in this section can have positive environmental benefits including the reduction of: • airborne emissions such as particulates, nitrous oxides, carbon monoxides and other organic compounds generated by many fuels • acid deposition, which causes infrastructure degradation and may lead to acid rain; • soot deposition on both natural and human infrastructure. Similarly emissions from many of the liquid based fuels contaminate wetlands and groundwater resources
Climate change mitigation benefits	Significant reduction in GHG emissions, net of emissions related from the use of grid electricity that is derived mainly from the combustion of fuel oil.
Financial Requirements and Costs	The financial requirement is mostly from the investor point of view. The government will only have to ensure proper access to the market.
Advantages/Disadvantages	With the current framework in place, the cost of these technologies such as electric cars is very competitive with conventional technologies. The main disadvantage is that the market for the after care of these technologies in not picking up with the market penetration of the

Technology	Low-carbon private car fleet
	technologies.

Technology	Victoria traffic management plan (VTMP)
Technology characteristics	
Introduction	Proper traffic management can ensure that traffic flows smoothly and efficiently; there is fair access for different transport modes; roads and streets are safe for all users; roads full of motorised traffic do not constitute barriers blocking movement between areas; congestion, local pollution and noise are minimised; neighbourhoods, pedestrian areas and the overall character of localities are protected from the negative impact of high traffic levels; and greenhouse gas is reduced.
Technology characteristics/highlights	This can be achieved through a range of measures, which can be divided into the following categories: • the creation of a rational hierarchy of roads and streets that ensures particular street use, and so vehicles tend to be restricted to the most suitable thoroughfares to minimise traffic impacts • roadways designed to maximise connectivity, with minimal dead-ends, especially for pedestrians and cyclists • the use of design features and road laws to 'calm' or slow down traffic • the allocation of road lanes and space to favour more efficient modes • proper traffic control at intersections, in the interests of safety, fair access for all traffic modes, and smooth flow of traffic • demand management measures, including pricing mechanisms and restrictions on road space and parking, to ensure that more smoothly flowing traffic does not have the adverse effect of encouraging large numbers of extra motorised vehicles onto the roads • driver education and the proper enforcement of road laws.
Country specific applicability and potential	Given the traffic congestion issues, especially in Victoria during the week, it is clear that there is an urgent need for a proper traffic management plan to be put in place. This has to have very quick low cost short term benefits. The growth in private vehicle is gaining momentum and with the increase average income of individuals, there is no end in sight for this growth.
Status of technology in country	Public travel space is for everyone, not just for users of cars and other private vehicles. Achieving smoother private vehicle flows by giving such vehicles priority, or by building bigger and better roads for them, increases their numbers on the roads and the traffic injuries and deaths, air pollution and greenhouse gases they generate. In the end it does not even ease congestion, because vehicle numbers increase as a result. But effective traffic management can give all travellers good access to

Technology	Victoria traffic management plan (VTMP)
	travel space, substantially reduce the adverse effects of traffic on communities, and contribute to the lowering of greenhouse gas emissions, if the measures described in this section are adopted.
Benefits to economic / social and environmental development	When traffic is well-managed, urban areas are safer, healthier and more pleasant to live in. There is less traffic intrusion into neighbourhoods and other social spaces. Those on low incomes have better transport services because public transit, cycling and walking gain better and safer access to travel space and thus become more viable alternatives to private vehicle use (Trubka et al., 2010). If traffic is well-managed, vehicles travel more smoothly and there are fewer delays. This means time is saved and there is less wear and tear on vehicles. There are fewer costs to health from pollution and accidents. And as public transit, walking and cycling gain a bigger share of all travel undertaken, the total cost of transport to society as a whole goes down (Newman & Kenworthy, 1999). More smoothly flowing traffic, as long as it is associated with greater use of transit, walking and cycling, will reduce pollution and greenhouse gas production. If it is accomplished by building substantially more road capacity it can just increase the use of private vehicles and hence increase transport carbon. Also, when traffic congestion is reduced by increasing other modes and calming motorised traffic there is less noise and more balanced and sociable use of public spaces.
Climate change mitigation benefits	The potential for greenhouse gas savings from traffic management measures is a complex and controversial subject. Reducing traffic congestion by increasing road capacity will lead to greenhouse gas reductions for individual vehicles, as they can travel more efficiently, but it does not lead to reductions overall as it attracts more vehicles onto the roads (Newman & Kenworthy, 1988). A car travelling smoothly at a moderate speed may be more efficient that one engaged in stop-start travel, but if this smoother traffic leads to an increase in the number of vehicles on the road the outcome is a net increase in greenhouse gas emissions. However if traffic congestion can be eased while at the same time reducing private vehicle use – through traffic calming, reduced road space for these vehicles, and a range of demand management measures – then greenhouse gas reductions can be achieved.
Financial Requirements and Costs	Traffic management measures vary greatly, depending on what is done, over what area or length of road or pathway (if it is a physical measure), and the degree of change necessary. Some of the major measures involved, as describe in this section, are alterations to roads for traffic calming, creation of dedicated lanes for buses and bikes, better controls and safety at intersections, driver education, and stronger enforcement. These could be partly funded out of taxes and

Technology	Victoria traffic management plan (VTMP)
	charges on private vehicles. The implementation of the VTMP will cost an estimated USD55.1m, comprising of the software and hardware components of this technology.
Advantages/Disadvantages	This technology will significantly reduce the idle time.

Technology	Electric scooters
Technology characteristics	
Introduction	Electric scooters are plug-in electric vehicles with two wheels powered by electricity. The electricity is stored on board in a rechargeable battery, which drives one or more electric motors. Electric scooters (as distinct from motorcycles) have a step-through frame.
Technology characteristics/highlights	These scooters looks like and are operated very much like a motorcycle, or motorized scooter. However, rather than a internal combustion engine and a gas tank, these have a rechargeable battery and a DC electric motor. There are some batteries with a low life of only 100 charges and then there are batteries that can be recharged more than 300 times, there are batteries with 15AH and there are batteries with 20AH. Electric scooter are relatively easy to maintain compared to a conventional scooters as the system is relatively simple, there is no lubricating and adjusting and tuning you have to do. You basically just worry about consumables: brake pads, tires, maybe a brake fluid flush.
Country specific applicability and potential	Electric scooters have a competitive advantage over bicycles for office workers on the main island, given the terrain of the island.
Status of technology in country	So far, there is very limited use of this technology, mainly in luxury residence estates and resorts. The limited range and higher costs of this technology is one limiting factor to mass use of it.
Benefits to economic / social and environmental development	If this technology is coupled with a charging source that is renewable such as solar of wind, then there is a reduction in fossil fuel use which is translated to a reduction in foreign exchange spending. This savings also has a social dimension to it as more money saved by the economy will mean that there is more money available for other, possibly social, health and education projects. Scooters can effectively reduce traffic congestions that is a common occurrence in all major cities around the world. In the Seychelles, many have adopted scooters as a way of getting around the traffic problem. This technology also requires much less land to develop road networks and parking spaces.
Climate change mitigation	Emissions will be reduced as electric scooters will reduce the number

Technology	Electric scooters
benefits	of car trips, and hence car fuel emissions. This will be net of the emissions from the generation of electricity that is needed to charge the electric scooters.
Financial Requirements and Costs	Electric scooters is more expansive then their fuel powered counterparts, however, given that there is no tax imposed on the importation of electric scooters, then the financial feasibility may make sense. The low maintenance cost will also be a long term financial advantage. To achieve this target, the cost estimated is around USD6m
Advantages/Disadvantages	The main issue with this technology is range and battery life, this may be complemented by the size of the island.

Annex V: MCA calculators

POWER SECTOR

Please see Excel file named “MCA Calculator – Power Sector – TNA Seychelles.xlsx”.

LAND TRANSPORT

Please see Excel file named “MCA Calculator – Transport Sector – TNA Seychelles.xlsx”.