Republic of Seychelles

BARRIER ANALYSIS & ENABLING FRAMEWORK REPORT – MITIGATION

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SEYCHELLES BARRIER ANALYSIS & ENABLING FRAMEWORK 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	Kilotonne 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
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
PPA	Power Purchase Agreement
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
TMP	Transportation Master Plan
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

With the completion of the TNA report (Government of Seychelles, 2017), the second phase of the TNA project is to identify barriers hindering the acquisition and diffusion of prioritised technologies and to develop enabling frameworks to overcome the barriers and facilitate the transfer, adoption and diffusion of selected technologies in the Seychelles.

The Seychelles prioritised the power and land transport sectors for technical assistance under the Technology Needs Assessment (TNA) project as they are the highest GHG emitting sectors in Seychelles (Government of Seychelles, 2017). The choice of priority mitigation sectors is also aligned with the Seychelles Nationally Determined Contributions (NDC) that has been submitted to the UNFCCC (Government of Seychelles, 2015).

In this report, barriers hindering the acquisition and diffusion of prioritised mitigation technologies for the power and land transport sector have been identified, and measures to overcome the barriers and facilitate the transfer, adoption and diffusion of these technologies are elaborated. To facilitate the identification of barriers, logical problem analysis (LPA) was used to identify the root causes of the main barriers that hinder the implementation of each mitigation technology. Using a Problem Tree (PT), the main barriers were decomposed to identify the root causes of barriers, and an Objective Tree (OT) that mirrors the PT was developed to identify possible measures to overcome the root causes. The transfer and diffusion of the mitigation technologies is substantiated using detailed cost-benefit analysis (CBA). Further, the enabling environments that will support the reduction or elimination of barriers confronting each technology are discussed.

<u>Summary for power sector</u>

Based on the technology prioritisation that has been carried out (Government of Seychelles, 2017), three technologies were analysed. The penetration levels of mitigation technologies in the power sector were defined by stakeholders and the targets were used to inform technology prioritisation in the TNA Report (Government of Seychelles, 2017). The targets that have been established for the mitigation technologies are:

1. **Waste heat recovery at Roche Caiman thermal power plant**: The target is to produce 12MW of thermal energy using steam cycle generation from waste heat recovery by 2030 with the intermediary target of 5MW generation in 2020;
2. **Waste-to-energy**: The generation of 4MW of grid-fed power from centralised anaerobic digestion of landfill waste by 2019; and
3. **Agro-forestry**: The thermal generation of 5MW of baseload power from agro-forestry products in 2025.

The mitigation technologies in the power sector faced similar barriers, including:

- ➢ Economic and financial barriers;
- ➢ Regulatory barriers;
- ➢ Market barriers;
- ➢ Human capacity barriers;
- ➢ Institutional barriers; and
- ➢ Technical barriers.

Each mitigation technology can be classified as a capital good. The technology is characterised by its implementation at limited sites and requiring relatively large capital investment. The main measures that have been proposed are summarised in **Table 1**.

Table 1. Summary of main measures proposed for mitigation technologies in the power sector.

Barriers	Measures
Economic and financial	*Waste heat recovery at Roche Caiman power plant* - a government-guaranteed loan denominated in foreign currency (i.e. US$) at a fixed concessional interest rate of 2% per annum for a period of 15 years *WTE and Agro-forestry* - a tariff incentive set at 0.88% of the marginal cost of production using fuel oil
Regulatory (common to all technologies)	- Updating the Energy Act 2012: (1) to define the power sector market activities and the roles of market actors; and (2) to give the SEC the powers it needs to regulate the entire electricity market sector - Accompanying institutional and human capacity strengthening for the SEC through a combination of trainings and exchanges with overseas energy sector regulators - Developing a standardised PPA and tendering process
Market (common to all technologies)	This is taken care of through the setting up of a competitive bidding process as mentioned above. In the case of waste heat recovery at Roche Caiman power station, the prospect of developing a public-private partnership (PPP) should be investigated.
Human capacity	Developing human capacity and expertise by providing appropriate training in the prioritised technology.
Institutional	*WTE and Agro-forestry* - a detailed institutional review of all the relevant institutions, and formulating clear guidelines for institutional roles and responsibilities according to institutional mandates - setting up a multi-stakeholder coordination mechanism for establishing direct lines of communications and knowledge and information sharing between all the stakeholders
Technical	*WTE and Agro-forestry* - Detailed solid was characterisation (WTE) and biomass resources assessment (agro-forestry) in Seychelles

The benefit-cost ratio (BCR) of the three mitigation technologies are summarised in **Table 2**. In all cases, the benefits of the proposed measures outweigh their cost of implementation, implying that the proposed measures are economically attractive.

Table 2. Values of BCR for mitigation technologies in the power sector.

Technology	BCR
Waste heat recovery at Roche Caiman power station	2.84
Water-to-energy (WTE)	4.41
Power generation from agro-forestry feedstocks	4.80

The similar barriers that the technologies face, coupled with the fact that they have similar market and supply chain characteristics implies that there are several synergies that may be had across all the mitigation technologies by adopting an integrated approach to designing the intervention measures and putting in place an adequate enabling environment.

The enabling environment to promote all three mitigation technologies can be enhanced in two main ways:

- Given the initial cost burden of the projects in the power sector, the government must ensure that it takes every step to minimise the investment risks for the developer, be it PUC or otherwise. This may come as a form of a co-guarantee for any investment to be undertaken or putting in place the appropriate and acceptable tariff. Developing a standardised PPA and tendering process will provide more visibility to private investors, thereby decreasing market risks; and
- Further, the SEC should focus its activities on regulating the sector and the government should set up a section under the Department of Energy and Climate Change to design and implement new projects in the power sector. The SEC must ensure that it hires staff and train them with the help of the international consultants and study tours (at least initially), and a succession plan has to be developed to ensure the sustainability of institutional strengthening.

Summary for land transport

There are no official targets for the transfer and diffusion of mitigation technologies in the road transport sub-sector. Targets for technology diffusion have been set using the expert knowledge of stakeholders and guided by the objectives of the Nationally Determined Contribution (Government of Seychelles, 2015):

1. **Low-carbon private car fleet:** By 2030, 70% and 10% of the total car fleet are hybrid and electric vehicles, respectively;
2. **Victoria Traffic Management Plan (VTMP):** The VTMP proposes a host of actions to remedy this problem, namely: (1) relocation of the central bus terminal in Victoria to two separate facilities (one at Roche Caiman and one at Ile du Port) by making provision for faster and more reliable services, (2) construction of the Western Victoria bypass between Beau Vallon and Saint Louis, which includes a new stretch of road and highway improvement works; and (3) dualisation of the Bois de Rose venue/Providence Highway/East Coast Road between Victoria and Anse Royale.; and
3. **Electric scooters:** It is proposed to have a total of 1,500 electric scooters by 2030.

LPA has shown that the common barriers hampering the uptake of land transport mitigation technologies were:

- Economic and financial barriers;
- Policy barriers;

- Market barriers; and
- Human capacity barriers;

Regarding the VTMP, additional barriers were identified as institutional barriers and technical barriers.

The VTMP can be classified as a publicly-provided good. Traffic congestion is a collective action problem and the solutions and investments will be driven mainly by the government without excluding the possible involvement of private partnerships. The other two mitigation technologies are classified as consumer goods. Consequently, the proposed measures for low-carbon cars and electric scooters (e-scooters) are quite similar. The main measures that have been proposed are summarised in **Table 3**.

Table 3. Summary of main measures proposed for land transport mitigation technologies.

Barriers	Measures
Economic and financial	*Low-carbon cars & e-scooters* - 1.5% and 4% subsidy on loan interest for hybrid and electric cars, respectively - 2% subsidy on loan interest for e-scooters *VTMP* - a government-guaranteed loan denominated in foreign currency (i.e. US$) at a fixed concessional interest rate of 2% per annum for a period of 15 years
Regulatory	*Low-carbon cars & e-scooters* - establishing of a legal framework so that only authorised dealers are able to import low-carbon vehicles in the country
Policy	*Low-carbon cars & e-scooters* - formulating policies for promoting low-carbon motorised vehicles *VTMP* - proposed designated authority to seek endorsement of the Seychelles Strategic Plan (SSP) by the Cabinet of Ministers, and to declare the SSP as the national master plan for the Seychelles
Human capacity	*Low-carbon cars & e-scooters* - training technicians for providing specialised technical services to owners of hybrid and electric vehicles, and for e-scooters *VTMP* - study tours for selected public staff in order to increase their knowledge and skills in specific areas, such as urban planning, multi-modal development planning in urbanised areas, and deployment and use of real-time traffic management technologies for efficient traffic management
Institutional	*VTMP* - setting up of a high level inter-ministerial steering committee to oversee the implementation of the VTMP

Barriers	Measures
Technical & technological	*VTMP* - introduction of technologies for the real-time monitoring of traffic in and around Victoria - prospecting the merits of using of bridges, over passes, and roads built on pillars as alternatives to land reclamation

The benefit-cost ratio (BCR) of the land transport mitigation technologies are summarised in **Table 4**, revealing that the benefits of the proposed measures outweigh their cost of implementation.

Table 4. Values of BCR for land transport mitigation technologies.

Technology	BCR
Low-carbon cars (electric and hybrid)	1.17
VTMP	2.83
Electric scooters	1.34

The enabling framework for the land transport sector should include the following:

- Drafting and approval of a land transport policy that would set priorities for managing land transport activities and improving energy efficiency in the transport sector. In parallel, the land transport legislation should be consolidated under one act, where the roles and responsibilities of all stakeholders would be designated, thereby eliminating the conflicts of interest amongst them;
- Putting in place the necessary financial instruments for technology implementation. For the consumer goods, the proposed financial instruments must be facilitated by government in collaboration with financial institutions; and
- While the distribution of the low-carbon motorized vehicles may use existing supply chains, it will be important to regulate the supply chain through the setting up of accredited and registered vehicle dealers that will ensure warrantee on vehicles sold, provide adequate after sales services, and ensure availability of spare parts and batteries.

Chapter 1 Power Sector

The Seychelles prioritised the power sector for technical assistance under the Technology Needs Assessment (TNA) project as it is the highest GHG emitting sector in Seychelles (Government of Seychelles, 2017). The choice of this sector is aligned with the Seychelles Nationally Determined Contributions (NDC) that has been submitted to the UNFCCC (Government of Seychelles, 2015a). Three technologies were prioritised for further analysis during the first stage of the TNA project (Government of Seychelles, 2017):

1. **Waste heat recovery at Roche Caiman thermal power plant for electricity generation**
   The Public Utilities Corporation (PUC) has experience with the recovery of waste heat for pre-heating HFO used in thermal power generation. This experience will be extended to the recovery of waste heat during combustion of fuel oil for power generation using steam cycle generation.

2. **Waste-to-energy**
   Centralised anaerobic digestion technology was chosen to be built very close to the current landfill. GHG emission reduction will accrue from landfill waste diversion and savings on grid electricity generated using fuel oil.

3. **Centralised utility-scale PV** (with some battery storage)
   There is a sizeable scope for the scaling up of utility-scale PV in Seychelles. The realistic potential for utility-scale PV is between 21.5 MW and 57.2 MW by 2030. Given that the generation of electricity from PV may not be limited to the three most populated islands where existing thermal generation can be used to back up the intermittency of PV, battery storage is proposed on the islands of Romainville and Praslin.

The first two technologies have been retained for carrying out detailed barriers analyses, including cost-benefit analyses. Centralised utility-scale PV is already the subject of attention for a funding proposal under the Green Climate Fund (GCF), and, therefore, has not been analysed further in the TNA project. It is pointed out that the GCF project proposal was initiated after completion of the TNA Report. Also, there is already political commitment from both the government and the PUC to for the development of a 7MW PV farm with a 5MW battery storage system by the end of the year. In order to maintain 3 prioritised technologies for developing Technology Action Plans (TAPs), the mitigation technology that was prioritised fourth – i.e. – has been included in the barriers analysis. The details of this technology are:

4. **Agro-forestry for power generation**
   According to one study (Moustache, 2011), there should be sufficient biomass for base load power generation. There is also potential for generating electricity from agricultural residues, and agro-forestry through the generation of biomass or energy crops. The target is to generate 5 MW of baseload power using agro-forestry products.

1.1 Preliminary targets for technology transfer and diffusion in the power sector

The Seychelles relies heavily on imported fossil fuel for almost 100% of its primary energy requirement with the exception of the Port Victoria Wind farm and roof top PV that provide about 2.5% of the national electricity needs (Government of Seychelles, 2017). Because of this high dependence on imported fossil fuels, Seychelles is vulnerable to international fuel market prices. Fuel imports for electricity generation alone account for ~12% of the total government budget (NBS, 2015) thereby adversely affecting balance of trade.

The *Energy Policy* 2010 – 2030 (Van Vreden et al., 2010) has set a target for 5% of energy supply to be met from renewable energy sources in 2020 and 15% to be met by 2030. In the long term, the Policy has an objective of 100% energy supply from renewable energy sources. It should be mentioned that the government has not yet identified a clear strategy and action plan for implementing the Policy in order to promote renewable energy (RE) resources and technologies. However, discussions with the Seychelles Energy Commission (SEC) have revealed that these targets are now being applied primarily to the power sector rather than being applied to general national energy supply (Government of Seychelles, 2017).

The Policy has also proposed the adoption of demand side management or energy efficiency (EE) practices that would decrease the energy intensity by at least 10% in 2020 (Van Vreden et al., 2010). The government, through a UNDP-GEF project, intends to develop clear and precise policies for improving EE. The intention is to also address the supply short comings in the power sector with the definition of clear and concise targets for specific contributions from RE sources and technologies.

With these considerations in mind, the targets that have been established for mitigation technologies are:

4. **Waste heat recovery at Roche Caiman thermal power plant**: The target is to produce 12MW of thermal energy using steam cycle generation from waste heat recovery by 2030 with the intermediary target of 5MW generation in 2020;
5. **Waste-to-energy**: The generation of 4MW of grid-fed power from centralised anaerobic digestion of landfill waste by 2019; and
6. **Agro-forestry**: The thermal generation of 5MW of baseload power from agro-forestry products in 2025.

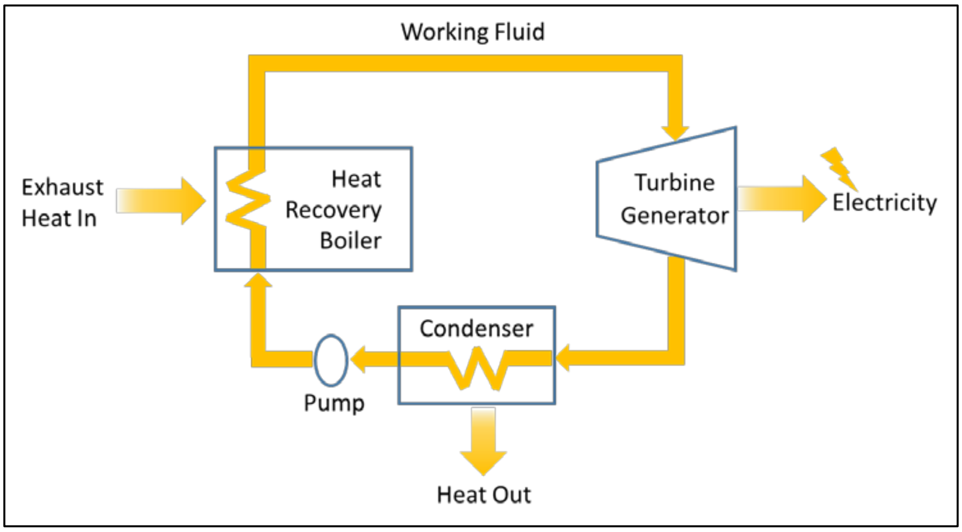
The penetration levels of mitigation technologies in the power sector were defined by stakeholders and these targets informed the multi-criteria analyses (MCA) that were used for technology prioritisation. More details can be found in the TNA Report – Mitigation (Government of Seychelles, 2017; Table 15).

1.2 Barrier analysis and enabling measures for waste heat recovery at Roche Caiman power plant

1.2.1 General description of waste heat recovery technology

Waste heat recovery is an innovative way to increase the efficiency and generating capacity of a power station without having to increase the number of generators. The aim is to capture and use the waste heat generated by existing thermal generators to produce more electricity. Alternatively, the heat can be recovered for desalination or to produce cold for district cooling. Hence, the recovered waste heat can be used for a wide 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, and the potential utility of heat recovery is dependent on availability of a market and the economics of reusing the recovered thermal energy.

At the main power station on Mahé (i.e. at Roche Caiman), heavy fuel oil (HFO) is burned in generators to produce electricity. In this process, heat is generated and discarded through chimney stacks into the atmosphere. As illustrated in **Figure 1**, 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 to the atmosphere at a lower temperature.



Source: Zeb et al., 2017

Figure 1. Simplified waste heat recovery process to generate electricity.

This allows more electricity to be produced from the same quantity of fuel consumed, and thus increases the efficiency of the power station. The flue gases will be at a lower temperature and air pollution per unit of electricity generated will be lower.

The temperature of the flue gases without heat recovery is around 370°C (PUC, 2017). This is significantly higher than the minimum temperature of ~260°C that is required to economically extract energy through the WHP process. Waste heat recovery provides the opportunity to reduce the capital investment in additional thermal generation capacity. In addition, as the power station is in operation throughout the year, it will produce waste heat continuously so that the WHP process will run at a relatively high capacity factor and, therefore, have a relatively higher rate of return on the investment.

1.2.2 Identification of barriers to deployment of waste heat recovery

This section provides an analysis of barriers that hinder the uptake of the waste heat recovery for electricity generation in Seychelles. To facilitate the identification of barriers, logical problem analysis (LPA) was used to identify the root causes of the main barriers that hinder the implementation of waste heat recovery. Using Problem Trees (PT), the main barriers were decomposed to identify the root causes of barriers, and an Objective Tree (OT) that mirrors the PT was developed to identify possible measures to overcome the root causes (Nygaard and Hansen, 2015, Chapters 4 and 6). The PT and OT for waste heat recovery at Roche Caiman are found in **Annex I**. The main barriers that are associated with waste heat recovery are:

- Economic and financial barriers;
- Regulatory barriers;
- Market barriers;
- Human capacity barriers;
- Institutional barriers; and

- Technical barriers.

The PT for waste heat recovery does not show the deconvolution of regulatory and market barriers since these barriers and their root causes are the same as for waste-to-energy (WTE) mitigation technology as shown in the corresponding PT in **Annex I**.

Waste heat recovery is classified as a capital good that is characterised by its implementation at limited sites (i.e. in thermal power plants) and requiring relatively large capital investment (Nygaard and Hansen, 2015, Chapter 4). Since the demand for heat is driven by the need to produce electricity competitively with the prevailing thermal generation from fuel oil, one of the main barriers that hamper the uptake of this new technology in Seychelles are economic and financial. This is the reason why emphasis has been placed on carrying out a detailed cost-benefit analysis (CBA) to justify investments in waste heat recovery.

1.2.2.1 Economic and financial barriers

As shown in the PT in **Annex I**, waste heat recovery at Roche Caiman suffers from economic and financial barriers related to high up-front investment costs and high cost of capital. The latter reflects the risks that are underpinned by technology, institutional and human capacity barriers. Since the equipment will have to be purchased in foreign currency, there are additional currency exchange risks. The risks remain high since there are no derisking instruments (e.g. financial derisking and policy derisking instruments) in place to overcome or reduce the barriers underpinning them. The lack of financial derisking instrument is shown in the PT as ‘lack of adequate financing instruments’.

The high cost of capital that the technology faces is also related to the socio-economic priorities of the country. The Seychelles has been going through an International Monetary Fund (IMF) economic reform program, and there have been various restrictions in borrowing and spending imposed on the country. This has pushed the country to having to prioritise its borrowings for capital expenditure. If a project is not deemed vital (usually non-social projects) then it does not make the priority list. The PUC also has its own priority list of projects to implement, mostly to address the aging national infrastructure under its management. Further, the PUC has a limit on how much it can borrow, since its entire cash flow is dominated by the cost of fuel for producing electricity. These macro-economic conditions increase the cost of capital of innovative mitigation technologies, such as waste heat recovery for power generation that would not be considered a priority.

1.2.2.2 Non Financial barriers

The main non-financial barriers identified by stakeholders are institutional, human capacity and technical (see PT in **Annex I**). These are discussed below:

<u>Institutional and organisational barrier</u>

Most local companies and organisations, including government or private, have limited ability to absorb new technologies due to their relatively small sizes. The introduction of waste heat recovery at Roche Caiman will require PUC to set up dedicated project development, project implementation, and operation and maintenance (O&M) teams. This will put pressure on already limited resources of the organization to increase its capacity to deal with the implementation of such projects. The institutional barrier is further compounded by the lack of prior experience with heat recovery for generating electricity using the steam cycle – i.e. lack of project reference.

Regulatory barrier

Given that PUC may find it difficult to invest in this project, it has the possibility to tender out the project implementation to an independent power producer (IPP) or enter into a Public Private Partnership (PPP). However, the existing regulatory framework does not allow the private sector to participate in power generation. For such a project to be implemented with the private sector, changes to the regulatory framework will be required. The Seychelles Energy Commission, acting as regulator for the power sector, lacks the authority or capacity to adequately regulate the sector. The PT for waste heat recovery at Roche Caiman in **Annex I** does not show the 'regulatory barrier'. This is because this barrier was identical to that faced by the waste-to-energy mitigation technology as shown by the corresponding PT in **Annex I**, and has not been repeated.

Human capacity barrier

The scale and technical complexity of the technology, which will be a first-of-the-kind in Seychelles, will require a high level of expertise to design, implement and commission the project. However, there is a lack of domestic expertise to implement the technology. The lack of human capacity is directly related to the lack of a project reference discussed above. If local human capacity is not developed, project implementation would rely on inputs from foreign experts with the twin disadvantage of increased project costs and maintaining the low indigenous technical capacity to deal with similar technology implementation.

Because of its small population size, qualified and quality staff is in high demand in Seychelles. The small market for human capital exposes most local companies to high staff turnover. The PUC is also affected by this reality. So besides developing capacity that does not exist locally, companies have to also develop effective staff retention strategies.

Technical barrier

Roche Caiman power plant, where the technology will be implemented, is the main power station on Mahé. It generates 95% of the electricity requirement of the island. Hence, there is the risk of technical problems arising during project implementation that might result in country-wide blackout. Justifiably, the PUC is quite concerned about this risk. In the past, the PUC has experienced a few complete blackouts, which it wishes to avoid in future.

There are other elements of technology complexity that add to the technical barrier. Waste heat recovery is typically done in large scale power installations to make it technically and financially feasible (Zeb et al., 2017). The total installed capacity at the Power Station C (Roche Caiman) is 76 MW with peak demand reaching 56 MW. Consequently, maximum heat recovery will occur twice a day during peak load.

Power station C runs mostly on heavy fuel oil (HFO) and the heat content from the exhaust is not very high. Usually, the exhaust from gas turbines are preferred for this kind of project as the temperatures of the exhaust can be as high as 1,540^{o}C[1] compared to the exhaust temperature from HFO engines which is around 370^{o}C (PUC, 2017). This implies that the waste heat recovery equipment for this project may need modification to increase the output efficiency. Nevertheless, it is pointed out that

[1] Please see: https://en.wikipedia.org/wiki/Gas_turbine - accessed 14 June 2017.

alternative technologies (e.g. Organic Rankine Cycle technology) have been tested and proven to be economically and technically viable for electricity generation using heat recovered from exhaust with temperatures as low as 100 - 180°C (David, Michel and Sanchez, 2010). Nevertheless, ORC is still more expensive compared to conventional technology to recover heat at higher temperatures. It is also even technically feasible to produce electricity from waste heat recovered from a car engine, albeit the economics is not favourable (Orr and Akbarzadeh, 2017).

1.2.3 Identified measures for waste heat recovery

An OT was developed (**Annex I**) to identify main measures to support the implementation of waste heat recovery at Roche Caiman power station. The OT is a logically organised presentation of objectives, which when implemented increases the likelihood of technology diffusion or implementation. In principle, by implementing measures to achieve the objectives at the root of the tree, all the objectives above in the tree have an increased chance of being achieved. The collection of measures, therefore, provides a programme of action for implementing or scaling-up the technology. As shown in the OT for waste heat recovery, the proposed measures are articulated around the following:

- Increasing the financial attractiveness of waste heat recovery by providing financial incentives to reduce the cost of capital. This will also address the issue of high upfront capital investments;
- Strengthening the policy and legal framework to allow IPPs to operate in the power market;
- Enhancing institutional learning by creating opportunities for exchanges and sharing of lessons learned. This measure will also contribute to reducing the technical risks associated with the complexity of the technology; and
- Developing human capacity and expertise by providing appropriate training.

The measures proposed for each component are discussed below.

1.2.3.1 Economic and financial measures for waste heat recovery

Clean energy technologies in Seychelles already benefit from Value Added Tax (VAT) exemption. The Waste Heat Recovery project also falls into the category of projects that could benefit from VAT exemption. Given the high cost of producing electricity in the conventional way, any project that lowers the production cost of electricity should be encouraged. Even with a high upfront capital cost, the benefits from lower production cost of electricity will significantly reduce the payback period.

The government can, nevertheless, enter into discussions with bilateral or multilateral funding agencies, such as the European Investment Bank (EIB), to find cheaper sources of capital. This would mean that PUC will be able to afford to take a loan and implement this project with reduced risks. The risk profile of the technology will also be lowered by the accompanying non-financial measures discussed in the next section.

The measure identified is, therefore, a government-guaranteed loan denominated in foreign currency (i.e. US$) at a fixed concessional interest rate of 2% per annum for a period of 15 years. In the analysis, any cost reduction associated with VAT exemption has not been taken into account, making the calculations conservative. Cost-benefit analysis (CBA) discussed in section 1.2.3.3 also includes a sensitivity analysis on the interest rate for the guaranteed loan.

1.2.3.2 Non-financial measures for waste heat recovery

Institutional and organisational measure

Ideally, it would make more sense for PUC to venture into a partnership with a private company (i.e. PPP modality) or tender out the project to an IPP. Since the utility is government-owned, the PPP modality may be preferred. This will ensure that the technical competency to design, implement and carry out O&M will not rely on PUC's already overstretched workforce – i.e. the onus will be placed on the private developer/partner to bring in necessary expertise to commission the technology and assuring O&M. This approach will eliminate the institutional and organisational barrier discussed in section 1.2.2.2 without having to incur additional costs in building up the capacity of PUC staff to design and implement waste heat recovery for power generation.

Human capacity development

In this scenario, it is most likely that a foreign company with the necessary technical competency and project reference will be chosen through competitive bidding to implement the mitigation technology. But as this is a once off project, it may not be necessary to build human capacity in the design and implementation phase. It will suffice to build human capacity in technology O&M. The proposed measure is for local technicians to be trained in the O&M of the waste heat recovery technology. An accompanying measure that will reduce risks related to the complexity of the technology is to sponsor selected management and technical staff (from PUC and SEC) on a study tour to learn more about the technology. Such a study tour will assist local experts to better assess the risks and opportunities that the new technology offers.

Regulatory strengthening

If a PPP or IPP setup is used, the SEC must be also be strengthened to ensure it can effectively play its role as the regulator of the electricity sector. SEC has the mandate to regulate the sector but it lacks the authority and necessary resources to effectively carryout its mandate. This will require updating the Energy Act 2012 to properly define the sector by designating the market activities and who (including private proponents) can be the actors in the market activities. The Act should also give the SEC the powers it needs to regulate the entire electricity market sector. This measure needs to be accompanied with institutional and human capacity strengthening through a combination of trainings and exchanges with overseas energy sector regulators.

The costs associated with the implementation of the non-financial measures are discussed in the next section.

1.2.3.3 Cost-benefit analysis of measures for waste heat recovery

Considering the high dependency on imported petroleum products and the volatility of the world petroleum market, the incentive for the government to push this project is high. In order to justify investments in waste heat recovery at Roche Caiman, a CBA of the measures proposed in sections 1.2.3.1 and 1.2.3.2 has been carried out.

The costs and benefits that are discussed below are calculated using an investment cost analysis rather than using an incremental cost analysis. In the absence of the measures, it is assumed that power generation will be carried out using the prevailing technology – i.e. thermal combustion of fuel oil. In this case, the benefits such as reductions in emission reductions and avoided energy bill that are used in the CBA would not be obtained.

Cost of measures

The parameters used for calculating the cost of the measures proposed in sections 1.2.3.1 and 1.2.3.2 are summarised in **Table 3**.

Table 5. Parameters used for calculating the cost of measures for waste heat recovery.

Measure proposed	Remarks
Low-cost capital	The capital investment, and operation and maintenance between 2020 and 2030 have been estimated at US$42.84 million. It is assumed that this amount will be borrowed at a concessional fixed annual interest rate of 2%.
Human capacity enhancement for O&M	There are two cost elements: (1) cost of training staff for O&M of mitigation technology. This takes place in 2020 and 2028 when new technology is implemented. It is assumed that the trained technicians will impart new knowledge to other technical staff through on the job training. This is a strategy to (at least partially) deal with any staff turnover. The cost of training is equal to the number of O&M jobs created in 2020 and 2028 multiplied by the cost of training per job created (assumed to be US$20,000 per person); and (2) cost of sending staff on study tours that take place in 2020, 2023, 2026 and 2030. It is assumed 2 persons are sponsored on each study tour at the cost of US$5,000 per person.
Regulatory strengthening	Consists of two cost elements: (1) the consultancy fee for updating the Energy Act is estimated at US$30,000 in 2019 and a further revision to the Act in 2027 would also cost US$30,000; and (2) cost of sending two persons from the Energy Regulator on overseas visits / study tours every three years between 2019 and 2028 (i.e. 4 study tours at the cost of US$4,000 per person).

Source: TNA project

Benefits accruing from measures

The benefits that have been monetised are: (1) sales of electricity generated from waste heat recovery; (2) GHG emission reductions; (3) avoided importation of fuel oil; and (4) creation of jobs.

The methodologies for calculating GHG emission reductions, avoided importation of fuel oil and job creation were detailed in section 3.3 of the TNA Report – Mitigation (Government of Seychelles, 2017). The parameters used for calculating benefits are summarised in **Table 4**.

Table 6. Parameters used for calculating the benefits accruing from waste heat recovery.

Benefits accruing from measures	Remarks
Revenue from the sales of additional electricity	The generation of revenues from the sales of electricity has been calculated using a price of 0.14 US$/kWh.[2] The quantity of electricity generated is the same as what is used to calculate GHG emission reductions.
GHG emission reductions	A grid emission factor equal to 0.6594 tCO_2/MWh is used to calculate GHG emissions from quantity of additional electricity generated. The prices of emission reductions were: 2 US$/$tCO_2$ before 2020 and 26 US$/$tCO_2$ after 2020.[3]
Avoided energy bill	This is calculated as the product of quantity of fuel oil avoided and cost of fuel oil (~331.3 US$/tonne(fuel)). The quantity of fuel oil avoided is calculated using the specific fuel consumption 0.2177 t(fuel)/MWh generated multiplied by the quantity of electricity generated (MWh).
Value of jobs created	Total number of jobs created multiplied by yearly average salary of US$10,800 per person.

Source: TNA project

Benefit-Cost Ratio (BCR)

The net present value (NPV) of the total value of the costs and benefits of the proposed measures were calculated using a discount rate of 8%, which corresponds to the long-term (10 years) return on bonds issued by the Central Bank of Seychelles (CBS, 2017). The NPC of total costs and benefits were estimated at US$ 29.9 million and US$ 85.0 million, respectively.

Using the above assumptions, the BCR = 2.84 showing that the benefits of the proposed measures to support the implementation of waste heat recovery at Roche Caiman for power generation outweigh their cost of implementation.[4] A sensitivity analysis of BCR on different parameters has been carried and the results are summarised in **Table 5**. The changes in model parameters are relative to the base case described in **Table 3** and **Table 4**. The results in **Table 5** show that the implementation of waste heat recovery remains attractive under all parameter changes. The BCR is expected to increase with increasing price of fuel oil. For instance, when the price of fuel oil is increased by 10%, the BCR increases by ~4.9%.

[2] This is the mode of the average price of electricity for a 10-year period as used in the base case for the GCF project proposal entitled 'Targeting 100% Renewable Energy Future in Seychelles (100%RESey)'.

[3] www.synapse-energy.com/sites/.../2015%20Carbon%20Dioxide%20Price%20Report.pdf – accessed 18 April 2017.

[4] The BCR has not been calculated in the absence of the measures. In the absence of implementing the programme of measures, the benefits associated with mitigation technology would not accrue. It is assumed that additional power would then be produced using thermal combustion of fuel oil that would increase both GHG emissions and the energy bill of the country.

Table 7. Sensitivity analyses of BCR for waste heat recovery.

BCR	Parameter changes
2.61	Increase in interest rate of concessional loan to 3% per annum.
2.41	Increase in interest rate of concessional loan to 4% per annum.
3.13	Average price of electricity is increased to 0.17 US$/kWh.
2.66	Increase in interest rate of concessional loan to 4% per annum; and Average price of electricity is increased to 0.17 US$/kWh.
2.85 (negligible change)	Pre-2020 price of carbon is increased to 13 US$/t$CO_2$.
2.77	Post-2020 price of carbon is decreased to 13 US$/t$CO_2$.
2.85 or (2.84) (negligible change)	Increasing yearly average salary of O&M staff to US$14,400 per person or (decreasing yearly average salary of O&M staff to US$7,200 per person).
2.83 (negligible change)	Doubling the costs of training and study tours for both human capacity development for O&M and regulatory strengthening.

Source: TNA project

1.3 Barriers analysis and enabling measures for waste-to-energy project

1.3.1 General description of waste-to-energy technology

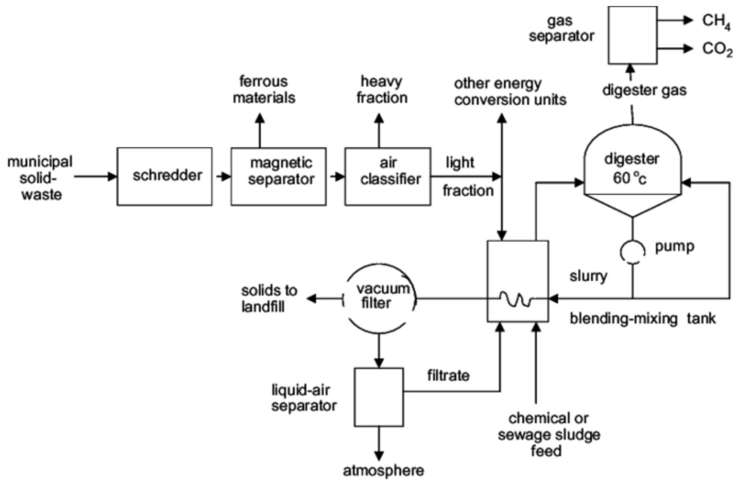
The process of anaerobic digestion (AD) is the decomposition of biodegradable material by micro-organisms in the absence of oxygen. This process is often used for industrial or domestic purposes to manage waste streams. As a result, the process produces a biogas, consisting mainly of methane (CH_4) and carbon dioxide (CO_2), which can be combusted directly or used for energy production in a combined heat and power plant. Second, the process results in a nutrient-rich digestate, which can be composted for soil enrichment. The use of AD as a means of integrated solid waste management in Seychelles has recently been studied (Lai et al., 2016).

The compaction and burial of municipal solid waste at landfill facilities creates an anaerobic environment for the decomposition of organic waste. Consequently, landfills naturally produce large amounts of CH_4 and this is usually released directly into the atmosphere. Gas emitted from the landfill facilities is referred to as 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% compared to 55-70%, respectively (Brockway, 2012).

There are two basic types of anaerobic digesters, namely: batch and continuous.[5] Batch-type digesters are the simplest to build. Their operation consists of loading the digester with organic materials and allowing it to decay anaerobically. 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.

[5] http://www.climatetechwiki.org/technology/jiqweb-anbt - accessed 15 September 2017.

Figure 2 illustrates a continuous anaerobic digestion system that uses unsorted municipal solid waste as feedstock. The final CH_4 stream is then used for power generation.



Source: Hilkiah Igoni et al., 2008

Figure 2. Schematic illustration of continuous flow anaerobic digestion of municipal solid waste.

1.3.2 Identification of barriers to deployment of waste-to-energy

LPA is used to identify the root causes that hinder the implementation of waste-to-energy (WTE) using municipal solid waste in Seychelles. The PT and OT for waste-to-energy are shown in **Annex I**. The PT reveals that the barriers hampering the uptake of centralised anaerobic digestion of municipal solid waste for power generation are:

- Economic and financial barriers;
- Regulatory barriers;
- Market barriers;
- Human capacity barriers;
- Institutional barriers; and
- Technical barriers.

These barriers are discussed in mode details below. WTE using centralised anaerobic digester is classified as a capital good. The technology is characterised by its implementation at limited sites (i.e. in the vicinity of landfill) and requiring relatively large capital investment (Nygaard and Hansen, 2015, Chapter 4). One of the main barriers that hamper the uptake of centralised digesters is economic and financial. Consequently, detailed CBA has been carried out to justify investments in WTE technology.

1.3.2.1 Economic and financial barriers for waste to energy

WTE plants usually carry high initial capital investments, especially where there is no sorting of waste at source, as is the case in Seychelles. Specialised plants have to be built to separate the biodegradable component of the waste from the non-biodegradable part. This is needed to ensure the optimum performance of the AD plants, as these plants only require the biodegradable component of the solid waste to produce biogas. Total investment costs for such plants that also include other component to ensure only biodegradable waste is delivered to the digesters can be between US$ 2,574 – 6,104/kW installed.[6] 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 investment cost and cost of operation &

[6] Please see: https://www.irena.org/.../Publications/RE_Technologies_Cost_Analysis-BIOMASS.pdf - accessed 19 June 2017.

maintenance (O&M) for WTE that were used to carry out multi-criteria analysis (MCA) in the TNA Report – Mitigation (Government of Seychelles, 2017) were US$3,830 / kW installed and US$ 95,000 / MW / year, respectively.[7] If biogas is used to generate electricity, the investment costs of the CHP unit will also have an effect on the overall cost of an anaerobic digester system. In Seychelles, the incremental cost of the biodigester is determined by comparing it with the cost of generating an equivalent amount of power – i.e. 4 MW – using thermal generators running on HFO.

At present, private investors cannot carry out a detailed financial viability of WTE power project, as there is no standardised power purchase agreement (PPA) that can provide visibility on the purchase tariff to the IPP.[8] The regulatory barrier is further discussed below. Most investors would also like to see the government provide a subsidy for WTE power generation because the government was paying the waste management company a significant amount of money to manage the landfill. This would assist in making the project more viable financially.

1.3.2.2 Non Financial barriers for waste to energy

The main non-financial barriers identified by stakeholders are institutional, market, human capacity and technical.

Market imperfection

The government has taken the decision that the WTE project will be developed by a private company on an IPP modality.[9] However, the electricity sector is dominated by one incumbent, namely the government-owned utility that was setup by law to produce, transmit and distribute electricity in the country (Government of Seychelles, 1986). This situation creates a problem for any private sector participation in the power market as the utility may see the competition as a form of revenue erosion. Also, the legislation that sets up the utility (Government of Seychelles, 1986) allows it to be self-regulating even with the existence of a regulator. Another form of market distortion emanates from the fact that the utility receives subsidies on the fuel it uses to produce electricity. This undermines the financial competitiveness of alternative power generation technologies, such as WTE using AD of municipal solid waste.

Policy, legal and regulatory barrier

There is to date, no clear government policies and appropriate regulatory framework for private sector participation in the power sector (except for small scale, rooftop PV systems). This situation presents high risks for investors. The Energy Act 2012 (Government of Seychelles, 2012a) is supposed to provide the framework for IPPs to operate in the power market. However, the act remains incomplete with many of the supporting legislations missing.

The lack of a liberalisation model for power generation is compounded by the lack of power purchase agreement (PPA) model for IPPs. There are no technical guidelines (e.g. grid code) for connecting utility-scale power plants to the grid, and, as mentioned above, there are no purchase tariffs for

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[7] Please see section 3.2.1 in report at: http://bv.com/docs/reports-studies/nrel-cost-report.pdf - accessed 31 October 2016.

[8] In the analysis of the cost of the financial measure, an incentive to IPPs equal to 88% of the marginal cost of electricity from thermal generation has been used. This estimated value of incentive was obtained through conversations with the PUC and the SEC.

[9] http://www.sec.sc/index.php/electricity-sector/generation/renewable-energy - accessed 15 September 2017.

benchmarking the financial viability of power generation projects. These prevailing conditions make it difficult for prospective IPPs to negotiate with the regulator. It has been confirmed that the act will be reviewed in the near future to bridge existing gaps.

Although the Energy Act 2012 established a regulator with specific roles, it did not empower this regulator with the appropriate authority to effectively execute its mandate. Hence, this makes for a weak regulatory body in the energy sector for private sector participation.

Institutional barrier

The generation of power from municipal solid waste is a cross-sectoral issue. One that requires close coordination between different line ministries (e.g. Ministry of Environment, Energy and Climate Change, Ministry of Finance, Trade and the Blue Economy, Ministry of Land Use and Habitat) and other stakeholders (e.g. PUC, Seychelles Energy Commission, local communities). The efficient and effective design, conceptualisation and implementation of the mitigation technology will require close coordination between all these stakeholders. Currently, one of the barriers facing the technology is insufficient coordination between relevant ministries and stakeholders. This can be as simple as the sharing of data to draw up projects or the alignment of strategies for the sustainable development of Seychelles.

Human skills

One of the significant issues with the WTE project is the availability of human skills to develop and implement the technology, and, above all, to provide the necessary after sales service and maintenance support. There is also a lack of local expertise to design a transparent tendering process for this project and to evaluate the technical and financial offers. This expertise will have to be imported and, in this case, there is always the uncertainty regarding the institutionalisation of new knowledge and knowhow in the country.

Technical Barriers

There are still data gaps concerning the characterisation of municipal solid waste – i.e. the accurate breakdown of waste collected on the islands of Mahé, Praslin and La Digue by type and quantity (Lai et al., 2016). Although the quantity of waste on Praslin and La Digue may be small, it is important to understand whether this waste can be used for WTE on Mahé. As the AD process relies purely on biodegradable waste, the design of this system must take into account all the waste on the 3 main islands.

The diversion of organic waste from the landfill for power generation will result in avoided CH_4 emissions at the landfill. There is a lack of information on avoided CH_4 from the landfill for proper GHG accounting procedures, and to make the climate change mitigation case for the project.

Further, it is pointed out that land for the WTE project is yet to be confirmed. For better visibility and reduced project uncertainty, it is important to have a commitment from government for the availability of land for this project before any consideration is given to launching a tender.

1.3.3 Identified measures for waste to energy

The OT for waste to energy using centralised AD is shown in **Annex I**. The proposed measures are articulated around the following:

- Increasing the financial attractiveness of waste to energy by providing financial instruments to reduce the cost of capital. This will also address the issue of high upfront capital investments;
- Strengthening the policy and legal framework for allowing IPPs to operate in the power market;
- Enhancing institutional coordination;
- Developing human capacity and expertise by providing appropriate trainings; and
- Carrying out detailed characterisation of municipal solid waste.

The proposed measures are discussed below.

1.3.3.1 Economic and financial measures for waste to energy

As with the waste heat recovery project, there is not much that can be done to reduce the high investment cost of the technology as this is dictated by international market forces. Further, there is a lack of local expertise and the necessary value chain for local manufacturing of some parts of the technology. However, there are some elements that are conducive for the technology uptake such as tax exemption on equipment and the high cost of producing electricity in the country. While these factors are supportive of WTE, they are not sufficient. It is important for the ministry responsible for energy matters and the SEC to come up with a feed-in-tariff (FiT) schedule for the electricity sector. This is an essential policy instrument that every project developer in the electricity sector needs to fully carry out the feasibility studies for the project.

1.3.3.2 Non-financial measures for waste to energy

Market openness

Competitive bidding must determine the right company to carry out this work though a legal and transparent tender process for both the waste collection and the WTE project. The participation of the private sector in power generation will require regulatory improvements as discussed in section 1.2.3.2, and that are further analysed below. As shown in the OT for WTE in **Annex I**, the barrier related to market concentration is connected with legal and regulatory barriers. Overcoming the latter will simultaneously unlock the power market for private sector participation in power generation.

Measure to improve institutional and organisational capacity

It is important for clear and precise functions to be allocated to all respective organisations to do with waste management. Although this exists on paper right now, there is too much interference and instances whereby the policies and guidelines are ignored. This translates into market interference. One clear example is the fact that the waste collection and landfill management contracts are not with LWMA, the institution set up to manage contracts, but rather with the parent ministry. This must be rectified and the duties of all organisations in the sector must be clearly defined and respected. The measure proposed here is to carry out a detailed institutional review in the solid waste sector, and to formulate clear guidelines for institutional roles and responsibilities according to institutional mandates. In order to ensure that these guidelines are not ignored, it is also proposed to set up a multi-stakeholder coordination mechanism for establishing direct lines of communications and knowledge and information sharing between all the stakeholders of the WTE project.

Legal and regulatory strengthening

All future waste collection and management contracts must be done through a fair and equitable tender process. This tender must also be aligned with the WTE project in order to avoid possible conflicts between the two activities and must be aligned to effectively ensure a coordinated work schedule for all parties. The waste collector must be clearly informed that the WTE project is bound by a power purchase agreement (PPA), and that this agreement usually carries penalties for the non-delivery of electricity. So, the collector must, through a legal agreement, agree to have timely delivery of waste to the WTE facility. The measure proposed here is to develop a tendering process and standardised contractual documents for solid waste collection and delivery to the WTE operator.

Similar to the case of waste heat recovery for power generation discussed in section 1.2.3.2, there must be a strengthening of the SEC to ensure it can effectively play its role as the regulator in the electricity sector. This is also an institutional and organisational capacity measure. In order to support an open playing field in power generation the following measures are also proposed:

- Updating the Energy Act 2012: (1) to define the power sector market activities and the roles of market actors; and (2) to give the SEC the powers it needs to regulate the entire electricity market sector; and
- Accompanying institutional and human capacity strengthening for the SEC through a combination of trainings and exchanges with overseas energy sector regulators.

Human skills

The measure proposed here is to train staff for the O&M of the central AD and power generation units.

Technical Barriers

A longitudinal study covering at least one whole year will be carried out on the islands of Mahé, Praslin and La Digue to characterise municipal solid waste by type and quantity. This study will be carried out in 2018 and repeated after five years to investigate any changes in waste disposal patterns.

It is pointed that the lack of sorting of waste at source can be a technical barrier in any WTE project. Since carrying out sorting of waste on a large scale is very challenging, the alternative is to adopt a WTE technology that includes a waste sorting pre-treatment plant.

Scenario analysis for investigating reduction of GHGs accruing from a diversion of solid waste from the landfill and its alternative uses can be carried out under the Third National Communication (TNC) project, and has not been budgeted in the CBA carried out here.

1.3.3.3 Cost-benefit analysis of measures for waste to energy

The approach used for carrying out CBA is based on incremental analysis. It is generally agreed that WTE will be carried out by a private promoter and for which there will be the need to set up a FiT.

Cost of measures

As discussed in section 1.3.3.1, the financial measure that is proposed is the setting up of a FiT to promote private investments in WTE using centralised AD. The measures for regulatory strengthening are the same as from waste heat recovery at Roche Caiman power station. The parameters are summarised in **Table 6**.

Table 8. Parameters used for calculating the cost of measures for waste to energy.

Measure proposed	Remarks
Financial measures	Two costs are related to this measure, namely: (1) consultancy fees to carry out a study to set FiTs for various renewable energy production technologies, and a review carried out every 5 years. The cost of each consultancy is budgeted at US$30,000; and (2) the incremental cost (relative to the average cost of electricity of 0.14 US$/kWh) of providing a FiT for WTE. This is set at 0.88% of the marginal cost of production using fuel oil.
Human capacity enhancement for O&M	There are two cost elements: (1) cost of training staff for O&M of WTE mitigation technology. This takes place in 2019 when new technology is introduced. The cost of training is equal to the number of one third of O&M jobs created in 2019 multiplied by the cost of training per job created (assumed to be US$20,000 per person); and (2) cost of sending staff on study tours that take place in 2019, 2022, 2025 and 2028. It is assumed 2 persons are sponsored on each study tour at the cost of US$5,000 per person.
Legal and Regulatory strengthening	The proposed measures for strengthening the regulator are the same as for waste heat recovery at Roche Caiman power station. Please see **Table 1**. The additional measures proposed are the development of a transparent tendering process and the accompanying tendering documents, including a standardised contractual document for the waste collector. These are done through technical assistance in 2018 at a cost of US$50,000.
Waste characterisation	Technical data on quantity and type of waste generated on the three most populated islands will be carried out in 2018 through technical assistance costing US$75,000. The waste characterisation study will be updated five years later.
Institutional and organisational coordination	The two cost elements are: (1) technical assistance to carry out a review of institutional mandates, and to propose clear roles and responsibilities in the solid waste management sector. This will be carried out in 2018 through technical assistance costing US$25,000; and (2) an annual budget of US$ 2,000 to operationalise and support the coordination of stakeholders in the solid waste sector.

Source: TNA project

<u>Benefits accruing from measures</u>

The incremental benefits that have been estimated are: (1) GHG emission reductions; and (2) avoided importation of fuel oil. It has been assumed that the implementation of WTE does not generate any net new jobs nor does it produce any net incremental amount of electricity that would otherwise have been generated thermally using fuel oil. The methodologies and parameters used to calculate and monetise the benefits are provided in section 3.3 of the TNA Report – Mitigation (Government of Seychelles, 2017), and **Table 2**.

The present analysis has not accounted for the additional benefit that may accrue from the sale of solid fertiliser derived from the digestate from AD. This is mainly for two reasons as found in a recent study (Lai et al., 2016):

1. The lack of large-scale demand for compost in Mahe; and
2. Additionally, the issues of producing lower quality compost from AD compared to aerobic treatment, and the need for the treatment of the digestate obtained from sewage sludge before it can be used for agricultural purposes still remain.

Benefit-Cost Ratio (BCR)

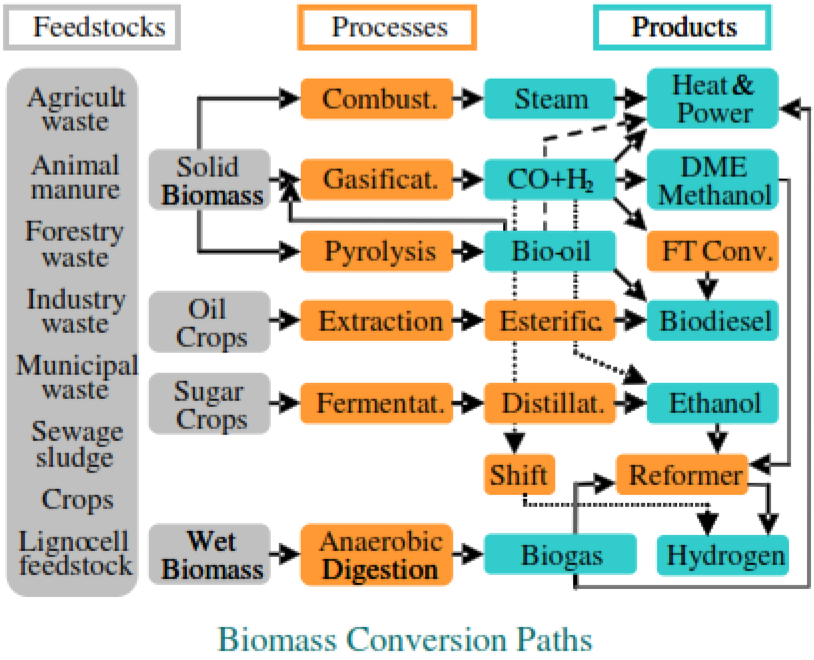
Using the above assumptions, the BCR = 4.41 showing that the benefits of the proposed measures to support the implementation of WTE outweigh their cost of implementation. The proposed measures are therefore financially beneficial. The parameter that has the biggest influence on the BCR is the FiT. When the FiT is set at the marginal cost of production, the BCR is lowered to 2.59. Decreasing the post-2020 price of carbon to 13 US$/t$CO_2$ (all else being equal), the BCR drops to 4.21. Changes in the other parameters do not significantly influence the BCR.

As is the case of waste heat recovery at Roche Caiman power station, the BCR is expected to increase with increasing price of fuel oil. In the case of WTE, a 10% increase in the price of fuel oil results in the BCR increasing by ~9.1%.

1.4 Barriers analysis and enabling measures for agro-forestry project

1.4.1 General description of power generation from agro-forestry

Agro-forestry, as defined by the World Agro-forestry Centre, is "a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels" (Leakey, 1996). In addition to mitigation benefits, agro-forestry can also address the need for improved food security and increased energy resources, as well as the need to sustainably manage agricultural landscapes. Agro-forestry products can be used as feedstock for energy production either in the form of power and heat or in the form of an energy carried as illustrated in **Figure 3**.



Source: https://www.iea.org/publications/freepublications/publication/essentials3.pdf

Figure 3. Alternative ways of producing energy from agro-forestry feedstocks.

The option being considered for the Seychelles is the (central) combustion technology, which is the most common way of converting solid biomass fuels to energy. However, there will need to be a proper feasibility study to determine the specific technology that will be suitable for the local feedstocks.

Worldwide, agro-forestry already provides over 90% of the energy generated from biomass, a significant part of which in the form of traditional uses for cooking and heating. Biomass of different forms can also be used to produce power (and heat) in small-scale distributed generation facilities used for rural electrification, in industrial scale applications, as well as in larger scale electricity generation and district heating plants. Two technologically mature and cost-attractive options involve burning biomass in standalone units or co-firing it with fossil fuels (e.g. coal) in standard thermal power plants.[10]

Biomass is an interesting option for electricity and heat production in parts of the world where supplies of residues from agriculture or the forest products industry are abundant. It can significantly lower GHG emissions and local air pollutants from power generation, contribute to improved energy security and general jobs and income. As mentioned in the TNA Report (Government of Seychelles, 2017), it was estimated that there was enough biomass from woody invasive species to produce power for 15 years. Once harvested, energy crops could be planted to provide a renewable source of biomass for baseload power production.

1.4.2 Identification of barriers to deployment of power generation from agro-forestry

Like for the previous mitigation technologies, LPA is used to identify the root causes that hinder power generation from agro-forestry feedstocks. The corresponding PT and OT are shown in **Annex I**.

[10] http://www.climatetechwiki.org/technology/biomass - accessed 30 August 2017.

The barriers are quite similar to the ones already discussed for the first two mitigation technologies, and more details are given below.

Power generation from agro-forestry feedstocks is classified as a capital good. The technology is characterised by its implementation at limited sites (most probably only one site in Seychelles) and requiring relatively large capital investment (Nygaard and Hansen, 2015, Chapter 4). The main barriers that hamper the uptake of this technology are economic and financial, and the lack of detailed assessment of agro-forestry resources for power generation. Detailed CBA has been carried out to justify investments in the basket of measures to promote the uptake of power generation from agro-forestry.

1.4.2.1 Economic and financial barriers for power generation from agro-forestry

Similar to the previous mitigation technologies for the power sector, one of the main barriers is the high initial investment cost that will be required for this technology. There are to components to this technology, the supply of biomass resources and the combustion plant itself. It has not been possible during the course of the TNA project to estimate the cost of supplying agro-forestry residues, and this cost component has not been included in the CBA. As with the case of WTE, it has been assumed that there is no transfer price for the feedstock.

The technology that has been considered is that of a biomass-fired combustion plant that drives steam turbines in combined cycle mode. The investment cost[11] and cost of operation & maintenance (O&M)[12] for the technology that were used to carry out multi-criteria analysis (MCA) in the TNA Report – Mitigation (Government of Seychelles, 2017) were US$1,293 / kW installed and US$ 20,000 / MW / year, respectively.

This barrier is compounded by the lack of visibility for private investors to invest in the sector. As discussed below, this is due to a lack of liberalisation model, involving the setting up of a transparent bidding mechanism supported by the availability of a standardised Power Purchase Agreement (PPA) that would provide investor confidence and longer-term visibility on the return on the initially high investments.

1.4.2.2 Non Financial barriers for power generation from agro-forestry

As seen from the OTs in Annex 1, the non-financial barriers for power generation from agro-forestry are similar to those for WTE. Consequently, only the barriers that differ are discussed below.

Institutional barrier

The generation of power from agro-forestry feedstock is a cross-sectoral issue that will require close coordination between different line ministries (e.g. Ministry of Agriculture and Fisheries, Ministry of Environment, Energy and Climate Change, Ministry of Finance, Trade and the Blue Economy, Ministry of Land Use and Habitat) and other stakeholders (e.g. PUC, Seychelles Energy Commission, local communities). One of the barriers facing the technology is insufficient coordination between the relevant ministries and stakeholders. This can be as simple as the sharing of data to draw up projects or the alignment of strategies for the sustainable development of Seychelles.

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[11] This is the weighted average cost for biomass-fired steam generators as per http://www.eia.gov/electricity/generatorcosts/ - accessed 15 September 2017.

[12] Please see http://bv.com/docs/reports-studies/nrel-cost-report.pdf - accessed 31 October 2016.

Technical barriers

The exact amount of available biomass (both what can be harvested and grown) is not known, making project design and financial viability modeling difficult. This is despite previous attempts by private companies with a stake in the technology to carry out agro-forestry feedstock assessments.

1.4.3 Identified measures for power generation from agro-forestry

The OT for power generation from agro-forestry feedstocks is shown in **Annex I**. The proposed measures are articulated around the following, which are similar to the measures proposed for WTE:

- Increasing the financial attractiveness by providing an attractive (i.e. higher) purchase tariff for electricity compared to the baseline alternative. This will address the issue of high upfront capital investments;
- Strengthening the policy and legal framework for allowing IPPs to operate in the power market;
- Enhancing institutional coordination;
- Developing human capacity and expertise by providing appropriate trainings; and
- Carrying out detailed characterisation of municipal solid waste.

Since the proposed measures are similar to those for WTE, only the measures that differ are further discussed below.

1.4.3.1 Economic and financial measures for power generation from agro-forestry

The measure proposed here is the same as for WTE. It is the incremental cost (relative to the average cost of electricity of 0.14 US$/kWh) of providing a tariff incentive, as part of a standardised PPA, for power generation from agro-forestry feedstocks. This is set at 0.88% of the marginal cost[13] of production using fuel oil.

The analysis carried out here is conservative since the any reduction in the cost of hardware due to VAT exemption has not been taken into account.

1.4.3.2 Non-financial measures for power generation from agro-forestry

Market openness

This is the same as for WTE in Section 1.3.3.2.

Measure to improve institutional and organisational capacity

It is important for clear and precise functions to be allocated to all respective organisations regarding the generation and use of agro-forestry feedstocks for power generation. The measure proposed here is to carry out a detailed institutional review of all the institutions identified in Section 1.4.2.2, and to formulate clear guidelines for institutional roles and responsibilities according to institutional mandates. In order to ensure that these guidelines are implemented, it is also proposed to set up a multi-stakeholder coordination mechanism for establishing direct lines of communications and knowledge and information sharing between all the stakeholders of the agro-forestry project.

Legal and regulatory strengthening

This is same as for WTE in Section 1.3.3.2.

[13] Reference for FiT @ 0.88 x marginal cost.

Human skills
This is the similar as for WTE in Section 1.3.3.2.

Technical Barriers
It is proposed to carry out a detailed assessment of agro-forestry resources available for power generation, as well as the quantity of renewable biomass that can be produced annually (e.g. once invasive species have been used). This study will be carried out in 2020 to inform the design of the project that will be implemented in 2024 for commissioning by the end of 2025.

1.4.3.3 Cost-benefit analysis of measures for power generation from agro-forestry
In Seychelles, the incremental cost of producing electricity from agro-forestry products is determined by comparing it with the cost of generating an equivalent amount of electricity using thermal generators running on HFO.

Cost of measures
As discussed in section 1.3.3.1, the financial measure that is proposed is the setting up of a FiT to promote private investments in the use of agro-forestry feedstocks for power generation. The measures for regulatory strengthening are the same as from waste heat recovery at Roche Caiman power station and the WTE project. The parameters are summarised in **Table 7**.

Table 9. Parameters used for calculating the cost of measures for power generation from agro-forestry feedstocks.

Measure proposed	Remarks
Financial measures	Two costs are related to this measure, namely: (1) consultancy fees to carry out a study to set FiTs for various renewable energy production technologies, and a review carried out every 5 years. The cost of each consultancy is budgeted at US$30,000; and (2) the incremental cost (relative to the average cost of electricity of 0.14 US$/kWh) of providing a FiT for WTE. This is set at 0.88% of the marginal cost of production using fuel oil.
Human capacity enhancement for O&M	There are two cost elements: (1) cost of training staff for O&M of power generation from agro-forestry feedstocks. This takes place in 2025 at the time of new technology commissioning. The cost of training is equal to one third of O&M jobs created in 2025 multiplied by the cost of training per job created (assumed to be US$20,000 per person); and (2) cost of sending staff on study tours that take place in 2025 and 2028. It is assumed 2 persons are sponsored on each study tour at the cost of US$5,000 per person.
Legal and Regulatory strengthening	The proposed measures for strengthening the regulator are the same as for waste heat recovery at Roche Caiman power station. Please see **Table 3**. The additional measures proposed are the development of a

Measure proposed	Remarks
	transparent tendering process and the accompanying tendering documents, including a standardised contractual document for the waste collector. These are done through technical assistance in 2023 at a cost of US$50,000. The updating of the Energy Act 2012 will still be carried out in 2018 in order to be coherent with the introduction of previous mitigation technologies – i.e. updating the Energy Act is not technology-dependent. This is an area that provides linkages between the different mitigation technologies. Similarly, the study tours for SEC staff are maintained for 2019, 2022, 2025 and 2028. These overlapping costs can be avoided and this is investigated in the sensitivity analysis.
Biomass resources characterisation	Technical data on quantity and type of agro-forestry feedstocks on the three most populated islands will be carried out in 2019 through technical assistance costing US$75,000. The biomass resources characterisation study will be updated five years later.
Institutional and organisational coordination	The two cost elements are: (1) technical assistance to carry out a review of institutional mandates, and to propose clear roles and responsibilities in the solid waste management sector. This will be carried out in 2019 through technical assistance costing US$25,000; and (2) an annual budget of US$ 2,000 to operationalise and support the coordination of stakeholders in the solid waste sector. It is pointed out that these activities could be synergised with the similar ones for WTE. Consequently, these costs can be eliminated.

Source: TNA project

Benefits accruing from measures

The incremental benefits that have been estimated are: (1) GHG emission reductions; and (2) avoided importation of fuel oil. It has been assumed that the implementation of power generation from agro-forestry feedstocks does not generate any net new jobs nor does it produce any net incremental amount of electricity that would otherwise have been generated thermally using fuel oil. The methodologies and parameters used to calculate and monetise the benefits are provided in section 3.3 of the TNA Report – Mitigation (Government of Seychelles, 2017) and **Table 4**.

Benefit-Cost Ratio (BCR)

Using the above assumptions, the BCR = 4.80 showing that the benefits of the proposed measures to support the implementation of power generation from agro-forestry feedstocks outweigh their cost of implementation. The proposed measures are therefore financially beneficial. The NPV for the costs and benefits are US$ 2.83 million and US$ 13.57 million, respectively. Excluding the costs associated with removal of legal and regulatory, and institutional coordination barriers (because of synergies and cross-linkages with WTE as discussed in **Table 7**) increases the BCR to 5.08.

The parameter that has the most significant influence on the BCR is the FiT. When the FiT is set at the marginal cost of production, the BCR is lowered to 2.91 (NPV for cost of measures increases to US$4.67 million). The other parameter has affects BCR significantly is the price of fuel oil used to calculate the avoided cost of energy bill. In this case, a 10% increase in the price of fuel oil results in the BCR increasing to 5.23 (i.e. ~9.0% increase).

Since emission reductions accrue only after 2025, the post-2020 price of carbon has a relatively smaller influence on BCR. Decreasing the post-2020 price of carbon to 13 US$/t$CO_2$ (i.e. 50% decrease) results in the BCR dropping to 4.56 (i.e. ~5.3% decrease). Changes in the other parameters do not significantly influence the BCR.

1.5 Linkages of barriers identified for the power sector

Linkages of barriers have been assessed from two perspectives. First, there are barriers that are common to all technologies, and hence common measures which can benefit all technologies. Therefore, implementing measures to overcome the common barriers can lead to more effective scaling up of mitigation actions, and hence increases the ambition of GHG emission reductions. Second, there are linkages between barriers for each technology. These are further discussed below.

These linkages imply that a holistic or integrated approach has to be adopted when developing the technology action plans (TAPs) in order to avoid partial implementation of measures proposed for the mitigation technologies. Disregard to the technology-specific inter-barrier linkages could slow down technology transfer and diffusion or prevent the implementation of the mitigation technologies. The integrated approach proposes to use the linkages of barriers as a lever to scaling up mitigation actions by simultaneously promoting the diffusion of multiple mitigation technologies, while at the same time increasing the cost effectiveness of the proposed measures. For instance, all the technologies face the same policy and regulatory barriers, and institutional coordination barriers are similar for WTE and power generation from agro-forestry feedstocks. Hence, the cost of measures to overcome these barriers can be accounted for one technology only, while ensuring that the scope of measures covers all proposed mitigation technologies.

Linkages across technologies

As mentioned in section 1.2.2, regulatory and market barriers are common to all the mitigation technologies. Both technologies are expected to benefit from the participation of private producers or operators in power generation. However, the prevailing regulatory framework that is dominated by the incumbent public utility acts as a barrier for private participation in power generation at the detriment of the mitigation technologies. This situation is exacerbated by the presence of a poorly resourced regulator that oversees the energy sector. Further, the lack of a power generation deregulation model implies market distortion in the form of a monopoly situation dominated by the incumbent public utility.

Technology specific inter-barrier linkages

Institutional and human capacity barriers are recurrent barriers for all mitigation technologies in the power sector, but at the same time the capacity constraints are technology specific. As a country with a very small population, Seychelles faces challenges of human resources scarcity. The limited pool of human resources implies limited human expertise in innovative technologies, which then results in correspondingly low institutional capacity. Investing in human capacity development is often linked with high staff turnover as trained personnel are easily attracted to better paid jobs in the market or overseas. The issue here is two-fold, namely: (1) human capacity development must be set within the broader context of human resources management, including salary schemes, motivation strategies, and continuous career development, among other, in the organisation that will promote any specific mitigation technology. These broader human resources management issues to enhance the retention of trained staff are not covered in the present analyses; and (2) although three technologies have been considered, the development of the training course should take into consideration common elements of power generation from the three mitigation technologies in order to decrease the multiplicity of training courses, especially when the demand for such courses will most probably remain low. For instance, there could be core subjects that are common to all the technologies with only few electives providing specialisation in each specific technology.

1.6 Enabling framework for overcoming the barriers in the power sector

As indicated in section 1.4, the projects in the power sector are once off projects, with very limited scope for replicability due to size of the market and lack of economies of scale. Further, as shown by the market maps there are no local suppliers for these technologies. The enabling framework to promote the mitigation technologies in the power sector should, therefore, take note of these local specificities.

The main issue is that, given the initial cost burden of the projects in the power sector, the government must ensure that it takes every step to minimise the investment risks for the developer, be it PUC or otherwise. This may come as a form of a co-guarantee for any investment to be undertaken or putting in place the appropriate and acceptable FiT. If this is to be achieved, the legal and regulatory framework must be addressed. Developing a standardised PPA and tendering process will provide more visibility to private investors, thereby decreasing market risks.

Further, the SEC should focus its activities on regulating the sector and the government should set up a section under the Department of Energy and Climate Change to design and implement new projects in the power sector. At the moment, the SEC is also involved in the identification and development of power projects, which are taking most of the time of the SEC. The budgetary requirement for SEC to staff up must be granted by the ministry responsible for finance. In the short term, SEC will find it difficult to hire locally for staff with the right skills to regulate the sector and it will have to hire, maybe, short term international consultants. But, it must ensure that it hires staff and train them with the help of the international consultants, and a succession plan has to be developed to ensure the sustainability of institutional strengthening.

Chapter 2 Land Transport Sub-sector

Land Transport was another sub-sector that was prioritised for technical assistance under the TNA project as it is the second largest GHG emitting sub-sector in Seychelles (Government of Seychelles, 2017). The choice of this sub-sector is also aligned with the Seychelles Nationally Determined Contributions (NDC) that has been submitted to the UNFCCC (Government of Seychelles, 2015a). Three land transport technologies were prioritised for further analysis during the first stage of the TNA project (Government of Seychelles, 2017):

1. **Low-carbon private car fleet**
   While transport is the second largest emitting sub-sector in Seychelles, approximately 77% of this emission emanates from road transport. Further, more than two-thirds of all motorised vehicles are privately-owned cars (Government of Seychelles, 2017). Except for few hybrid and electric cars, the overwhelming majority of the cars have internal combustion engines burning gasoline and diesel. The proposed mitigation technologies are for the higher penetration of hybrid and electric cars.

2. **Victoria Traffic Management Plan (VTMP)**
   Congestion is a major issue across Seychelles, and particularly in Victoria, where bus journey times and reliability are significantly impacted. The VTMP proposes a host of actions to remedy this problem as discussed in section 2.1.

3. **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.

2.1 Preliminary targets for technology transfer and diffusion in the land transport sub-sector

The transport sector falls under the Department of Land Transport (DLT), within the Ministry of Habitat, Infrastructure and Land Transport. The Department is generally responsible for policies related to surface transport, including provision and maintenance of roads. Although there is no Transportation Master Plan (TMP) at this time, DLT is cognisant of the need for one. A TMP is required to govern the transportation development and investments in both the supply and demand sides in an overarching manner. As travel demand increases with population and economic growth, coherent policies are necessary to both control the growth of demand as well as guide the supply side. This will include investments in transportation systems involving both roads and public transport. Demand management schemes should also be included, and consideration given to the possibility of transit-supportive Travel Demand Management initiatives, including park-and-ride facilities at the peripheries of Victoria. Construction of HOV (High Occupancy Vehicle) lanes reserved for vehicles occupied by two or more persons) and HOT (High Occupation Toll) lanes, similar to HOV but which require tolls may also be considered as transit-supporting.

There are no official targets for the transfer and diffusion of mitigation technologies in the road transport sub-sector. The Nationally Determined Contribution (NDC) (Government of Seychelles, 2015) mentions a target of 30% GHG emissions reductions in the transport sector relative to the baseline scenario without providing details of the technological means of implementation. With these qualifications in mind, the stakeholders (see **Annex III**) of the TNA project have agreed to the following technology targets:

4. **Low-carbon private car fleet:** By 2030, 70% and 10% of the total car fleet are hybrid and electric vehicles, respectively;
5. **Victoria Traffic Management Plan (VTMP):** The VTMP proposes a host of actions to remedy this problem, namely: (1) relocation of the central bus terminal in Victoria to two separate facilities (one at Roche Caiman and one at Ile du Port) by making provision for faster and more reliable services, (2) construction of a bypass between Beau Vallon and Saint Louis; and (3) dualisation of several roads. The overall result is expected to be a 5% reduction in national fuel consumption by 2030; and
6. **Electric scooters:** There will be a total of 1,500 electric scooters (thereafter, e-scooters) by 2030. An incentive programme is expected to be deployed in 2018 that is expected to result in an initial adoption of 100 e-scooters per year. The e-scooters are expected to displace commuting typically carried out using gasoline-powered cars on the road.

The penetration levels of mitigation technologies in the land-transport sub-sector were also used to establish the target for the transport sector. More details can be found in the TNA Report – Mitigation (Government of Seychelles, 2017; Table 22).

2.2 Barrier analysis and enabling measures for low-carbon car fleet

2.2.1 General description of low-carbon car fleet technologies

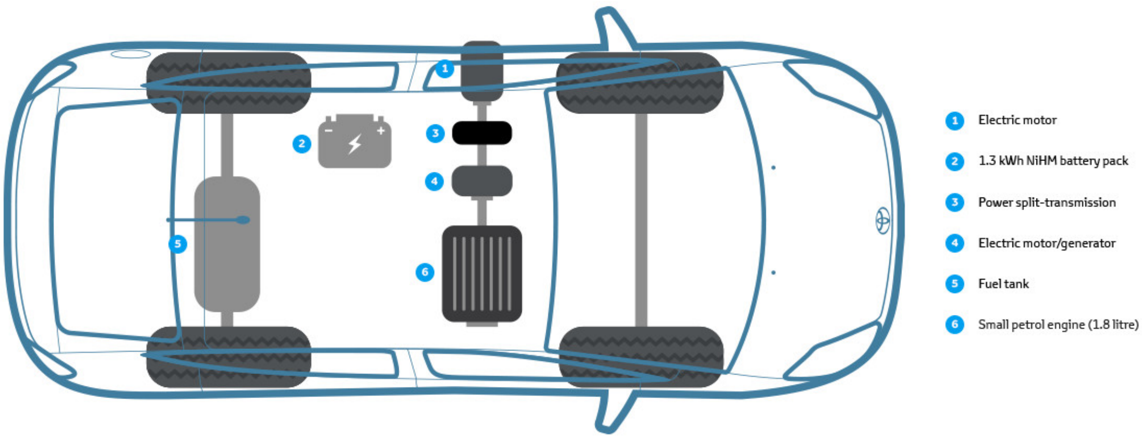
Generally, the technology options for the private car fleet have undergone significant innovation and efficiency improvements over the years. The current pace of innovation means that most technological opportunities are nowhere near their full potential. Selection of appropriate vehicle and fuel technologies 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 of people versus individual travel
- Energy infrastructure: investment needs, competition and energy security
- Range versus efficiency
- Maturity of technology for commercial deployment

In the Seychelles, the uptake of renewable energy technologies is rapidly growing and this could prove to be advantageous for plug in hybrids and electric vehicles. These vehicles may be charged using solar energy and other renewable energy sources. As discussed in the TNA Report – Mitigation (Government of Seychelles, 2017; Table 22), there were approximately 300 hybrid and 18 electric cars in Seychelles in 2015. The introduction of these low-carbon road transport technologies started as a consequence of government providing financial incentives in the form of reduced the taxes and duties on all electric and hybrid vehicles.

<u>Hybrid car</u>

A hybrid car has a dual drive system that couples an electric motor with a convention internal combustion engine via a power-split transmission system as illustrated in **Figure 4**. The electric motor is powered by a battery that can be recharged using the cars kinetic energy (e.g. during deceleration) or directly by the internal combustion engine. The choice of powering mode depends on the driving circumstances (see **Table 8**), and is controlled intelligently.



Source: https://www.toyota.co.uk/hybrid/how-hybrid-works.json.

Figure 4. Schematic illustrating the dual drive system of a hybrid car.

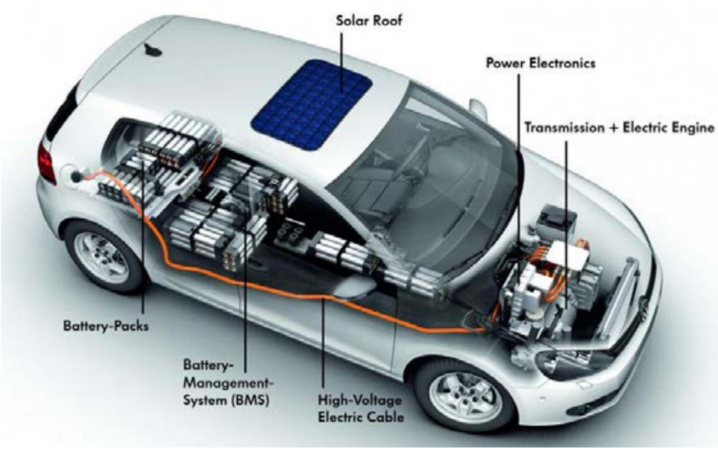
Table 10. Powering mode of a hybrid car for different driving circumstances.

Driving circumstance	Powering mode
1. When pulling away from a stop	This is one of the main reasons why hybrids cars are more efficient for city driving. At low speeds (e.g. up to ~25 km/h), the electric motor powers the car.
2. During normal cruising	This is when the normal petrol engine is used as it is most efficient. The engine can also power the generator while cruising, which produces electricity and stores it in the batteries for later use.
3. During heavy acceleration	Both the conventional engine and electric motors work together to increase power to the wheels. At the same time the petrol engine also powers the generator and the electric motor uses electricity from the battery and generator as needed.
4. During braking and cruising	A clever system called ‘regenerative braking’ is used to power the vehicle’s generator, which produces electricity and stores it in the battery for later use.
5. When reaching a complete stop	Both the conventional engine and electric motor turn off and the car switches to battery power to run everything it needs to – radio, air conditioning, lights etc.

Source: https://www.toyota.co.uk/hybrid/how-hybrid-works.json

<u>Electric car</u>

Electric cars use the energy stored in a battery bank for vehicle propulsion. The main components of an electric car are: (1) the electric motor; (2) the motor's controller consisting of the battery management system and power electronics; and (3) the batteries. The controller manages power transmission from the batteries to the motor. The amount of power delivered to the motor is controlled by a pair of variable resistors (potentiometers), the setting of which is in turn dictated by the position of the accelerator. The battery management system is also used to regulate battery recharging with the twin objectives of (1) charging the batteries as quickly as the batteries will allow, and (2) monitoring the batteries in order to avoid damaging them during the charging process. Typically, the battery management system monitors battery voltage, current flow and battery temperature to minimise charging time.



Source: http://www.alternative-energy-news.info/technology/transportation/electric-cars/ - accessed 22 June 2017.

Source : http://auto.howstuffworks.com/electric-car5.htm - accessed 22 June 2017

Figure 5. Schematic of the main components of an electric car (top); photograph of electric car being charged (bottom).

2.2.2 Identification of barriers to deployment of low-carbon car fleet technologies

LPA was used to identify the root causes that hinder the wider uptake of low carbon cars in Seychelles. The PT for low-carbon cars is shown in **Annex II**. The PT reveals that the key barriers hampering the uptake of hybrid and electric cars are:

- Economic and financial barriers;
- Market barriers; and
- Human capacity barriers;

These barriers are discussed in mode details below. Cars are classified as a consumer good that have the following charecteristics: (1) there is a relatively high number of potential consumers given that the retirement of conventional cars can be replaced with low-carbon alternatives; around only 25% of households own a motorised vehicle; and that the number of registered vehicles on the roads has increased at a relatively high compound annual growth rate (CAGR) of 5.81% between 2010 and 2014 (Government of Seychelles, 2017); (2) the sales of electric and hybrid cars can use existing supply chains of importers and retailers, but marketing efforts are constrained by the higher complexity of the engine technologies and related infrastructure needs (at least for electric cars), and (3) the uptake of low-carbon cars will depend on the financial attractiveness compared to conventional cars, and also on the awareness of the benefits that these technologies confer over conventional ones (Nygaard and Hansen, 2015, Chapter 2).

2.2.2.1 Economic and financial barriers for low-carbon car fleet technologies

The uptake of low carbon cars in Seychelles, more specifically the electric and hybrid cars are partially restricted by financial barriers. As discussed in the TNA Report – Mitigation (Government of Seychelles, 2017; Table 19), the financial incentives provided in the form of lower (or none in the case of electric vehicles) trade and excise taxes on low-carbon vehicles has resulted in the uptake of mainly hybrid sports utility vehicles. Consequently, there has not been a transformation change away from conventional non-SUV vehicles. Compared to conventional cars (typically of engine capacity less than 1.5 L), electric vehicles still remain financially unattractive.[14] The majority of car buyers do so using commercial loans. The commercial financing mechanisms that are in place now command a relatively high interest. For example, an unsecured loan from commercial banks attracts a hefty interest rate of 27% per annum.[15] A secured loan currently requires a minimum guarantee equivalent to 100 % of the value of the loan, and it typically attracts a minimum of 10% interest rate. The government must set up favourable financing instruments in collaboration with financial institutions to facilitate the uptake of this technology.

The government is also concerned about loss of revenue from levies and duties from the sale of petroleum products as a result of increase sales of low carbon cars. The CBA discussed in section 2.2.3.3 is used to justify the promotion of hybrid and electric cars.

2.2.2.2 Non-financial barriers for low-carbon car fleet technologies

Human capacity & skills

There are currently none or limited trained and qualified local experts to maintain and repair the low carbon car fleet. Cars with electric drives pose real threats of electrocution or fire hazards when not handled by appropriately trained and accredited technicians.[16] The absence of accredited trainings for technicians is therefore considered to be a barrier to the promotion of hybrid and electric cars.

Market barrier

As the uptake of the low carbon car fleet increases, the market forces must be aligned with the market development. Along with the right policies and institutional settings, the provision of adequate after sale service must be put in place by car dealers. At the early stages of technology transfer, a lack of after sales service will create a negative image of the technology that may result in lower than expected social acceptability of low-carbon cars.

The market forces will also have to grapple with the fact that battery replacement and disposal will become increasingly more significant as the market penetration of low-carbon vehicles increases. It is estimated that the battery life of low-carbon cars is expected to be around 8 years. Both battery replacement and disposal will become more apparent when the batteries on the first vehicles to enter

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[14] In the benefit-cost analysis, the cost of a conventional and an electric car in Seychelles have been taken to be US$ 22,222 and US$ 31,481, respectively.

[15] Information obtained from Barclays Bank PLC.

[16] Please see: http://www.independent.co.uk/life-style/motoring/motoring-news/electric-cars-mechanics-with-no-specialist-training-risk-death-when-tinkering-with-the-vehicles-a6816786.html - accessed 28 June 2017.

the country will need replacing. Consequently, the supply chain will need to cater for battery replacements and the disposal of used batteries in a sustainable way.

2.2.3 Identified measures for low-carbon car fleet technologies

The OT for low-carbon cars is given in **Annex II**. The proposed measures are articulated around the following:

- Increasing the financial attractiveness of hybrid and electric cars by providing financial instruments to reduce their cost thereby making them more financially attractive compared to a conventional car;
- Developing human technical skills by providing appropriate training for developing accredited technicians; and
- Reorienting the car supply chain for promoting low-carbon cars by establishing legal dealerships.

The proposed measures are discussed below.

2.2.3.1 Economic and financial measures for low-carbon car fleet technologies

The main precondition for the accelerated uptake of this technology will be putting in place appropriate instruments to allow more consumers to afford this technology. Low interest loans should be one of the main instruments, similarly to the Seychelles Renewable Energy and Energy Efficiency Programme (SEEREP),[17] an instrument that sees the government subsidising the interest rates on loans, and also providing a default guarantee to the banks. This programme could also be extended to include low carbon cars. Since cars are more expensive and require loans in excess of the ceiling proposed under SEEREP, the financial measure proposed for the promotion of low-carbon vehicles is as follows: 1.5% and 4% subsidy on interest for hybrid and electric cars, respectively. As discussed in section 2.2.3.3, a sensitivity analysis of the benefit-cost ratio on subsidy on interest rate has been carried out.

Another element to substantiate the financial measure is for the DLT and the SEC to gather and analyse data, especially of fuel 'not' sold as a result of the higher market penetration of low-carbon land transport alternatives, and to carry out a detailed analysis of the net economic impacts on the country.

2.2.3.2 Non-financial measures for low-carbon car fleet technologies

The non-financial measures for this technology can be summarised into measures that create enabling or conducive market conditions to drive the uptake of low-carbon vehicles, with the government maintaining the fiscal incentives already in place.

[17] The Seychelles Renewable Energy and Energy Efficiency Programme (SEEREP) is a subsidised loan scheme to promote Energy Efficient appliances and Renewable Technologies in the residential sector. This loan targets the residential sector and most of the commercial banks offer this facility. The maximum amount available under this loan is SCR 150,000 per household, with 5 % rate of interest only. The duration of repayment may vary from 0 to 5 years with no personal contribution up to SCR 75,000. For loan above SCR 75,000 a personal contribution of 2.5 % is required. The loan subsidy is administered by the SEC. Information was obtained from http://www.sec.sc/index.php/promotion - accessed 28 June 2017.

One of the enabling market conditions is to train technicians for providing specialised technical services to owners of hybrid and electric vehicles. The measure will consist of developing a new course and to have it accredited by the Ministry of Education. As will be discussed further in the Technology Action Plan (TAP), the course can be developed and accredited by the Seychelles Institute of Technology (SIT).[18] As per the baseline established in 2015 (Government of Seychelles, 2017), there are at least 318 hybrid and electric cars already in use in Seychelles. In the short term, car dealers may get their technicians trained overseas as part of their franchise agreements, but the sustainable solution (i.e. with higher penetration of low-carbon vehicles) will be for technicians to be trained in Seychelles.

Another measure that will create an efficient market chain for low-carbon cars is the establishment of a legal framework so that only authorised dealers are able to import hybrid and electric vehicles in the country. Authorised car dealers will have the mandate to provide appropriate guarantees and after sales service, as well as make provision for the availability of batteries and spare parts for hybrid and electric cars.

2.2.3.3 Cost-benefit analysis of measures for low carbon car fleet technologies

Incremental cost analysis was used to carrying out CBA. This implies that the analyses of costs and benefits accruing from low carbon cars were calculated incrementally using a conventional car as the baseline. It is also assumed that the absence of the measures will result in the status quo with none of the benefits calculated below in the case of measures being implemented.

<u>Cost of measures</u>

As discussed in section 2.2.3.1, the financial measure proposed for the promotion of low-carbon vehicles is the provision of 1.5% and 4% subsidy on interest rates for incremental loans to purchase hybrid and electric cars, respectively. The costs of developing an accredited training programme for technicians and to establish a legal framework to regulate the dealership of low-carbon vehicles have also been included in the analyses. The parameters and assumptions used for costing the proposed measures to promote low-carbon cars are summarised in **Table 11**.

Table 11. Parameters and assumptions used for calculating the cost of measures for low-carbon cars.

Measure proposed	Remarks
Financial measures	1.5% and 4% subsidy on interest rates for incremental loans to purchase hybrid and electric cars, respectively. The approach here is to only give a rebate on the interest rate for the price differential between a low-carbon car and a conventional car. The motivation for this is that the financial measure should not generally promote private car ownership (regardless of GHG emissions) at the expense of more sustainable forms of mobility such as public transport. This is especially important in the case of Seychelles that has limited space for additional

[18] The SIT is a technical and vocational education and training (TVET) institution established as a Professional Centre from January 2015 under the Tertiary Education Act (TEA) 2011. It operates under the aegis of the Ministry of Education. It is composed of several departments, including the department of Motor Vehicle Engineering, which provides training in maintenance, servicing and repairs of light vehicles. Please see: http://www.sit.sc/index.html - accessed 28 June 2017.

Measure proposed	Remarks
	road infrastructure development. The cost of the financial measure is the cost of providing these concessions on loans. It is assumed that the 70% of the price of a car is financed through loan. The term of the loan is assumed to be 5 years with 20% repayments of capital and interest each year.
Human capacity enhancement	An accredited course is proposed to be developed through technical assistance that will cost US$30,000. An accompanying measure is to provide the training facility with a hybrid and an electric car costing US$24,000 and US$31,500, respectively. These cars will be used for vocational training in new car technologies. It is also planned that the accredited course will be updated in 2024 at a cost of US$10,000.
Legal framework for car dealership	In order to ensure that the market provides adequate technical and after sales service to customers, the car dealership for low-carbon vehicles has to be regulated. The necessary legislation will be put in place to regulate the market of hybrid and electric cars through technical assistance expected to cost US$30,000. The legislation is expected to be in place in 2018 and reviewed six years later at a cost of US$10,000.

Source: TNA project

Benefits accruing from measures

The incremental benefits that have been estimated are: (1) GHG emission reductions; and (2) avoided importation of gasolene.[19] The methodologies and parameters used to calculate and monetise the benefits are provided in section 4.3 of the TNA Report – Mitigation (Government of Seychelles, 2017), and **Table 12**.

Table 12. Parameters used for calculating the benefits accruing from low-carbon cars.

Benefits accruing from measures	Remarks
GHG emission reductions	The quantity of gasolene that is avoided through the diffusion of low-carbon vehicles has been calculated. First, a projection was made regarding the increase in private cars, taxis and self-drive vehicles using CAGR equal to 5.8% between 2015 and 2019; 4% between 2020 and 2024; and 2.5% between 2025 and 2030. The annual uptake of hybrid cars is assumed to be at: 5% absolute increase between 2018 and 2025, and 6% absolute increase thereafter. The penetration is 2% of stock of cars in

[19] As discussed in the TNA Report – Mitigation, it is assumed that hybrid and electric cars will displace conventional cars running on gasoline.

Benefits accruing from measures	Remarks
	2017 and 5% in 2018 The annual uptake of electric cars is assumed to be at: 0.5% absolute increase between 2018 and 2023, and 1% absolute increase thereafter. The uptake is0.25% in 2017. In the baseline scenario, the electric cars are charged using grid electricity with a grid emission factor equal to 0.6594 tCO_2/MWh. In this case, the total avoided GHG emission from gasoline displacement is net of grid emissions. A sensitivity analysis has been carried out whereby 30% of electricity for charging electric cars is produced using renewable energy sources by 2030. The prices of emission reductions were: 2 US$/$tCO_2$ before 2020 and 26 US$/$tCO_2$ after 2020.[20]
Avoided energy bill	This is calculated as the value of gasoline displaced in land transport net of the cost of fuel oil used to generate electricity to charge electric cars. The quantity of fuel oil avoided is calculated using the specific fuel consumption 0.2177 t(fuel)/MWh generated multiplied by the quantity of electricity required to charge cars (MWh). In the baseline scenario, the cost of gasoline is take as 626 US$/t(gasoline), and that of fuel oil as 331 US$/t(fuel oil).

Source: TNA project

Benefit-Cost Ratio (BCR)

Using the above assumptions, the BCR = 1.17 showing that the benefits of the proposed measures to support the promotion of low-carbon cars outweigh their cost of implementation. The proposed measures are therefore financially beneficial.[21] However, several parameters, especially the price of gasoline and fuel oil, and the subsidy on the interest rate for purchasing electric cars, influence the BCR as summarised in **Table 11**.

Table 13. Sensitivity analyses of BCR for low-carbon cars.

BCR	Parameter changes
1.00	The subsidy on concessional loan, especially for electric cars, has a significant impact on the BCR. All else being equal, the BCR drops to 1 when the subsidy on interest rate for electric cars is increased to 5.1%.
1.03	The percentage of debt contracted in loan also has a big influence on the BCR. The change reflects an increase in debt component of

[20] www.synapse-energy.com/sites/.../2015%20Carbon%20Dioxide%20Price%20Report.pdf – accessed 18 April 2017.

[21] The BCR has not been estimated without implementing the measures. This is because the benefits used in calculations such as avoided emissions and savings on energy bill do not accrue without them.

BCR	Parameter changes
	cost from 70% to 80%.
1.19	Increasing the percentage of renewable electricity used to charge electric cars from 0% in 2020 to 30% in 2030 results in an annual absolute increase of BCR?? of 3%.
1.11	Post-2020 price of carbon is decreased to 13 US$/t$CO_2$.
1.27	When the price of gasoline and fuel oil increase by 10%.
1.17	Increasing the price of gasoline and fuel oil by 10%, and increasing the subsidy on interest paid for incremental loan for electric cars to 4.6%. This shows that the subsidy on the incremental cost of vehicles can be pegged to the price of gasoline and fuel oil.
1.16 (negligible change)	Doubling the costs of all technical assistance to develop accreditation course for training technicians and to put in place legislation to regulate the market for dealership of low-carbon cars.

Source: TNA project

2.3 Barrier analysis and enabling measures for VTMP

2.3.1 General description of VTMP

As described in Table 22 of the TNA Report – Mitigation (Government of Seychelles, 2017; section 4.3), the VTMP is a collection of interventions proposed within the overall ambit of managing traffic in Victoria productively (i.e. effectively and efficiently). Roads, streets and paths provide the means of connectivity and mobility of people, goods and services. But to ensure that this can happen effectively, and that traffic on these routes is not detrimental to communities, the whole transport system comprising of travellers, vehicles and travel routes needs to be carefully managed. Proper traffic management can ensure that (Bannister, 2008):

- ➢ Traffic flows smoothly and efficiently in order to avoid unnecessary travel time delays and excessive fuel consumption;
- ➢ There is fair access to different transport modes, and the more sustainable modes are encouraged;
- ➢ Roads and streets are safe for all users, including pedestrians and cyclists;
- ➢ Roads full of motorised traffic do not constitute barriers blocking movement of non-motorised vehicles and pedestrians 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 emission is reduced.

Congestion is a major issue across Seychelles, and particularly in Victoria, where bus journey times and reliability are significantly impacted. The VTMP therefore proposes several interventions that will support achieving the above objectives that can be achieved by proper traffic management in Victoria. The main elements of the VTMP are (Government of Seychelles, 2017; Government of Seychelles, 2015b):

- ✓ 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 and 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 (see 'park and ride' description below);
- ✓ Putting in place incentives and disincentives that can support modal shift away from private car use towards public transport, 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);
- ✓ Construction of a Western Victoria bypass between Beau Vallon and Saint Louis which includes a new stretch of road and highway improvement works; and
- ✓ Dualling of the Bois de Rose venue/Providence Highway/East Coast Road between Victoria and Anse Royale.

2.3.2 Identification of barriers to deployment of VTMP

LPA is used to identify the root causes that hinder the implementation of VTMP. The corresponding PT is shown in **Annex II**. The PT reveals that there are several barriers delaying the implementation of VTMP including:

- ➢ Economic and financial barriers;
- ➢ Institutional barriers
- ➢ Policy barriers
- ➢ Technical barriers; and
- ➢ Human capacity barriers;

These barriers are discussed in more details in the next two sections. As can be seen from the discussion above, the main interventions proposed in the VTMP such as road network extensions and the relocation of the bus terminal are site specific and requiring significant investments. Traffic congestion is a collective action problem and the solutions and investments will be driven mainly by the government without excluding the possible involvement of private partnerships. Consequently, the VTMP can be classified as a publicly-provided good (Nygaard and Hansen, 2015, Chapter 2).

2.3.2.1 Economic and financial barriers for VTMP

The main financial barrier to the project is the high up-front costs to implement the part of the project related to its hardware components such as the construction of roads, bridges and/or tunnels to facilitate the movement of pedestrians and vehicles in and around Victoria. The cost of construction in the Seychelles is already quite high because most construction materials have to be imported.

There is also limited land in the vicinity of Victoria to ensure the full implementation of the VTMP. Additional land and space will need to be acquired or created in the form of sea reclamation for this project to materialise. The acquisition and/or reclamation of land are very costly, and, with the current control on the government spending, it will be very difficult for the government to implement the project in the short term. There will therefore be a need for government to find low cost finance to implement this technology.

2.3.2.2 Non-financial barriers for VTMP

Policy, legal and regulatory

In a recent study to formulate the Seychelles Strategic Plan 2015-2040 (Government of Seychelles, 2015b), which included a study on the VTMP, it was observed that there was a lack of linkages between economic and development plans and programmes. The lack of coherence between existing policies, strategies and action plans reduces the ease implementation of the VTMP.

Institutional barrier

The institutional capability and support for monitoring and evaluation of the implementation of the VTMP is not in place. The institutional barrier is closely linked with the budgetary constraints of line ministries and their human capacity limitations. There are three main institutions (Government of Seychelles, 2017; see discussions on 'Institutional setup' in section 4.2; Government of Seychelles, 2012b) that deal with local transport issues, and they all have heavy workloads while being understaffed. For example, the heavy mandate of the RTC cannot be executed by only the two experts that it currently has. Another example is that the DLT has no officer to gather and analyse data, which is critical for making policy.

It is apparent that there is insufficient coordination between the parent ministries and other relevant stakeholders in the transport sector, which leads to difficulties in the teams agreeing on the best and most appropriate way forward. There is also the consideration that needs to be given regarding the alignment of sectoral plans and programs to make way for an easier implementation of the project. The process of aligning plans and programmes can only be carried out through multi-stakeholder coordination, which is currently lacking. Increased stakeholder engagement in the VTMP is also a means of facilitating its implementation.

Human capacity barrier

There is a lack of domestic consultants to assess and address traffic management issues in the country. Even at the DLT, the SLTA and the RTC, there is not enough staff with the required knowhow to address the policy and legislative issues related to traffic, and also deal with the implementation of the VTMP. There is very little applied research on the appropriate technologies that will be useful for the project due to the shortage of staff and also lack of opportunities for developing the necessary skills.

Technical barriers

Associated with the low human and institutional capacity levels are technical barriers that strain the implementation of the VTMP. There are two notable technical challenges, namely: (1) the lack of land availability for infrastructure development that was discussed earlier may require sea reclamation works, which, in addition to being very costly, will require technical expertise that is not available in the country; and (2) there is also a lack of technical expertise on the use of real-time traffic monitoring that is needed as part of the VTMP.

2.3.3 Identified measures for VTMP

The OT for the VTMP is given in **Annex II**. The proposed measures are:

- Increasing the financial attractiveness of the VTMP by securing a concessional loan with attractive repayment terms;
- The creation of a multi-stakeholder coordination mechanism for steering the management, including design, implementation and monitoring and evaluation of the VTMP;

- Alignment of sectoral strategies, plans and programmes in order to develop a coherent policy and institutionally-harmonised approach to the VTMP;
- Developing human technical skills by providing appropriate trainings through exchange programmes and study tours; and
- The introduction of real-time traffic monitoring technology and finding alternatives to costly land reclamation projects.

The proposed measures are discussed below.

2.3.3.1 Economic and financial measures for VTMP

High investment costs and high capital costs are major challenges for the implementation of this project. This technology will be most likely be financed through funds borrowed from a public (bilateral or multilateral) or private financial institutions at a negotiated concessional interest rate and attractive terms of repayment. The former usually comes with a lower interest rates and maybe more favourable. The measure identified is, therefore, a government-guaranteed loan denominated in foreign currency (i.e. US$) at a fixed concessional interest rate of 2% per annum for a period of 15 years.

2.3.3.2 Non-financial measures for VTMP

Policy, legal and regulatory measures

Within the ambit of the institutional mechanism described below, the designated authority (i.e. legally mandated existing institution or high-level steering committee) will oversee the development of clear traffic management policies while ensuring necessary linkages are created with other sectoral plans. In fact, the integration of sectoral plans was completed during the development of the Seychelles Strategic Plan 2015-2040 (Government of Seychelles, 2015b). The designated authority therefore has to get the Cabinet of Ministers to endorse the SSP and declare it as the national master plan for the Seychelles. This is a low hanging fruit that needs to be preceded by the setting up of the institutional coordination mechanism discussed next.

Institutional coordination mechanism

Given that there are numerous organisations that would be involved in this technology, two things are proposed to ensure that these organisations align their policies and strategies and work together to realise this project. Either one of the key organisations involved in this project should be legally mandated to oversee the implementation of the project or a high level inter-ministerial steering committee is set up with the same functions. The second mechanism is proposed since this will provide high level political support for the implementation of the VTMP. The VTMP will remain under the management of the DLT that will also ensure monitoring of its implementation under the oversight of the inter-ministerial steering committee.

Measures to improve human skills

Assuming the SSP is in place, the issue of human skills will also need to be addressed. Given the complexity of the VTMP, part of the work will have to be contracted out to foreign consultants. Local personnel can then learn from the foreign consultants through a learning-by-doing process. Over and above this opportunity for learning, the TNA project proposes to send selected public staff on study tours in order to increase their knowledge and skills in specific areas, such as urban planning, multi-modal development planning in urbanised areas, preferably in the context of small island states and deployment and use of real-time traffic management technologies for efficient traffic management, among others.

Technical solutions

The following measures are proposed as technical solutions to the technical barriers discussed in section 2.3.2.2. First, the VTMP will include the use of technologies for the real-time monitoring of traffic in and around Victoria. The introduction of this new technology will be supported by the human capacity building that was discussed above. Second, since land reclamation is prohibitively expensive, the road infrastructure development should also carry out comparative analysis of financial, technical and socio-cultural merits of alternatives such as the use of bridges, over passes, and roads built on pillars.

2.3.3.3 Cost-benefit analysis of measures for VTMP

First, it is to be noted that, as a public good, this project may not have immediate and apparent returns on investment. Also, the cost of environmental degradation is usually small compared to the economic losses associated with traffic congestion. Hence, any CBA needs to include the dimension of economic losses or the reduction thereof when interventions such as those contained in the VTMP are implemented. This is especially important because the upfront cost of implementing the VTMP is significant, and with benefits accruing in the future.

However, no studies have been carried out to date to inform the estimation of economic losses and environmental externalities arising from traffic congestion in Victoria. Also, there are no empirical data regarding the magnitude of increase in fuel consumption (and hence GHG emissions) due to reduced mobility and idleness in congested traffic conditions in Victoria.

Nevertheless, an attempt has been made to carry out BCA of the measures proposed in sections 2.3.3.1 and 2.3.3.2 using the best available expert knowledge among stakeholders (**Annex III**) and drawing on studies carried out elsewhere. As far as practicable, a conservative approach has been adopted to not overestimate the economic losses arising from congestion, so that the benefits accruing from the proposed measures are also not overestimated.

Cost of measures

The main cost of implementing the VTMP is associated with the high cost of road infrastructure development and the relocation of the Victoria bus terminal. The total cost of the hardware component of the VTMP, including the use of technologies for the real-time monitoring of traffic in and around Victoria, was estimated at US$55million in the TNA Report – Mitigation (Government of Seychelles, 2017; Table 22), and an additional cost of US$100,000 was identified for soft interventions. The soft interventions include sending selected public staff on study tours in order to increase their knowledge and skills in specific areas, such as urban planning, multi-modal development planning in urbanised areas, and on the deployment and use of real-time traffic management technologies for efficient traffic management.

The total cost of US$55.1 million is expected to be sourced as a government-guaranteed loan at a fixed concessional interest rate of 2% per annum as discussed in section 2.3.3.1.

Benefits accruing from measures

The three main benefits that have been estimated are: (1) the reduction in economic losses due to reduced traffic congestion in Victoria; (2) reductions in GHG emissions; and (3) avoided energy bill due to lower consumption in road transport fuels. The methodology and parameters used to estimate the benefits are described in **Table 14**.

Table 14. Summary of methodology and parameters for estimating benefits accruing from the VTMP.

Reduction in economic losses from reduced traffic congestion in Victoria The reduction or avoidance of economic losses and negative externalities caused by traffic congestion is the main benefit accruing from the implementation of VTMP. The Total Cost of Congestion (TCC) has been estimated using the methodology in (Khan and Islam, 2013). In the case of Seychelles, only the Total Travel Cost (TTC), including the effect of time-travel variability (TTV), dead weight loss (DWL), and travel delay externality cost (E_{delay}) have been used to determine TCC. The effects of traffic congestion on vehicle operating cost (VOC) and environmental externality (E_e) have not been accounted for in TCC. One element of E_e – i.e. GHG emissions – is calculated separately, and its reduction due to decongestion is estimated as a separate benefit below. Parameters and assumptions • Only 20% and 40% of total stock of cars and buses, respectively, are assumed to transit or commute in Victoria. The choice of number of cars has a significant influence on TTC; • The stock of buses has been kept constant between 2017 and 2030 at 403 (i.e. 2% of stock of all registered motorised vehicles in 2015); • The occupancy (average) of cars and buses is 2 and 20 passengers per trip, respectively; • The average speed of cars and buses is 40 km/h and 25km/h, respectively; • The Value of Time (VOT) for passengers travelling in cars during peak traffic hours has been determined as 5.2 US$/h using an average monthly wage of 900 US$/month. The VOT for passengers travelling in buses has been assumed to be 1.5 times lower than for those travelling in cars. VOT is another parameter that has a significant effect on TCC; • The VOT for non-work time travel has been taken as 1.5 times lower than equivalent VOTs at peak hour; • For all less time-sensitive (LTS) travels, the VOTs have been assumed to be half the values of non-work time travel VOTs; • The infrastructure works will begin in 2018 and be completed over a period of 5 years.
Avoided energy bill due to a reduction in land transport fuel consumption The reduction of congestion will reduce land transport fuel consumption. As mentioned above, no detailed studies have been carried out in Seychelles to correlate traffic congestion and fuel consumption. The methodology used here is that used in MCA to prioritise mitigation technologies in the TNA Report – Mitigation (Government of Seychelles, 2017). In this case, it was assumed that implementing the VTMP would result in a 5% reduction in national land transport fuel consumption in 2030. The price of gasoline and diesel oil have been assumed to

be 626 US$/tonne and 544 US$/tonne, respectively. No indexation has been applied to project any increase in the price of fuels.
GHG emissions avoided This has been calculated based on the reduction in national transport fuel consumption, and applying the pre-2020 and post-2020 price of carbon mentioned in **Table 12**.

Source: TNA project

Benefit-Cost Ratio (BCR)

Using the above assumptions, the BCR = 2.83 showing that the total cost of measures proposed under the VTMP is outweighed by the benefits accruing from decongesting Victoria. The BCR is sensitive to several factors, namely the upfront cost of proposed measures, and the estimation of TCC. In turn, the estimation of TCC is highly dependent on the number of vehicles that is assumed to transit or commute trough Victoria, and VOT.

All else being equal, increasing the upfront cost of infrastructure development by 50% (i.e. from US$55 million to US$82.6 million), BCR decreases to 1.89. Doubling the infrastructure development cost decreases BCR to 1.42, showing that the benefits still outweigh the costs of the proposed measures.

The sensitivity of BCR on the number of vehicles (cars and buses) used to estimate TCC is summarised in **Table 15**. It shows that benefits outweigh the cost of measures even when the number of vehicles is set to conservatively low values. The BCR is unity when using the lower boundary values of number of vehicles and when the upfront cost of hardware for the VTMP is increased by 50%.

Table 15. Sensivity of BCR on the number of vehicles used to estimate TCC.

% cars	10%	20%	**20%**	20%	30%	40%	50%	75%	100%
% buses	20%	20%	**40%**	60%	40%	40%	40%	40%	100%
BCR	1.48	2.50	**2.83**	3.17	3.86	4.87	5.89	8.44	12.00

Source: TNA project

The effect of VOT (through changes in the average productivity and therefore improved income/monthly salary of commuters) on BCR is captured in **Table 16**. An average monthly wage of US$ 580 per month must be used in conjunction with the lower boundary number of vehicles shown in **Table 15** for BCR = 1.

Table 16. Sensitivity of BCR on the value of time when traveling in cars.

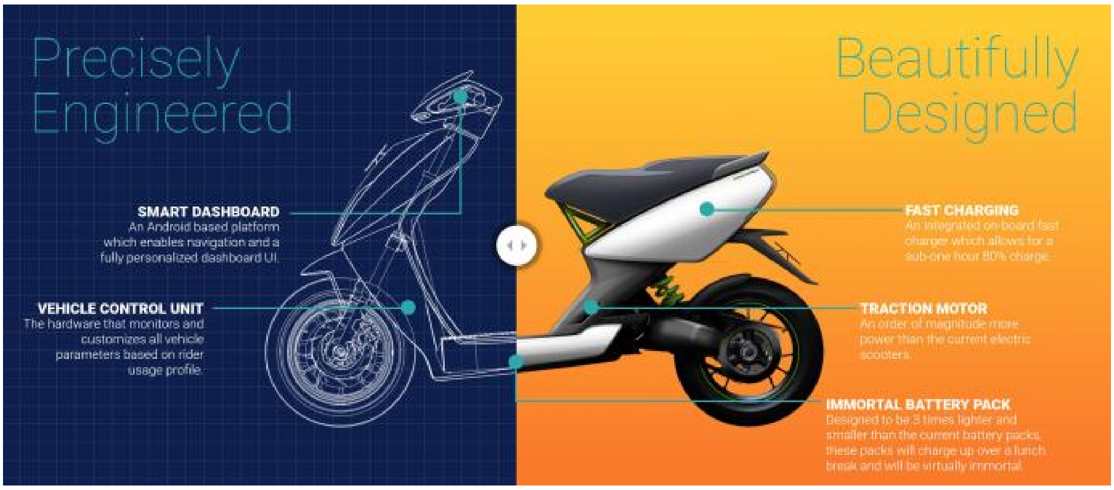
Wage (US$/month)	500	700	**900**	1,000	1,200
VOT(car) – peak time (US$/hr)	2.88	4.04	**5.19**	5.77	6.92
BCR	1.64	2.24	**2.83**	3.14	3.74

Source: TNA project

2.4 Barrier analysis and enabling measures for electric scooters

2.4.1 General description of electric scooters

The e-scooter has the same general appearance and is operated very much like a conventional motorcycle. However, there is no internal combustion engine and gas tank, which means that there are fewer moving parts and less engine wear out. Similar to electric cars, e-scooters are plug-in electric vehicles. They have two wheels powered by electric drives. Electricity is stored on board in a rechargeable battery, which drives one or more electric motors (**Figure 6**). There are several technological issues that may make an e-scooter less attractive than a conventional motorcycle, including: the range limitation of the e-scooter (due to the relatively small battery size), the low speed usually ranging between 30 to 40 km/h, and the time it takes to charge the battery (up to 8 hours).[22]



Source: https://www.atherenergy.com/press-releases/2015-07-20/2-young-engineers-are-changing-future-electric-scooters-forever-%E2%80%93-ather

Figure 6. Schematic of the main components of an e-scooter.

E-scooters are relatively easy to maintain compared to a conventional scooters as the system is relatively simple, there is no lubricating, adjusting and tuning to do. The main consumables are brake pads, tires, and potentially a brake fluid flush.

2.4.2 Identification of barriers to deployment of electric scooters

LPA was used to identify the root causes that hinder the market penetration of e-scooters in Seychelles. The PT for e-scooters is shown in **Annex II**. The PT reveals that the key barriers that hamper the uptake of e-scooters are qualitatively quite similar to those hampering the uptake of electric cars. The main barriers are:

- Economic and financial barriers;
- Market barriers;
- Human capacity barriers; and
- Policy barriers

These barriers are discussed in mode details below. Technology categorisation and market characterisation shows that e-scooters are consumer goods that have the same characteristics as electric cars, namely: (1) there is a relatively high number of potential consumers; (2) the sales of e-

[22] https://www.atherenergy.com/press-releases/2015-07-20/2-young-engineers-are-changing-future-electric-scooters-forever-%E2%80%93-ather – accessed 23 August 2017.

scooters can use existing supply chains of importers and retailers[23]; and (3) the uptake of e-scooters will depend on the financial attractiveness compared to conventional motorcycles, and also on the awareness of the benefits that these technologies confer over conventional ones (Nygaard and Hansen, 2015, Chapter 2).

2.4.2.1 Economic and financial barriers for electric scooters

As with the low carbon car fleet, the e-scooters usually cost more than conventional motorcycles. In the incremental costr analysis that is used in section 2.4.3.3, the cost of a conventional scooter is ~US$ 2,520, whereas the cost of an e-scooter is US$ 4,000. But the government has put in place a scheme (i.e. lower trade and excise taxes) to help promote this technology and as in the case with the low carbon cars, the risk to the government is that it will lose income, albeit to a much lower extent compared to the substitution of conventional cars with low-carbon vehicles,[24] from the high taxes that are imposed on gas powered vehicles.

Nevertheless, the lack of access to a cheap source of capital makes the acquisition of relatively more expensive vehicles prohibitive. The majority of buyers of motorised two-wheelers do so using commercial loans. The commercial financing mechanisms that are in place now command a relatively high interest. Currently, an unsecured loan from commercial banks attracts a hefty interest rate of 27% per annum.[25] A secured loan currently requires a minimum guarantee equivalent to 100 % of the value of the loan, and it typically attracts a minimum of 10% interest rate. There is therefore a lack of cheap capital available to borrowers for purchasing an e-scooter. Therefore, there is a need for government to develop financial instruments in collaboration with financing institutions in order to provide cheaper debt to facilitate the uptake of this technology.

2.4.2.2 Non-financial barriers for electric scooters

Policy and legal barriers

As with the case of the low carbon car fleet, there is no policy to guide and encourage the uptake of two-wheelers, including e-scooters. A lack of clear policy and legislation bears heavily on the chance for the technology to be successfully deployed in Seychelles.

Human capacity & skills

Just as in the case of low-carbon car fleet, the main issue here is the lack of trained and qualified local experts to maintain and repair e-scooters. It is imperative that properly trained and accredited technicians are available to work on the technology.

Market barriers

At the present, there are very few e-scooters in use in Seychelles. The existing few are mainly used in resorts because these are noiseless and, hence, do not disturb the guests. But there are none used for

[23] The market must be regulated so that authorised dealers are established. Authorised dealers will be better placed to provide after adequate sales services and to provide quality spare parts and batteries, especially when the market size is still small.

[24] Given that motorcycles cost much less than cars, and that the sales of motorcycles are lower since there are fewer motorcycles than cars in Seychelles. As discussed in section 4.1 of the TNA Report (Government of Seychelles, 2017), two-wheelers stood at only 1.3% of total number of motorised vehicles, whereas private cars represented 67% of the total registered motorised vehicles.

[25] Information obtained from Barclays Bank PLC.

in-city commuting, and this mostly due to the fact that riders are not aware of this technology and that there isn't any established dealership for guaranteeing quality after sales services and reliability in the availability of spare parts and batteries.

E-scooters generally suffer from having a short range that makes them unattractive compared to alternatives. To increase the range of these scooters, there will be the needs to set up fast charging stations and/or an on-the-go battery replacement service starting in the greater Victoria region. Currently, most two-wheelers are used in and around Victoria.

Furthermore, to ensure the environmental sustainability of the technology, users should be provided with an option to dispose of batteries in a sustainable manner beyond their lifetime.

2.4.3 Identified measures for electric scooters

To make this technology widespread locally, several measures should be undertaken and these steps are highlighted in the OP for e-scooters presented in **Annex III**. The financial and non-financial measures are articulated around the following:

- Increasing the financial attractiveness of e-scooters by providing financial instruments to reduce their cost thereby making them more financially attractive compared to a conventional car;
- Developing human technical skills by providing appropriate training for developing accredited technicians;
- Reorienting the supply chain of scooters by establishing legal dealerships; and
- Updating the Energy Policy to encourage the uptake of e-scooters (among others).

The proposed measures are discussed below.

2.4.3.1 Economic and financial measures for electric scooters

Financial measures can bring the much needed relief needed to successfully introduce the technology into the market by increasing the affordability of the technology. These measures can include, but not restricted to, tax breaks, and low interest loans, among others. As discussed for low-carbon vehicles (section 2.2.3.1), the government can extend the scope of the SEEREP to cover e-scooters, or to develop a similar programme for targeting the transport sector.

Since scooters are not as expensive as cars, the financial measure proposed for the promotion of e-scooters is a 2% subsidy on interest. As discussed in section 2.4.3.3, a sensitivity analysis of the benefit-cost ratio on subsidy on interest rate has been carried out.

2.4.3.2 Non-financial measures for electric scooters

The ministry responsible for land transport and its associated agencies should draft policies that would guide the uptake of e-scooters (and all forms of low-carbon motorised vehicles), and to create the market conditions for e-scooters. This should not be hard to carry out as there is already a proposal to draft policies for promoting low-carbon cars, and this initiative might be availed of to cover all forms of low-carbon motorised vehicles, including e-scooters.

The right policies, and accompanying legislations, will also create the necessary market conditions for the uptake of e-scooters as the policies can also dictate the conditions for dealers to get the necessary licenses to import the technology – i.e. to regulate the market so that only authorised dealers are allowed to import e-scooters in the country. The onus will then be placed on the authorised dealers to offer appropriate product guarantees and after sales services, including providing quality repairs and maintenance, and ensuring the availability of spare parts and batteries.

The authorised dealers will need to have trained and qualified technical staff to ensure a high level of after sales service. Since the necessary technical skills are not available in Seychelles, it is proposed to develop an accredited course by the SIT for training technicians. The training programme for e-scooters can be linked to that for electric cars (section 2.2.3.2).

2.4.3.3 Cost-benefit analysis of measures for electric scooters

As in the case for low-carbon cars, incremental cost analysis was used to carrying out CBA.

Cost of measures

As discussed in section 2.4.3.1, the financial measure proposed for the promotion of e-scooters is the provision of 2% subsidy on interest rates for incremental loans. The costs of developing an accredited training programme for technicians and to establish a legal framework to regulate the dealership of e-scooters are the same as for the promotion of low-carbon cars. Since investments to enhance technical skills and policy and legal framework are quite similar to those carried out for promoting electric cars, sensitivity analysis is also carried out to exclude these investment costs in the CBA for e-scooters. The parameters and assumptions used for costing the proposed measures to promote low-carbon cars are summarised in **Table 17**.

Table 17. Parameters and assumptions used for calculating the cost of measures for e-scooters.

Measure proposed	Remarks
Financial measures	2% subsidy on interest rate for an incremental loan to purchase an e-scooter. The logic used here is same as that used for low-carbon cars, and for not promoting private vehicle ownership over public transport. The cost of the financial measure is the cost of providing these concessions on loans. It is assumed that the 80% of the price of an e-scooter is financed through loan. The term of the loan is assumed to be 5 years with 20% repayments of capital and interest each year.
Human capacity enhancement	An accredited course is proposed to be developed through technical assistance that will cost US$30,000. An accompanying measure is to provide the training facility with a hybrid and an electric car costing US$24,000 and US$31,500, respectively. These cars will be used for vocational training in new car technologies. It is also planned that the accredited course will be updated in 2024 at a cost of US$10,000.
Policy and Legal framework for car dealership	In order to ensure that the market provides adequate technical and after sales service to customers, the car dealership for low-carbon vehicles has to be regulated. The necessary legislation will be put in place to regulate the market of hybrid and

Measure proposed	Remarks
	electric cars through technical assistance expected to cost US$30,000. The legislation is expected to be in place in 2018 given that there is already a review of policies for promoting a low-carbon agenda in the transport sector, and reviewed six years later at a cost of US$10,000.

Source: TNA project

Benefits accruing from measures

The incremental benefits that have been estimated are: (1) GHG emission reductions; and (2) avoided importation of gasolene.[26] The methodologies and parameters used to calculate and monetise the benefits are provided in section 4.3 of the TNA Report – Mitigation (Government of Seychelles, 2017), and **Table 18**.

Table 18. Parameters used for calculating the benefits accruing from e-scooters.

Benefits accruing from measures	Remarks
GHG emission reductions	The quantity of gasolene that is avoided through the diffusion of e-scooters has been calculated. It is assumed that there is an incremental addition of 100 scooters between 2018 and 2026, and 150 new scooters annually between 2027 and 2030. Each e-scooter is expected to displace 3,000 km per year, which would otherwise have been travelled using gasoline-powered cars. In the baseline scenario, e-scooters are charged using grid electricity. In this case, the total avoided GHG emission from gasoline displacement is net of grid emissions. A sensitivity analysis has been carried out whereby 30% of electricity for charging electric cars is produced using renewable energy sources by 2030. The prices of emission reductions were: 2 US$/t$CO_2$ before 2020 and 26 US$/t$CO_2$ after 2020.[27]
Avoided energy bill	This is calculated as the value of gasoline displaced in land transport net of the cost of fuel oil used to generate electricity to charge e-scooters. Parameters used for calculations are given in **Table 12**.

Source: TNA project

Benefit-Cost Ratio (BCR)

[26] As discussed in the TNA Report – Mitigation, it is assumed that e-scooters will displace conventional cars running on gasoline.

[27] www.synapse-energy.com/sites/.../2015%20Carbon%20Dioxide%20Price%20Report.pdf – accessed 18 April 2017.

Using the above assumptions, the BCR = 1.34 showing that the incremental benefits of the proposed measures to support the promotion of e-scooters outweigh their incremental cost of implementation. The proposed measures are therefore financially beneficial. Since the measures for human skills development and to enhance policy and regulatory framework are similar as those used to promote electric cars, the costs corresponding to these measures can be excluded in the analysis for e-scooters. In this case, the BCR increases to 1.60.

Several parameters, especially the price of gasoline and fuel oil, and the subsidy on the interest rate for purchasing e-scooters, influence the BCR as summarised in **Table 19**. The sensitivity analyses are carried out by including the cost of measures for enhancing technical skills, and for enhancing the policy and regulatory framework.

Table 19. Sensitivity analyses of BCR for e-scooters.

BCR	Parameter changes
1.00	The subsidy on concessional loan has a significant impact on the BCR. All else being equal, the BCR drops to 1 when the subsidy on interest rate is increased to 2.8%.
1.49	The percentage of debt contracted in loan also has a big influence on the BCR. Since commercial loans will only cover 80% of the cost of the product, the change reflects a decrease in debt component of cost from 80% to 70%.
1.35	Increasing the percentage of renewable electricity used to charge e-scooters from 0% in 2020 to 30% in 2030 at an increment of 3% per year.
1.27	Post-2020 price of carbon is decreased to 13 US$/t$CO_2$.
1.46	When the price of gasoline and fuel oil increase by 10%.
1.34	Increasing the price of gasoline and fuel oil by 10%, and increasing the subsidy on interest paid for incremental loan to 2.2%. This shows that the subsidy on the incremental cost of vehicles can be pegged to the price of gasoline and fuel oil.

Source: TNA project

2.5 Linkages of barriers identified in the land transport sub-sector

The two perspectives used in section 1.4 to identify linkages of barriers have been adopted.

Linkages across technologies

The two mitigation technologies discussed in sections 2.2 and 2.3 have very different characteristics. Low-carbon cars are consumer goods, whereas the VTMP is a publicly provided good. Consequently, there are no overlapping barriers between them.

Technology specific inter-barrier linkages

In the case of the VTMP, there is a strong relationship between human capacity constraints and institutional barriers. The linkage is the same as discussed in section 1.4. No inter-barrier linkages have been noted for low-carbon cars.

2.6 Enabling framework for overcoming the barriers in the land transport sub-sector

The enabling framework for the transport sector should start with the drafting and approval of a land transport policy that would set priorities for managing land transport activities and improving energy efficiency in the transport sector. In parallel, the land transport legislation should be consolidated under one act, where the roles and responsibilities of all stakeholders would be designated, thereby eliminating the conflicts of interest amongst them.

As discussed in the previous sections, all the land transport mitigation technologies will face financial barriers. Hence, an adequate enabling framework should put in place the necessary financial instruments for their implementation. Concerning the consumer goods such as low-carbon cars and e-scooters, the setting up of the proposed financial instruments must be facilitated by government in collaboration with financial institutions.

The social acceptance of the consumer land mitigation technologies requires the availability of good after sales service and the availability of spare parts, including batteries for cars and e-scooters. While the distribution of the low-carbon motorized vehicles may use existing supply chains, it will be important to regulate the supply chain through the setting up of accredited and registered vehicle dealers that will ensure warrantee on vehicles sold, provide adequate after sales services, and ensure availability of spare parts and batteries.

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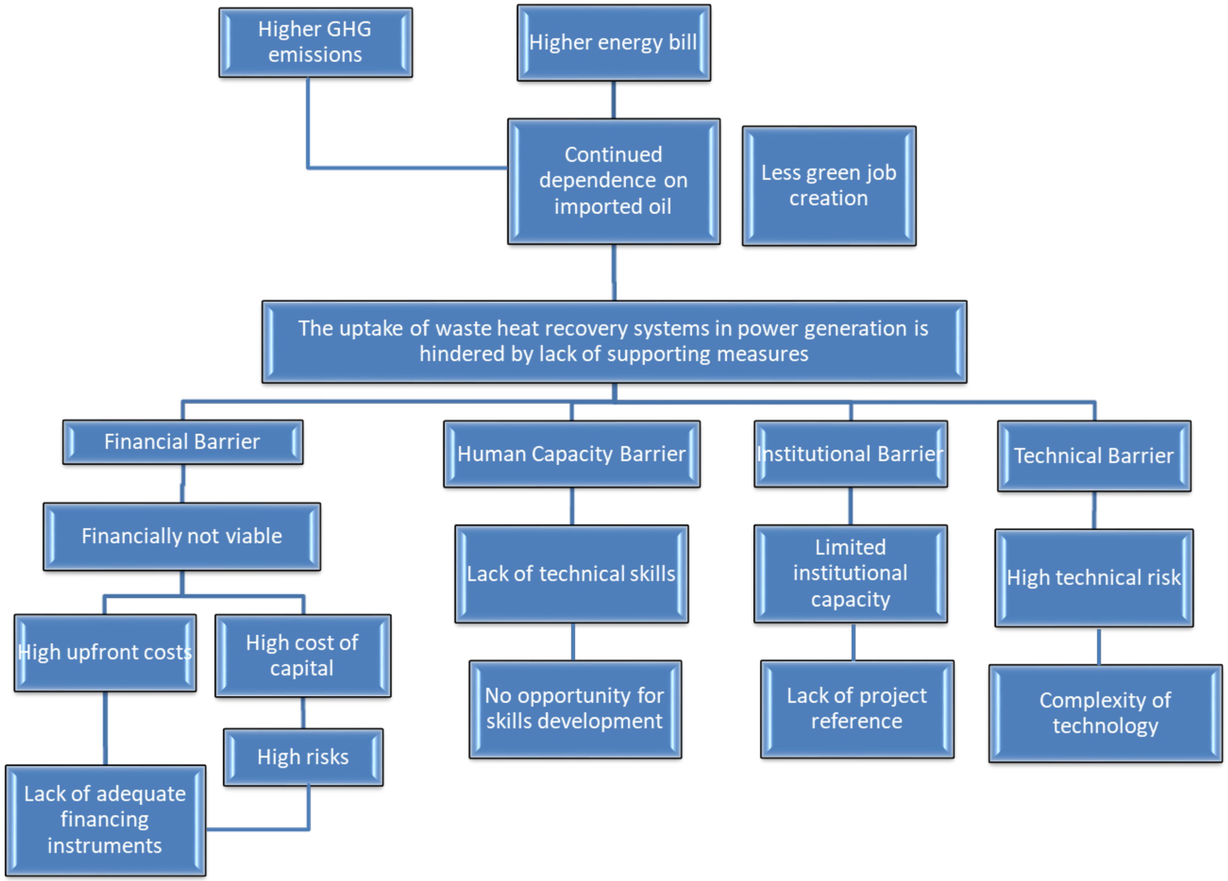
Annex I: Logical Problem Analysis and Market Mapping for Power Sector Mitigation Technologies

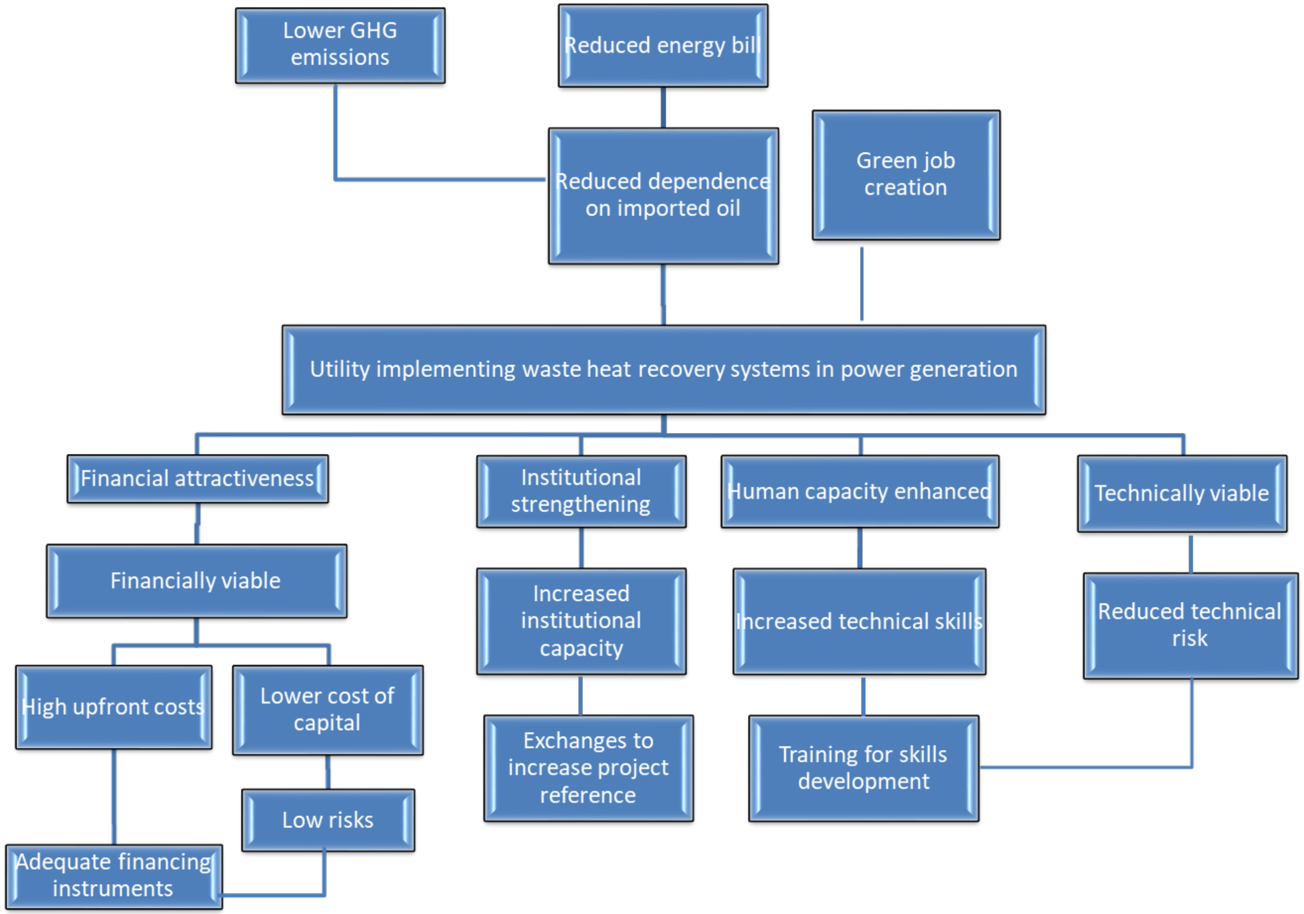
Waste Heat Recovery at Roche Caiman

Problem Tree (PT)

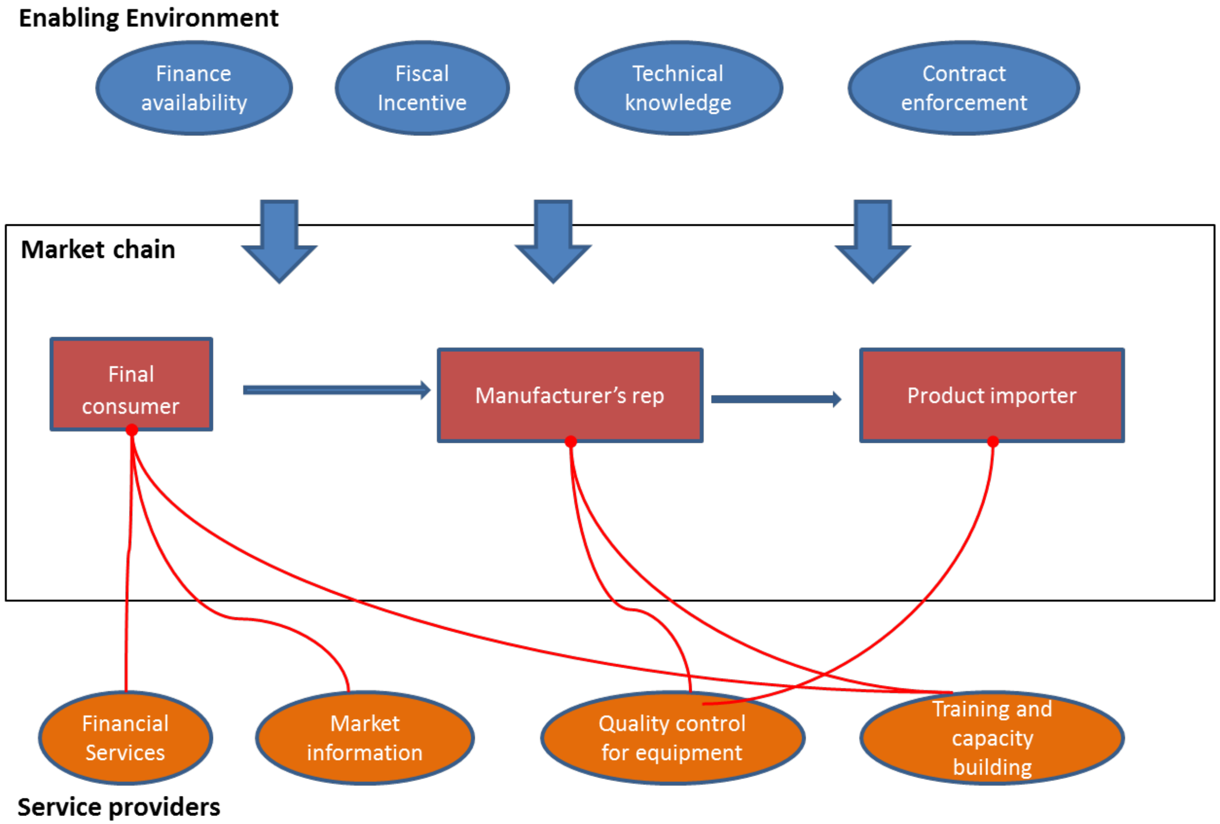


Waste Heat Recovery at Roche Caiman

Objective Tree (OT)

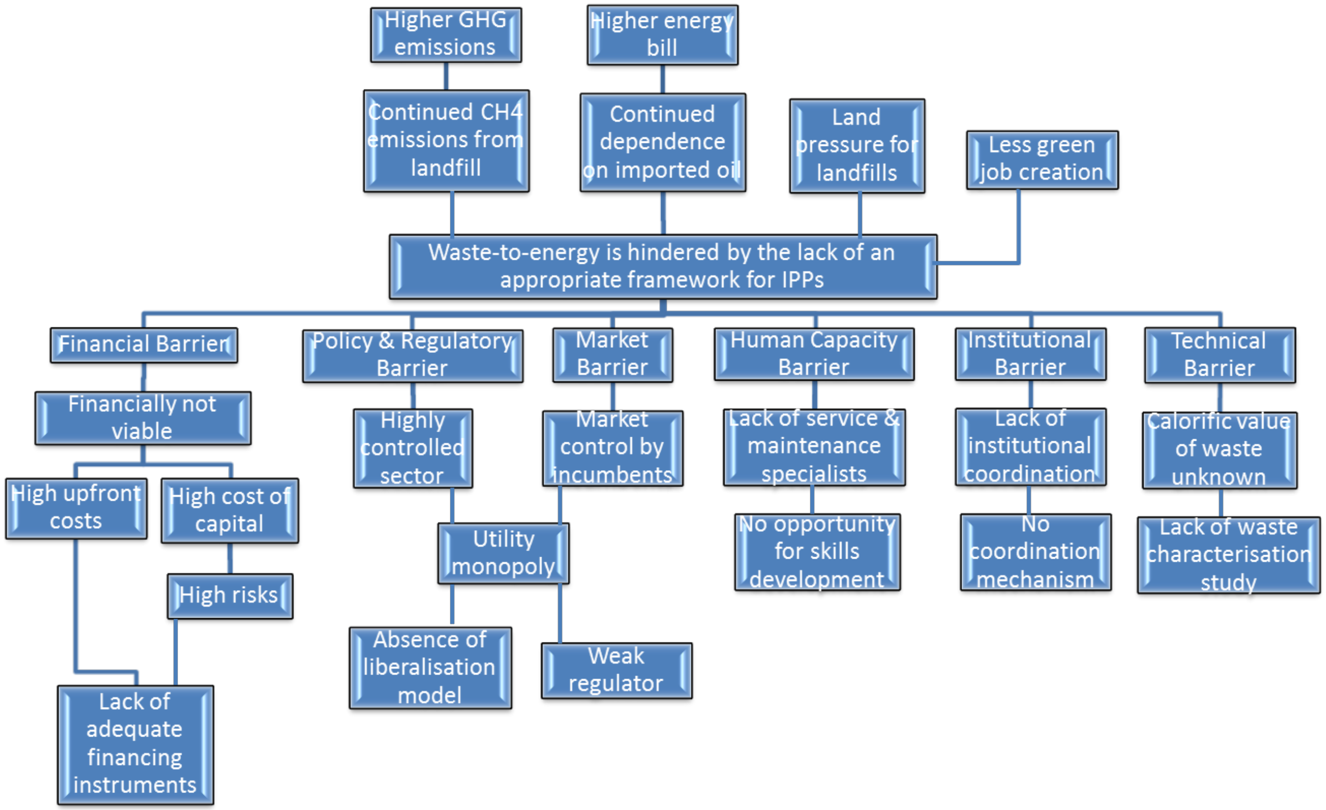


Waste Heat Recovery at Roche Caiman
Market Map



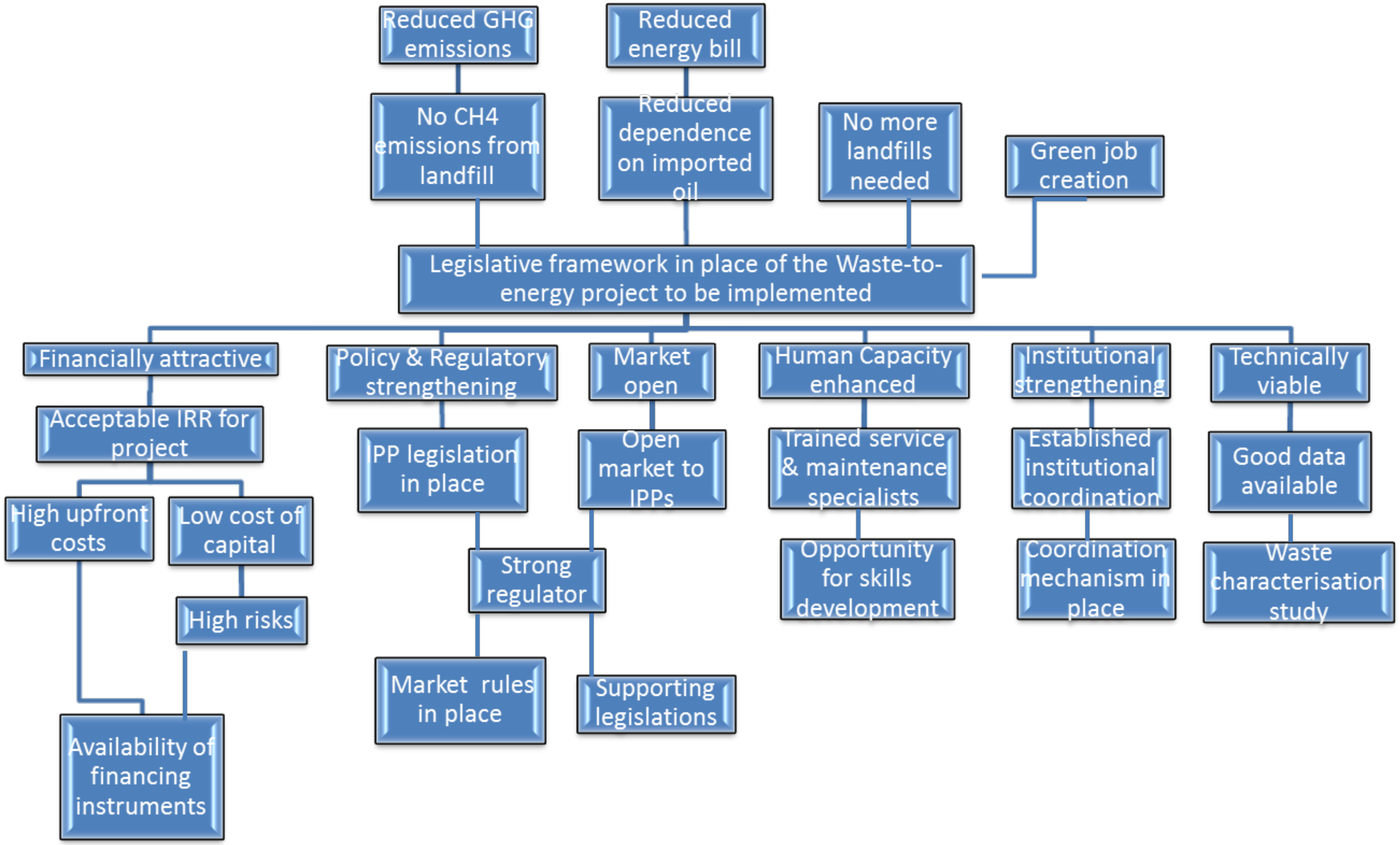
Waste-to-Energy (WTE)

Problem Tree (PT)

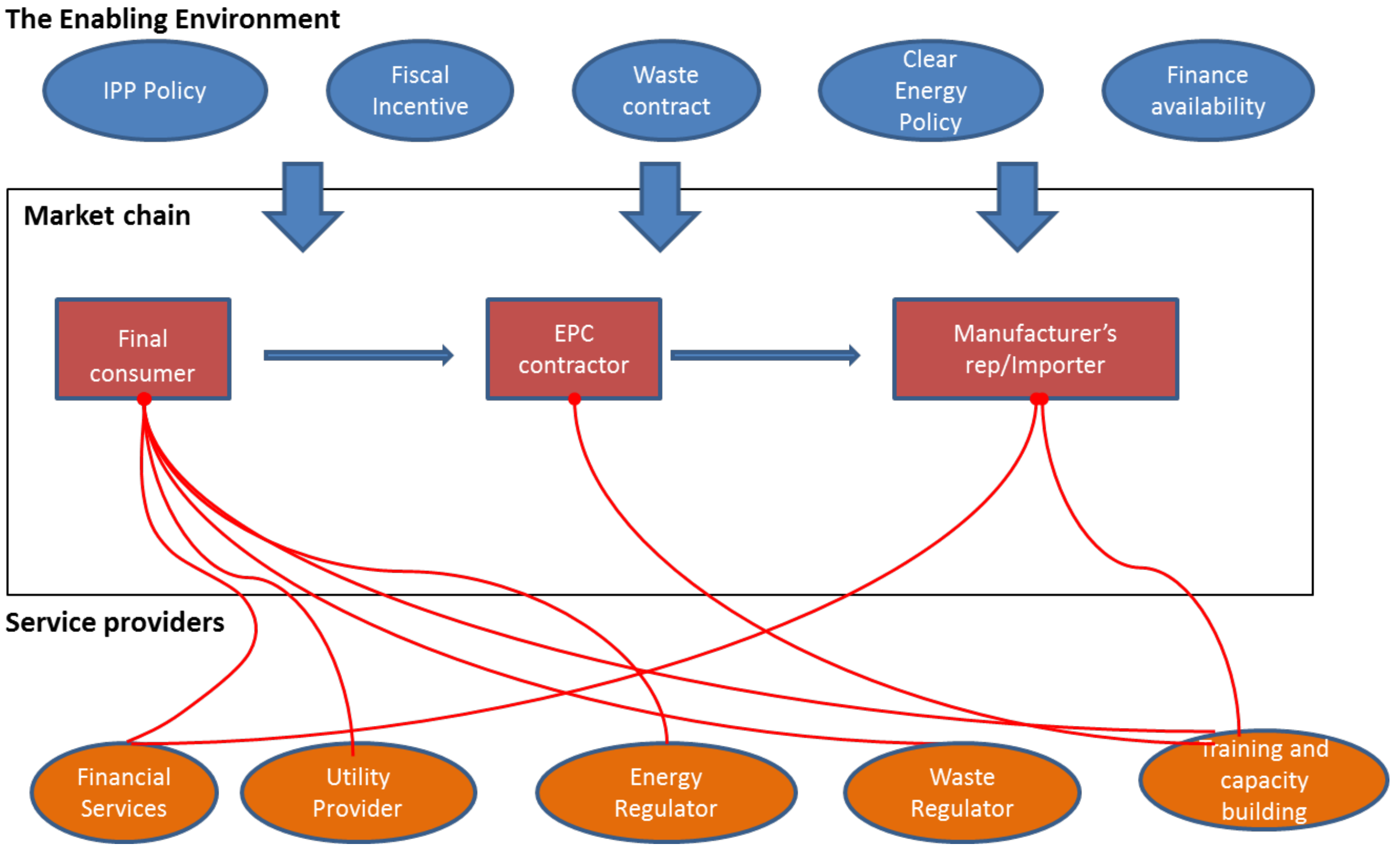


Waste-to-Energy (WTE)

Objective Tree (OT)

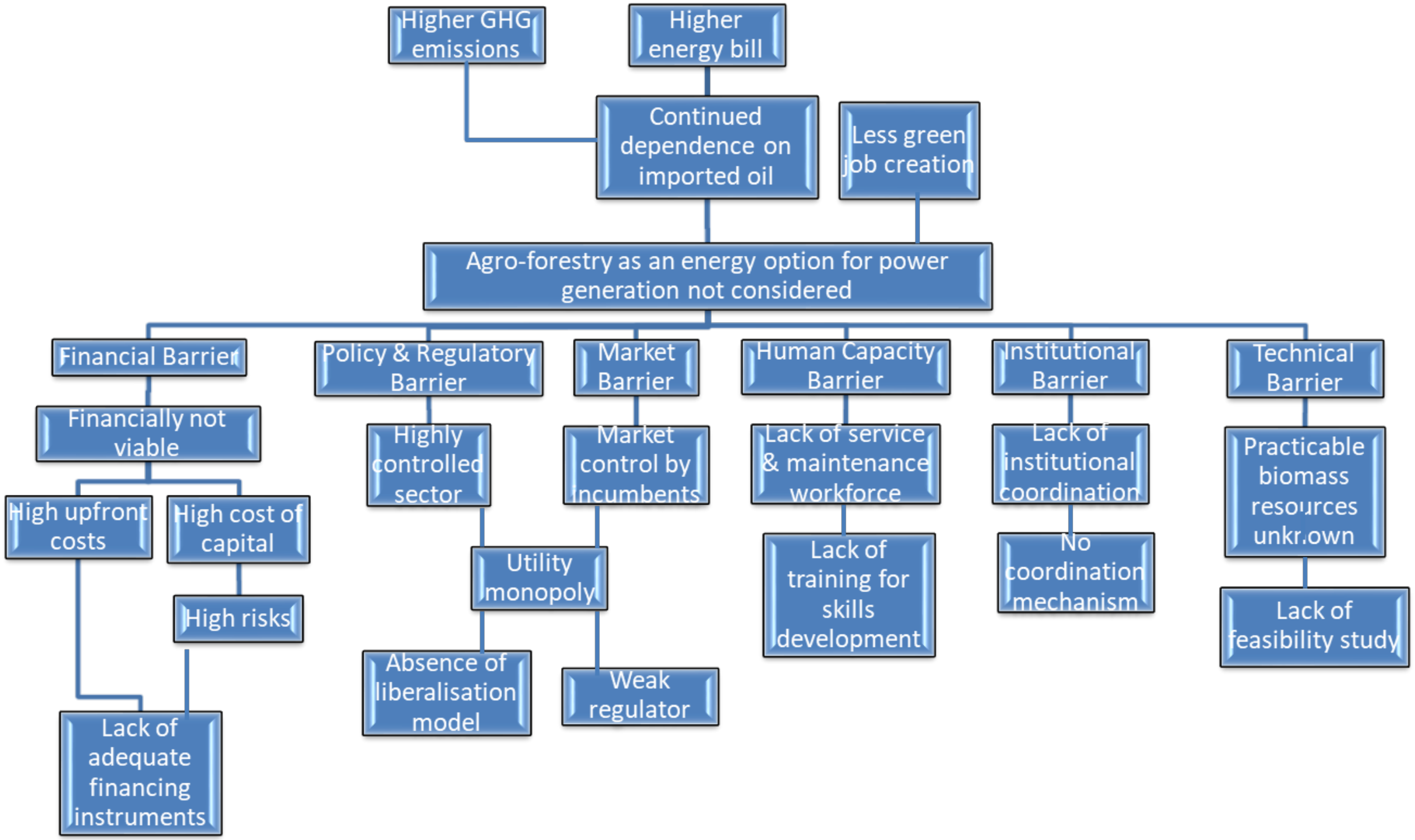


Waste-to-Energy (WTE)
Market Map



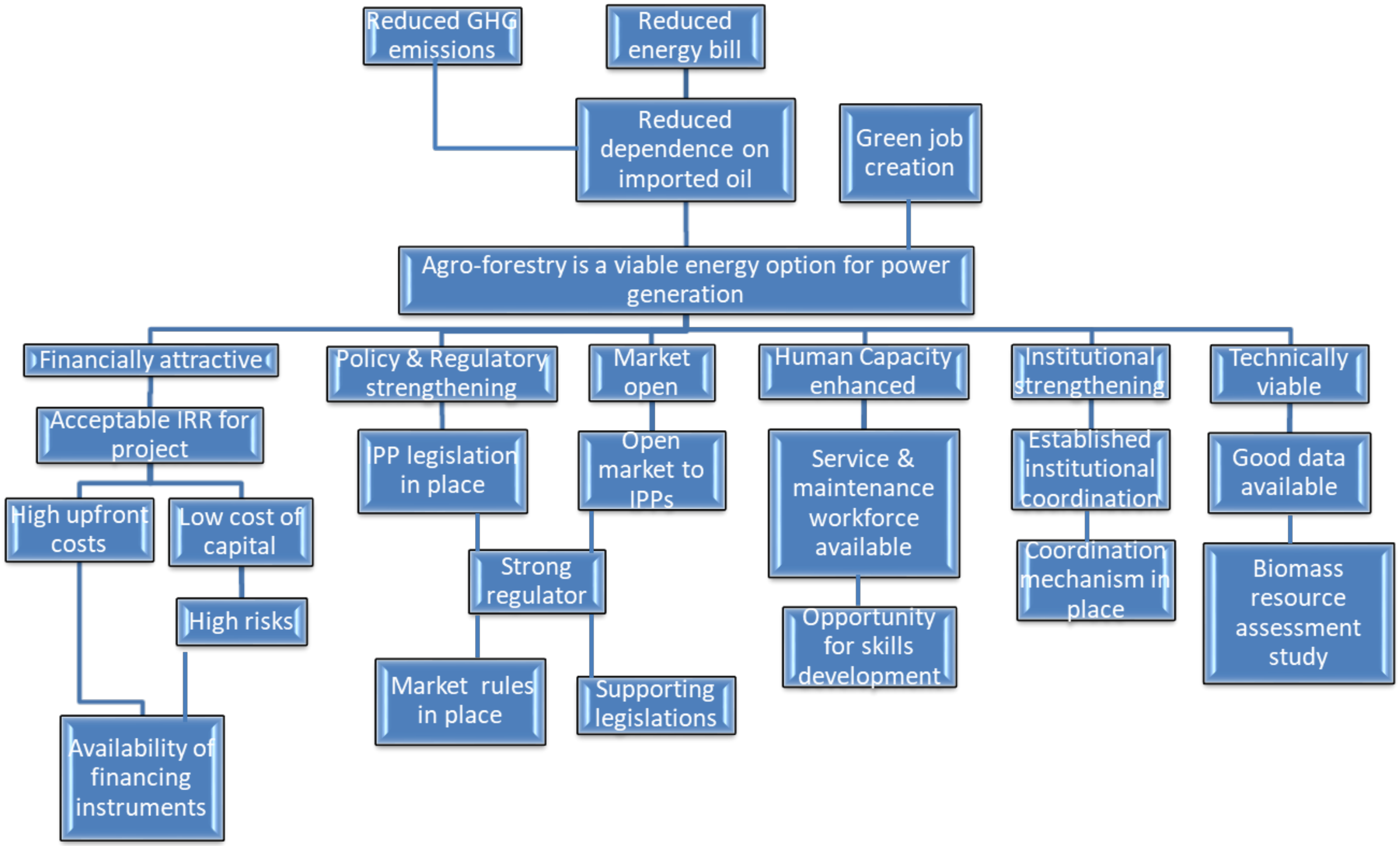
Agro-forestry for power generation

Problem Tree (PT)



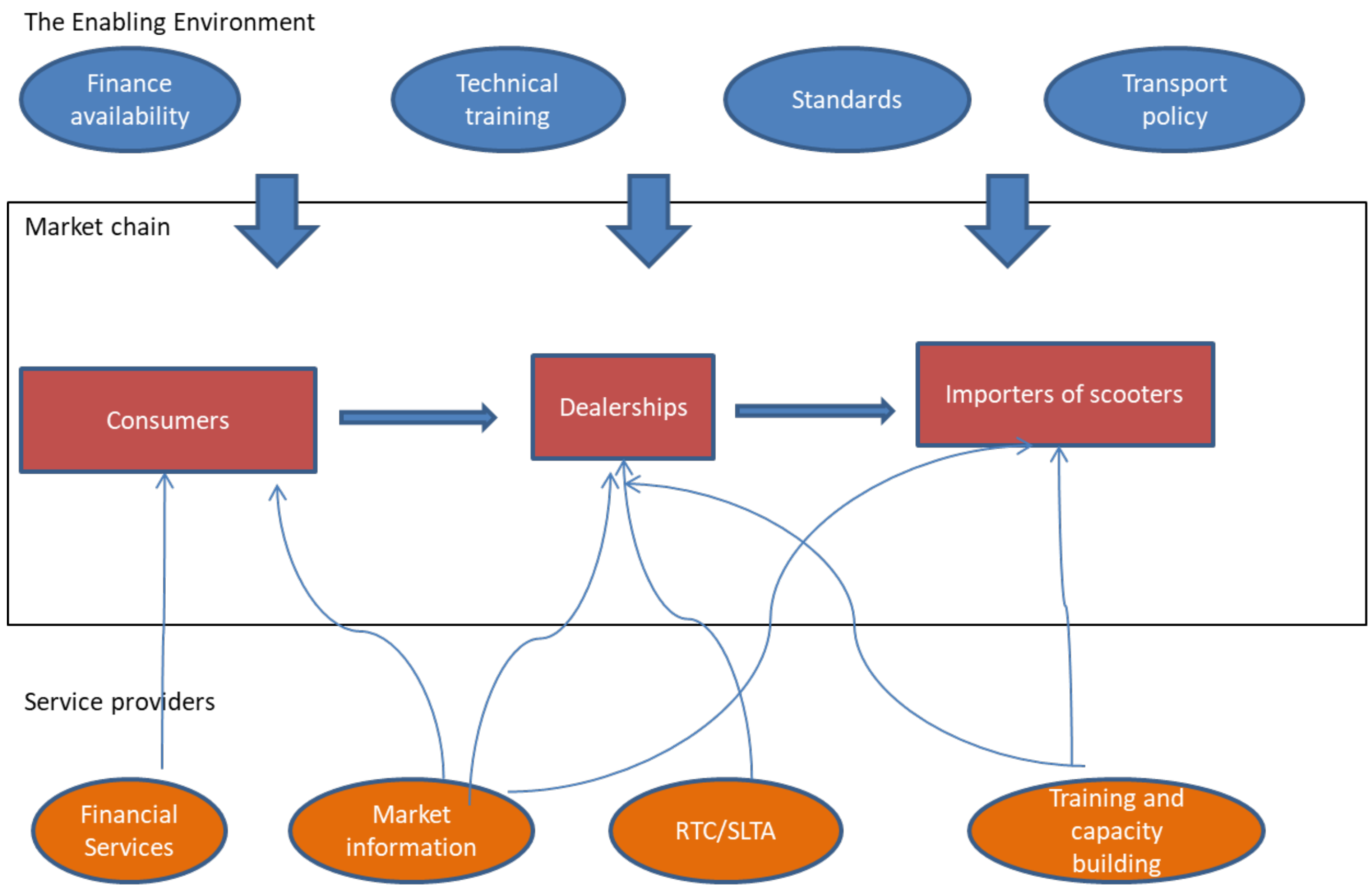
Agro-forestry for power generation

Objective Tree (OT)



Agro-forestry for power generation

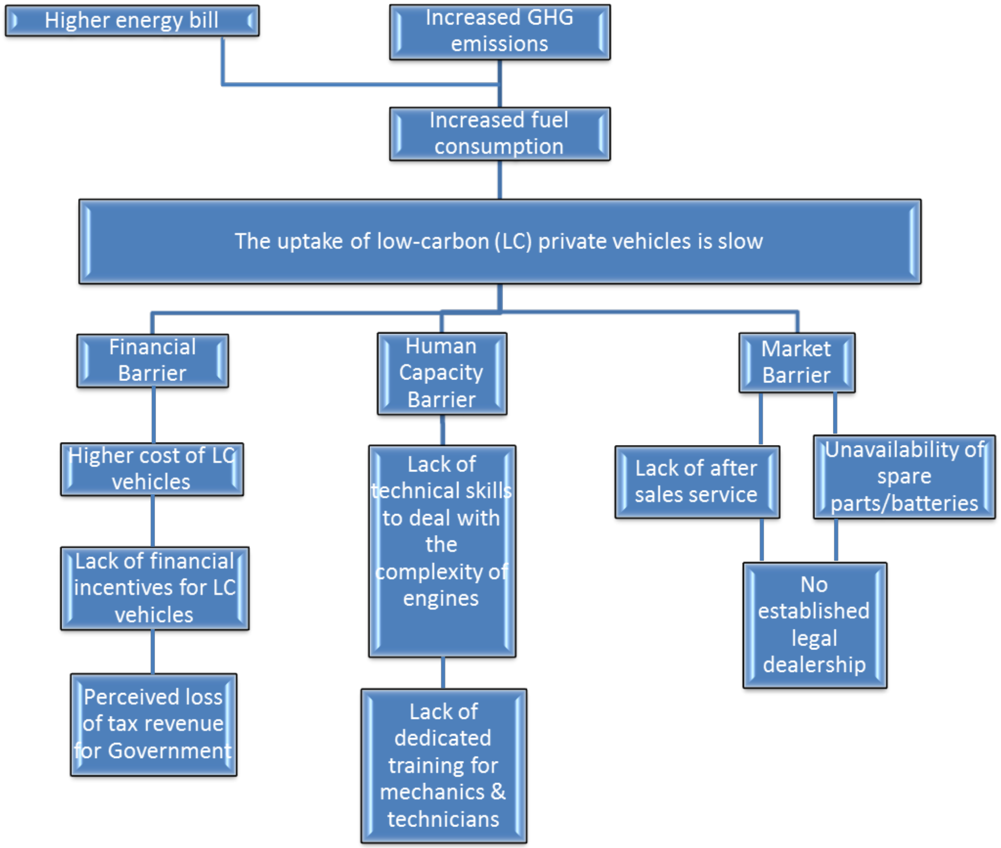
Market Map



Annex II: Logical Problem Analysis and Market Mapping for Land Transport Mitigation Technologies

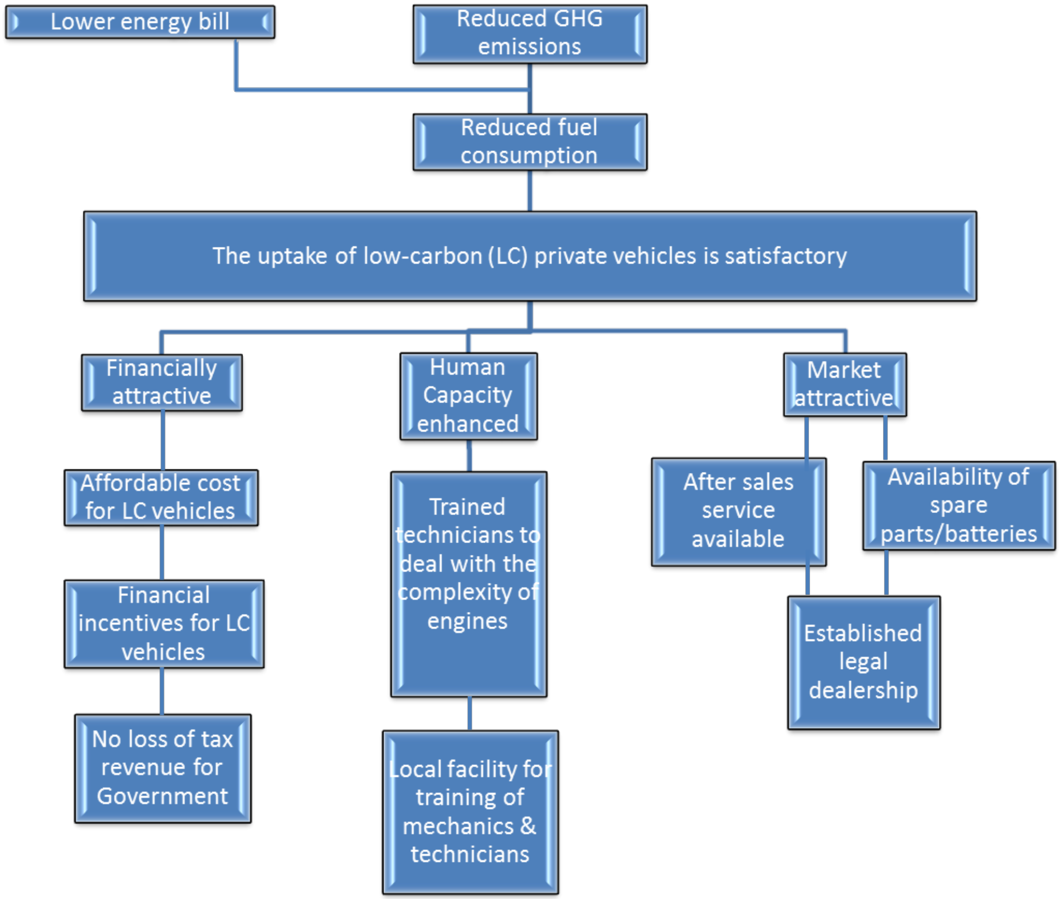
Low-carbon private car fleet

Problem Tree (PT)



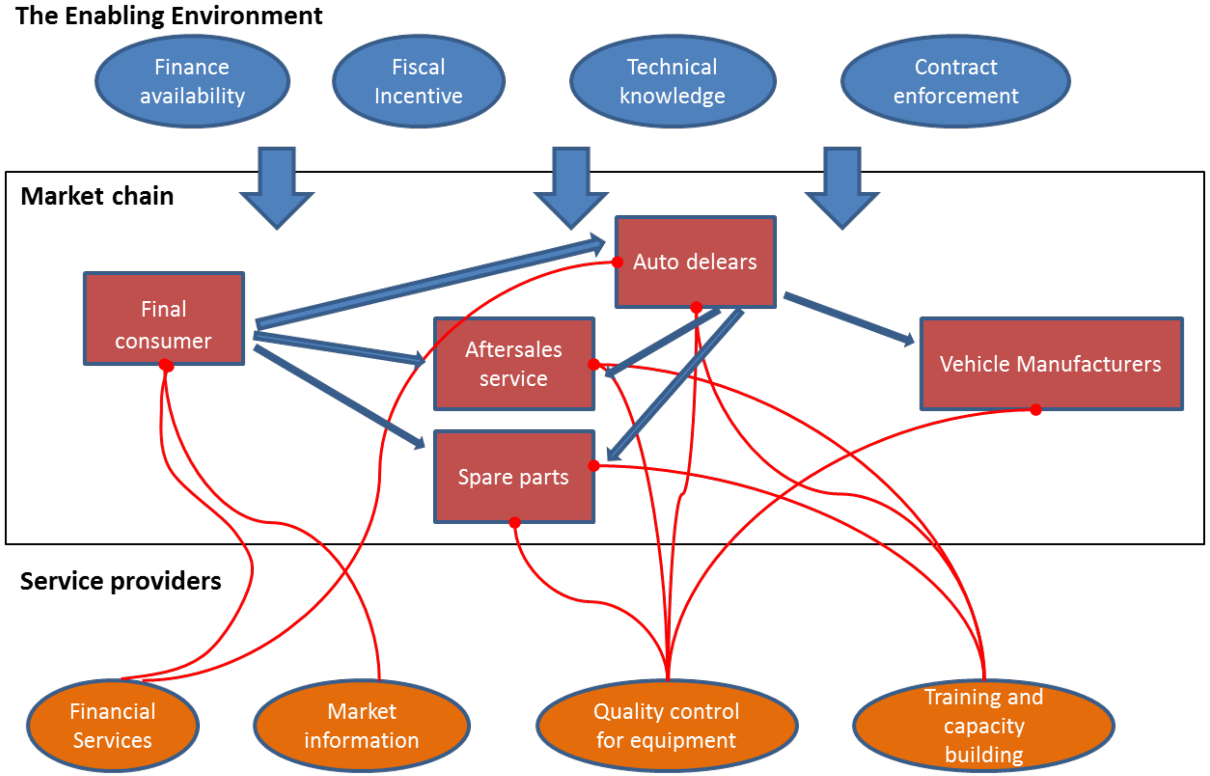
Low-carbon private car fleet

Objective Tree (OT)



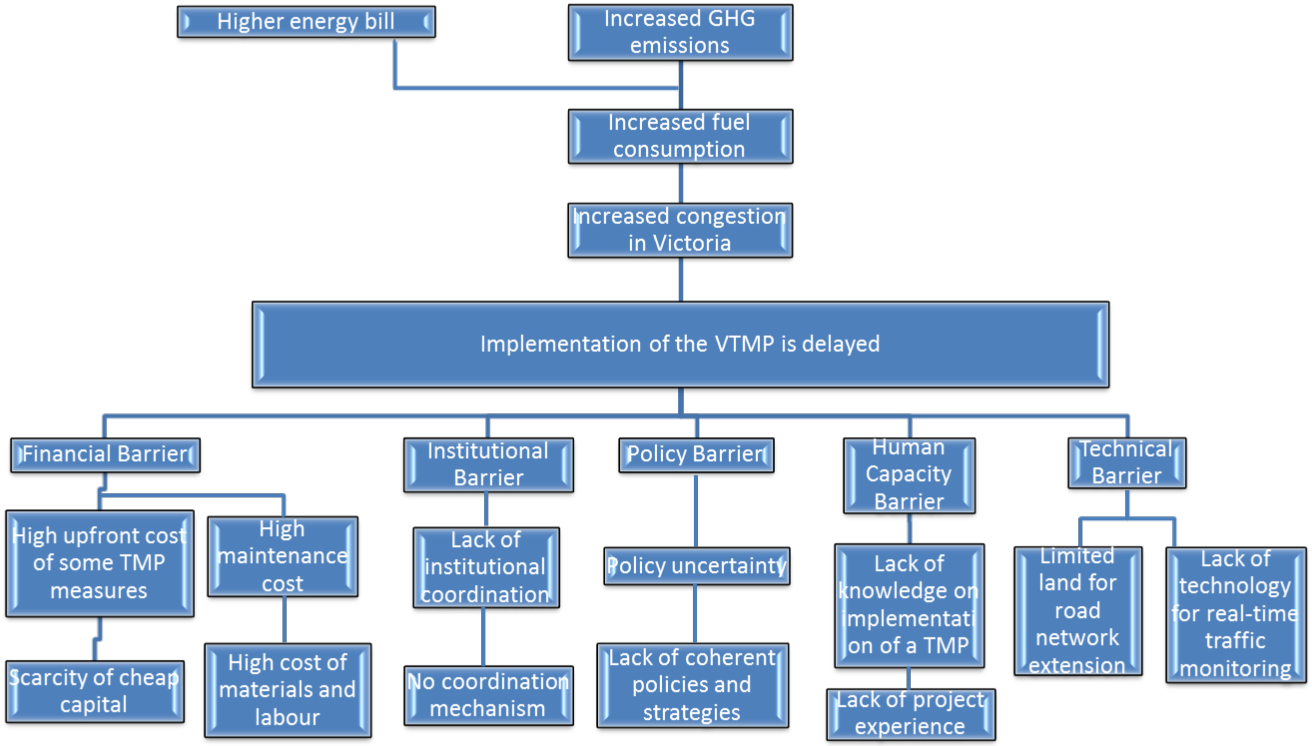
Low-carbon private car fleet

Market Map

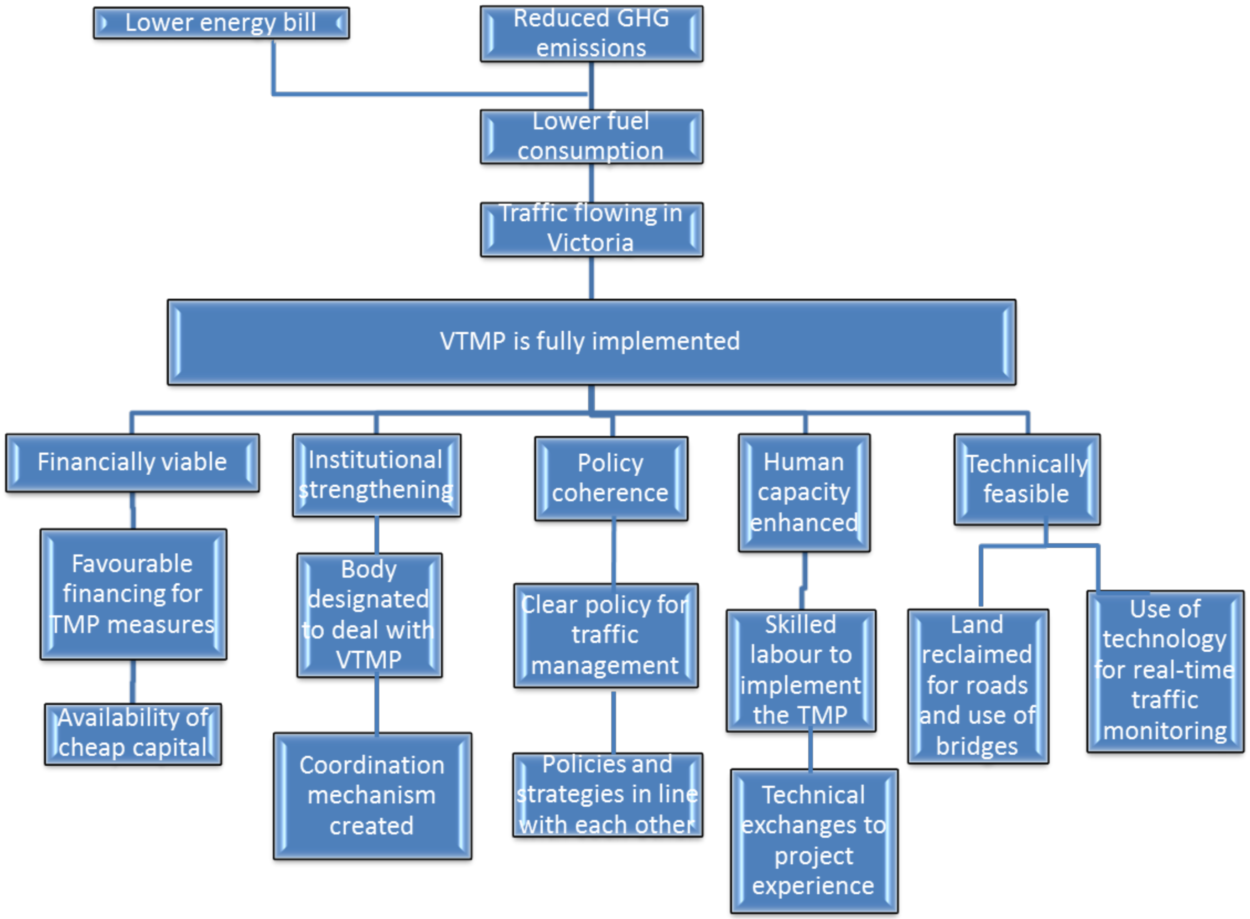


Victoria Traffic Management Plan (VTMP)

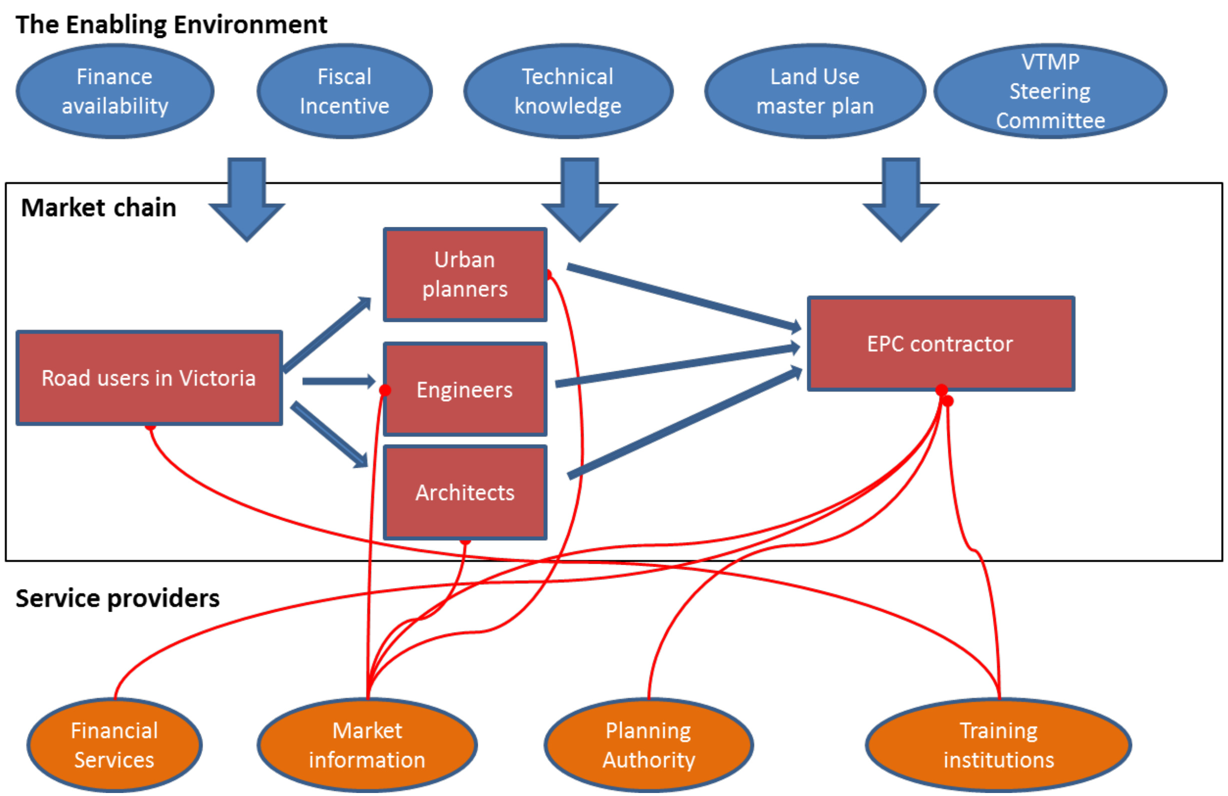
Problem Tree (PT)



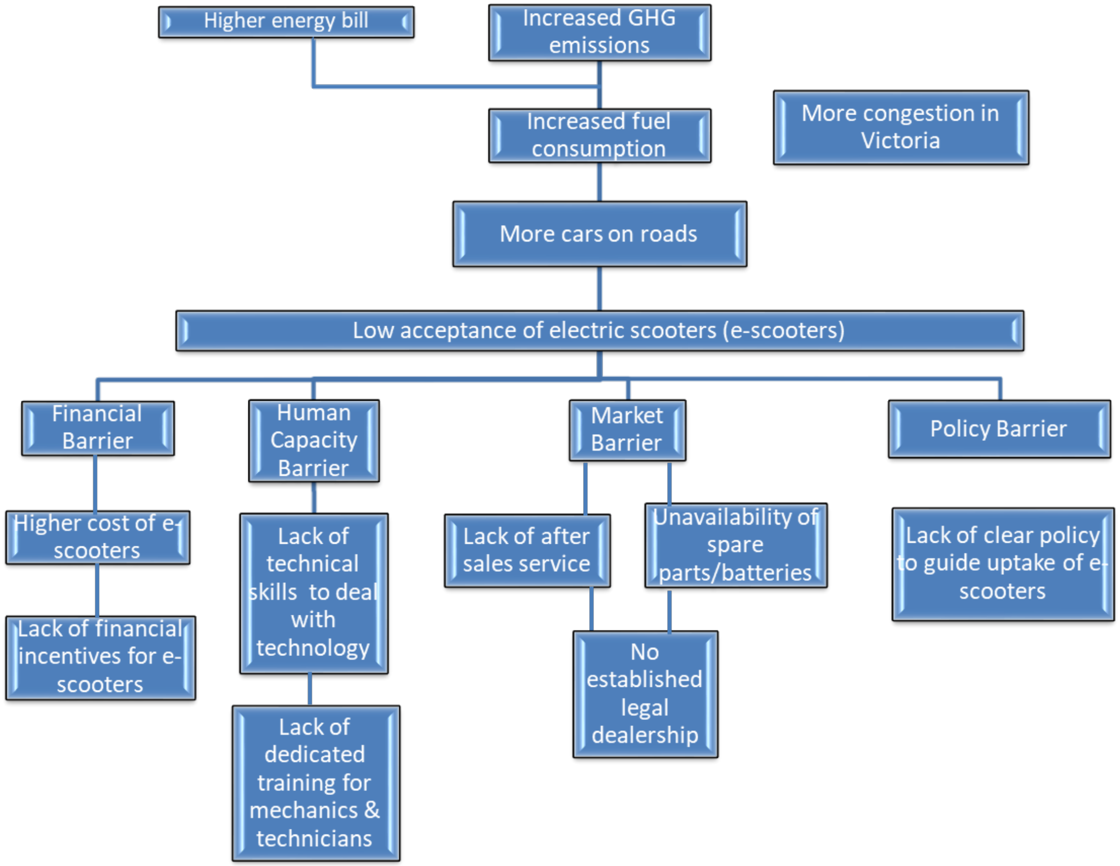
Victoria Traffic Management Plan (VTMP)
Objective Tree (OT)



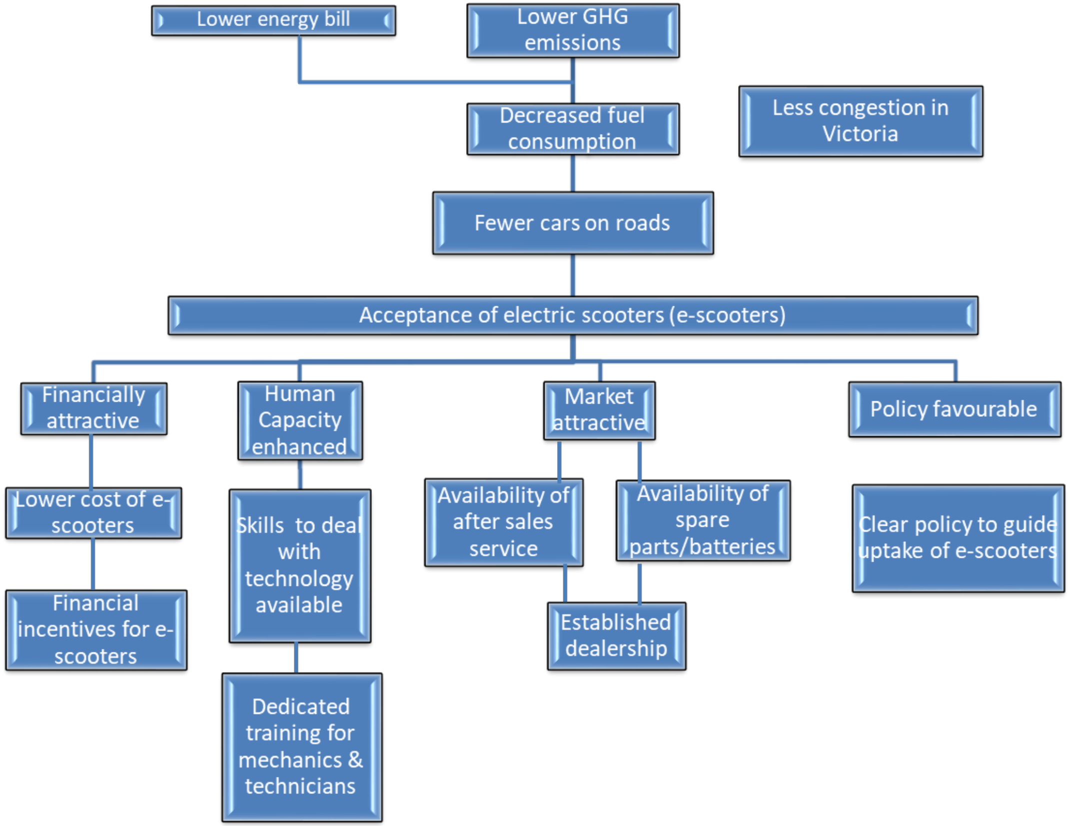
Victoria Traffic Management Plan (VTMP)
Market Map



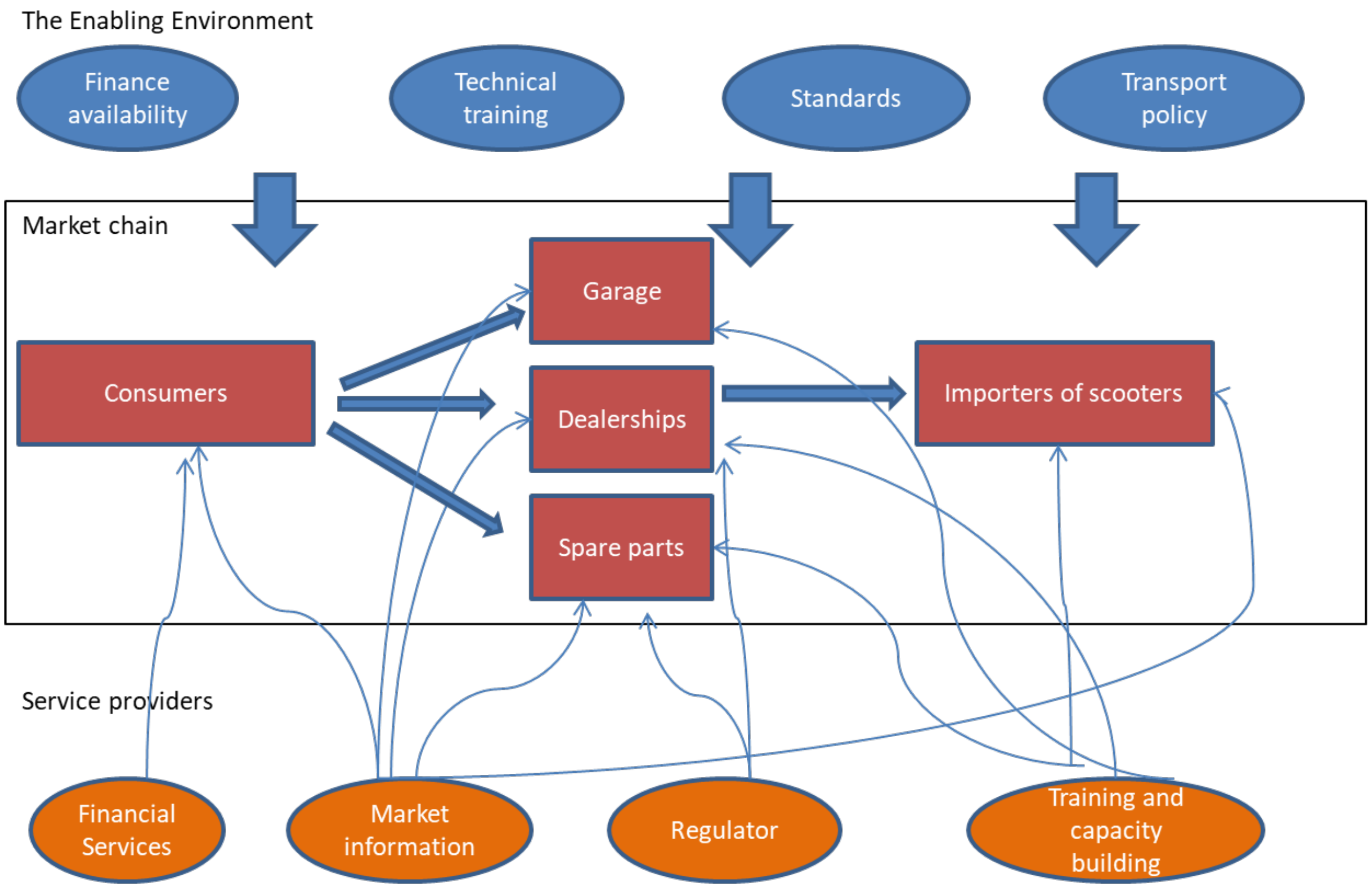
Electric scooters (e-scooters)
Problem Tree (PT)



Electric scooters (e-scooters)
Objective Tree (OT)



Electric scooters (e-scooters)
Market Map



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
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