Assessing the potential of grid-tied PV systems in accelerating Seychelles' energy transition

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Abstract

The dominance of fossil fuels in meeting the country's energy demand is a common feature of Small Island Developing States (SIDS). The Republic of Seychelles is no exception, with its electricity and transportation sectors almost completely dependent on imported oil. This has exposed its economy to global fuel supply chain risks and raised concerns over its energy security. Research has shown that investment in renewable technologies in SIDS can help considerably mitigate this risk. Additionally, Seychelles has set ambitious targets to reduce its economy-wide emissions by 2030. Transitioning its electricity mix away from fossil-fuel dependency toward larger penetration of renewable energy is key to achieving these targets. Solar photovoltaic (PV) technology has proved to be the most viable clean energy option in Seychelles and will be crucial in achieving the twin goals of improved energy security and reduced country-wide emissions.

In this context, this thesis aims to provide a comprehensive assessment of the potential of rooftop solar PV technology in contributing to the energy transition on Mahé, the country's largest and most populous island. This was conducted in three interconnected parts. Firstly, an analysis of historical development and the current state of rooftop solar PV installations on Mahé was conducted. This resulted in a thorough understanding of the status quo and the factors that led to it. Secondly, the risks and opportunities perceived by three stakeholder groups, governmental, commercial property owners, and homeowners, concerning the prospect of increasing the deployment of such installations were elicited and organised into risk perception matrices. They revealed the stakeholder group-specific barriers that must be appropriately addressed and opportunities to be built upon to increase and sustain deployment rates within them. Finally, an economic-based analysis was performed for the domestic sector on Mahé to determine how the attractiveness of a potential investment varies with the consumption level of a household, applicable electricity tariff rates to them, and the availability of financial incentives. This analysis was extended into a simplistic agent-based model (ABM) of the domestic sector on Mahé and was used to simulate the deployment rates within the sector for different policy scenarios.

Consequently, it was found that rooftop solar PV technology holds immense potential in accelerating Seychelles' energy transition. However, three identified challenge areas, institutional, economic, and non-economic, need to be adequately addressed to realize this potential.

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Abbreviations

ABM	Agent-Based Model
AP	Auto-Producer
BAU	Business as Usual
CEO	Chief Executive Officer
CNP	A commercial property owner who hasn't installed PV yet
CP	A commercial property owner who has installed PV
EV	Electric Vehicle
FI	Financial Incentive
FiT	Feed-in Tariff
FLH	Full Load Hours
FY	Financial Year
GDP	Gross Domestic Production
GEF	Global Environment Facility
GHG	Green House Gas
GIS	Geographic Information System
GoS	Government of Seychelles
HFO	Heavy Fuel Oil
HNP	A homeowner who hasn't installed PV yet
HP	A homeowner who has installed PV
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
LFO	Light Fuel Oil
MACCE	Ministry of Agriculture, Climate Change and Environment
NBS	National Bureau of Statistics
NEP	National Energy Policy
PPA	Power Purchase Agreement
PUC	Public Utilities Corporation
PV	Photo-Voltaic
RE	Renewable Energy
RQ	Research Question
SEC	Seychelles Energy Commission
SEEREP	Seychelles Energy Efficiency and Renewable Energy Programme
SIDS	Small Island Developing States
SME	Small and Medium Enterprises
TOE	Tonne of Oil Equivalents
VAT	Value Added Tax
WtE	Waste to Energy

1 Introduction

Energy consumption accounted for nearly 76% (about 37.2 $GtCO_2e$) of global anthropogenic greenhouse gas (GHG) emissions in 2018 (Ge et al., 2020). This represents the overall consumption in the energy sector, which comprises transportation, electricity and heat, manufacturing and construction, buildings, and fugitive emissions. Within this energy sector, ‘electricity and heat generation’ at about 15.6 $GtCO_2e$ and ‘transportation’ at 6.2 $GtCO_2e$ accounts for almost 60% of the overall emissions. This ratio was also maintained in 2019 (IEA, 2021), the last year for which data is available at this resolution.

Naturally, rapid and near full decarbonization of the power sector has been highlighted by intergovernmental organizations like the International Renewable Energy Agency (IRENA) (IRENA, 2021) and the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2022), as a crucial milestone in our collective path to achieve the goals set out in the Paris Agreement (UNFCCC, 2015). This entails an “energy transition”, which is a pathway toward the transformation of the global energy sector from fossil-fuel-based to zero-carbon by the second half of this century (IRENA, 2021). Energy transitions are complex undertakings, with pathways specific to the sector and country of concern and encompass both techno-economic as well as social aspects. Despite this, decision-makers accord lesser importance to the latter while privileging the former, which has vast implications for the energy system (Mejía-Montero et al., 2020).

Accelerating and managing the energy transition also proposes a challenge for Seychelles, a Small Island Developing State (SIDS) (UN-OHRLLS, 2013) in the Indian Ocean off the Eastern coast of Africa. Accomplishing this requires a deep understanding of the energy sector in Seychelles, and an assessment of the potential transition pathways specific to its sub-sectors. In that light, this thesis is intended to assess the potential of photovoltaic (PV) solar rooftop technology in accelerating the transition within the electricity sub-sector on Seychelles' largest island, Mahé. This introductory chapter provides the necessary background information (Section 1.1), namely about Seychelles as a country, why the energy transition is important, and about the potential of rooftop solar PV technology in contributing to this, before detailing the objective and research questions of this thesis (Section 1.2).

1.1 Background

1.1.1 General Information about Seychelles

The Republic of Seychelles comprises over 116 islands divided into two distinct collections: the Mahé group, 43 in total including the outlying islands, granitic with high hills and mountains; and the coralline group of over 73 (NBS, 2021b). The total land area of 460 km^2 (World Bank, 2021c) is distributed over 1 million square kilometres of the ocean (NBS, 2021b), with Mahé being the largest and most populated island. It is about 27 km long and 11 km wide, rising abruptly from the sea to a maximum altitude of 905 meters (NBS, 2021b). Two other important large and inhabited islands are Praslin and La Digue, about 33.6 and 48 kilometres to the East of Mahé. As of December 2021, the country had a total population of 99,728 (NBS, 2022b) which is projected to increase at a yearly growth rate of about 1% (NBS, 2021e). About 85% of this population resides on Mahé, 9.3% on Praslin, and only 4.1% on La Digue and the Outer islands (NBS, 2021b). In 2020, Seychelles had one of the highest nominal Gross Domestic Production (GDP) per capita of 14,080 USD[1] (World Bank, 2021b) in Africa, and a total GDP of 1.39 billion USD[2] (World Bank, 2021a), making it a high-income country. The economy is primarily driven by the tourism industry and fishing industry.

Seychelles is categorized as an SIDS owing to its specific social, economic, and environmental vulnerabilities (UN-OHRLLS, 2013). The country is situated outside the cyclone belt and enjoys an average sunshine of 7.2 hours per day and a shade temperature between 25 and 31˚C around the year (Seychelles Energy Commission, 2020).

1.1.2 Importance of transitioning Seychelles' electricity sector towards carbon neutrality

"*Energy mix*" refers to the combination of various primary sources of energy, including fossil fuels, nuclear and renewable energy (RE), used to meet the energy needs of a specific geographic region, like a country (Planete Energies, 2021). These primary energy sources are used to produce secondary energy sources for direct use, such as electricity, and fuels for transportation. The composition of the energy mix depends heavily on the country and on the time of concern. On the other hand, "*power generation mix*", or simply "*electricity mix*" refers to the combination of various primary sources of energy used to generate electricity in a given geographic region (Planete Energies, 2020). Any transition in the electricity sector implies the

[1] According to constant 2015 USD
[2] According to constant 2015 USD

transformation of a country's electricity mix away from fossil fuels, like coal, crude oil, and natural gas, toward cleaner renewable sources of energy like wind and solar power.

Despite Seychelles being amply endowed with renewable resources (MACCE, 2022a), 97.8% (437.8 GWh) of the electricity mix in 2019 was generated from fossil fuels by diesel generators running either on imported heavy fuel oil (HFO) or light fuel oil (LFO), with only the remaining 2.2% (9.69 GWh – 0.9% Solar PV and 1.3% Wind) from renewable energy (Seychelles Energy Commission, 2020). Following the same trend in 2020, Seychelles' electricity mix was distributed between HFO at 86.9%, LFO at 10.4%, wind energy at 1.4%, and Solar at 1.3%. This amounted to a renewable energy penetration of 2.7% (PUC, 2021).

Electricity for public use is generated and transmitted by a sole parastatal entity, the Public Utilities Corporation (PUC) (PUC, 2022a). The electricity consumption in the country grew at an annual growth rate of 4.9% between 2010 and 2019 (Seychelles Energy Commission, 2020). This is much higher than the average 1% rate at which the population has been growing each year (NBS, 2022c). Apart from this, there are around 18 "*auto-producers*" within the country, generating electricity for their individual use[3] (Energy Act, 2012; Seychelles Energy Commission, 2020), without supplying or being connected to the public grid. Together, they are estimated to have produced about 82 GWh of electricity (mostly using diesel generators) in 2019, which was approximately equivalent to a fifth of the total electricity generated by PUC (Seychelles Energy Commission, 2020).

Hence, it is apparent that Seychelles' *electricity mix* is almost completely dependent on fossil fuels, with negligible penetration of renewable sources, namely solar PV and wind. This pattern was identical for the country's *energy mix* in 2019: 99.58% dominated by fossil fuels (imported fuel oil, gas oil, gasoline, LPG, Jet A1) and only 0.42% by renewable sources (solar PV and wind only) (Seychelles Energy Commission, 2020). Hence, it is not surprising that about 95% of Seychelles' GHG emissions come from the energy sector, with the remaining 5% emitted by wetlands and landfills (Government of Seychelles, 2020). In its Updated Nationally Determined Contribution, the Government of Seychelles (GoS) has displayed cognizance of the issue and has made bold commitments to reduce these emissions (Government of Seychelles, 2021).

The dominance of fossil fuels in the country's energy and electricity mixes is a common feature of SIDS, and hence "*energy security*" becomes very important and has to be dealt with seriously (Raghoo et al., 2018). The International Energy Agency (IEA) (IEA, 2020) defines *energy security* as the "uninterrupted

[3] Mostly large hotels

availability of energy sources at an affordable price (IEA, 2019). In literature, it is widely agreed that "energy" here refers to both primary (for example oil, coal, and renewable energy) and secondary sources (for example electricity and transportation fuels) (Raghoo et al., 2018). All of the fossil fuels used in Seychelles are imported, exposing the country to global fuel price instabilities and risks to the security of supply. With the energy mix almost completely dominated by imported fossil fuels, this also exposes the country's economy to global fuel supply chain risks. Dornan and Jotzo (2015), have shown that investment in renewable technologies is likely to involve considerable risk mitigation benefits for SIDS. Therefore, expanding the renewable energy infrastructure in Seychelles can prove to be a multi-faceted solution that simultaneously contributes to the twin goals of generating clean sustainable energy and improving its energy security. However, this invokes several challenges to overcome, for example, financing the high investment costs and developing the human capacity to manage high technology equipment.

1.1.3 Renewable energy in Seychelles, the potential of PV technology in Seychelles

Despite their size and negligible contribution to global GHG emissions, SIDS show persistent endeavours in putting ambitious renewable energy commitments at the heart of their climate action (UNDP, 2021). In this sense, the Republic of Seychelles exhibits the same endeavour in its recently updated Nationally Determined Contribution (Government of Seychelles, 2021), wherein it sets the target of reducing economy-wide absolute GHG emissions by 26.4% compared to the business-as-usual scenario (BAU) by 2030 (i.e, from 1,114.4 $ktCO_{2e}$ to 820.7 $ktCO_{2e}$). Furthermore, the targeted emissions reductions in the energy sector amount to 124 $ktCO_{2e}$ (BAU in 2030 would be 454 $ktCO_{2e}$), which is sought to be achieved by augmenting the installed renewable energy generation capacity to 15% of the national electricity mix by 2030 from the current 2.16% (as of 2019; Government of Seychelles, 2021).

In pursuance of this target, the government has employed several consultancies who have produced technical reports on different aspects of the renewable energy system in Seychelles (EDP International, 2019; Energynautics, 2014; Okinawa Enetech, 2016). Given the growing annual electricity demand (Seychelles Energy Commission, 2020) and the difficulties with the prospect of large-scale integration of intermittent renewables in an oil-dominated generation system (Okinawa Enetech, 2016), achieving the 15% target by 2030 can be challenging. Focusing on the island of Mahé, the *Electricity Master Plan for Seychelles* (EDP International, 2019) analyses three different paths to realize this and recommends a scenario in which renewable energy is proposed to be generated from the following technologies in 2030: Biodiesel plant – 8 MW, Waste to Energy (WtE) plant – 5 MW, Roof-top photovoltaic systems – 6 MW, Photovoltaic Farms – 10 MW, Wind – 6 MW. This totals to an installed renewable energy capacity of 35 MW of which 22 MW is intermittent. This is appropriate as the same report analyses the voltage and current profile in Mahe's network for the year 2030 and concludes that with the integration of 22.9 MW of intermittent renewable generation capacity (solar and wind), it is possible to operate the network in compliance with technical limits.

Since 2013, PUC operates an onshore wind farm of 6 MW rated capacity at Ile du Port and Ile de Romainville (Seychelles Energy Commission, 2020). However, due to its relatively low productivity, there are no plans to further increase onshore wind capacity (EDP International, 2019; PUC, 2021). The discussion on potential investments in WtE and biodiesel plants is also in its infancy (SEC, 2022c). However, with almost 5.5 MW of installed capacity on Mahé (PUC, 2022c) and without productivity issues (SEC, 2022c), solar PV technology is the only mature and readily available option today for Seychelles to transition its electricity mix. Therefore, in this thesis, the focus is on the potential of grid-tied rooftop solar photovoltaic (PV) systems on Mahé in accelerating the country's energy transition. Increasing the capacity of grid-tied solar PV systems comes with multi-dimensional challenges: technical, economic, and social. These challenges arise from the risk perception of stakeholders concerned with the increased adoption of such rooftop solar PV systems (namely governmental stakeholders, homeowners, commercial entities, and the PV industry), and this thesis makes a systematic analysis of these risk perceptions specific to each stakeholder group.

1.2 Objective and Research Questions

While the technical feasibility of increasing the proportion of intermittent renewable energy sources in Seychelles' electricity mix has been studied previously (Brown et al., 2016; EDP International, 2019; Okinawa Enetech, 2016; PUC, 2022c), there have been no studies that unearth the socio-economic opportunities and risks concerning increasing rooftop solar panel installations in *Mahé*. This knowledge is crucial to understanding why different stakeholders favour or oppose low-carbon pathways like the adoption of PV systems and formulate strategies to accelerate the same (Lieu et al., 2020a).

This thesis aims to bridge this gap by first qualitatively deriving comprehensive matrices of risks (implementation risks – barriers, consequential risks – negative outcomes) and opportunities (enablers – synergies, benefits – positive outcomes) as perceived by different stakeholders involved with the process of increasing Mahé's rooftop solar PV capacity. While similar studies have been conducted in several European countries (Nygrén et al., 2015a; A. Palm, 2020; Reindl & Palm, 2021a), no such efforts have been undertaken on SIDS to the best of my knowledge. To that extent, this thesis also aims to fill that gap.

Further, the effect that different PV adoption policies would have on domestic deployment rates is quantitatively studied through economic analysis and the implementation of a simple Agent-Based Model (ABM). Finally, the learnings from the qualitative risks and opportunities matrix and quantitative economic analysis are leveraged to identify the major challenges that have to be addressed to accelerate the rooftop solar PV deployment rate in Mahé.

Therefore, this thesis aims to answer the following two research questions (RQ):

> RQ 1: What are the risks and opportunities as perceived by different stakeholders concerning expanding roof-top PV installations in Mahé?
>
> RQ 2: What effect would different PV adoption policy alternatives have on domestic deployment rates on the ground?

The obtained results are intended to aid decision-makers in developing effective PV deployment policies in Seychelles to achieve their energy transition goals.

2 Methodology and Methods

This chapter details the methodology followed to answer the research questions stated in Section 1.2. The research design and scope of this thesis are delineated in Section 2.1, before the data collection and analysis methods are described in Section 2.2 and Section 2.3 respectively.

2.1 Research Design and Scope of this Thesis

Transdisciplinary research is an interdisciplinary approach to scientific inquiry concerning complex, real-world problems, while also emphasizing joint problem framing between people inside and outside academia to develop potential solutions (Lang et al., 2012). This approach was adopted in this thesis, particularly since the Seychelles Energy Commission (SEC), the country's sole energy regulator (Energy Act, 2012) under the Ministry of Agriculture, Climate Change and Environment (MACCE) of the GoS, was deeply involved right from the scope definition and definition of research questions. SEC is responsible for coordinating and strategizing the development of the country's entire energy sector. To execute this, SEC is charged with several functions, like the formulation and implementation of national energy plans (for example, van Vreden et al., 2010), regulating the generation and supply of electricity, and, promoting the adoption of energy-efficient and renewable energy technologies (Energy Act, 2012).

During the joint problem framing phase, the scope of the thesis was agreed upon with SEC and is illustrated in Figure 1.

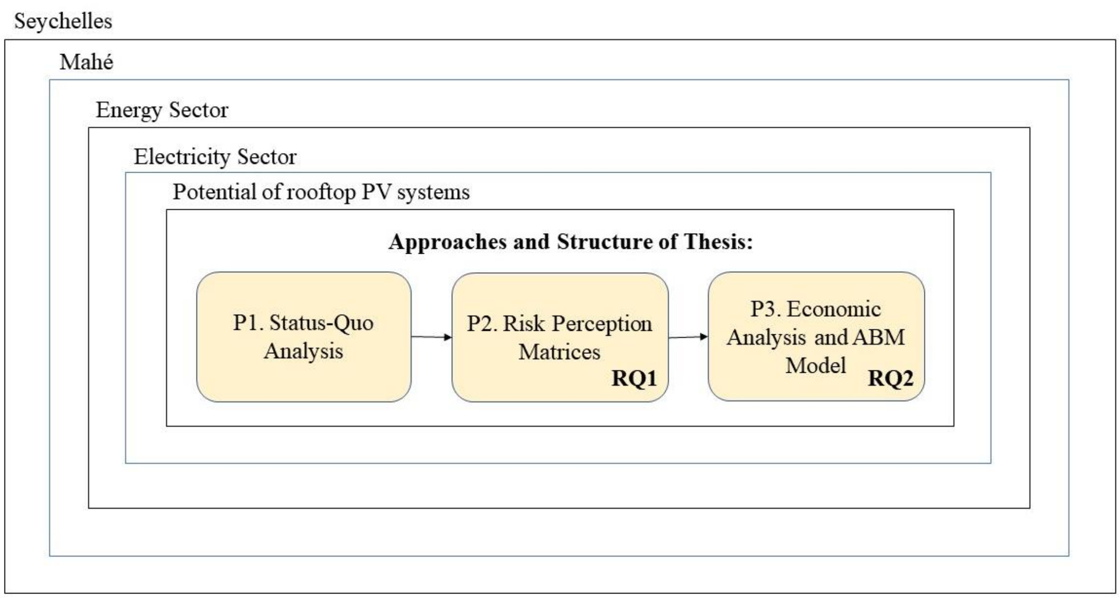

Figure 1: Scope and structure of the thesis.

The joint problem framed was that of the over-dependence of Mahé's electricity on imported fossil fuels and the need to move away from this. Consequently, it was decided that this thesis would focus on assessing rooftop solar PV system technology as a solution for hastening the transformation of Mahé's electricity sector, within the overall energy sector, away from fossil fuels.

As illustrated in Figure 1, the other two large, inhabited islands, Praslin and La Digue, do not fall within the scope of the thesis. Furthermore, Mahé's energy sector includes various sub-sectors, most importantly 'electricity', 'transportation', and 'industry' (Seychelles Energy Commission, 2020). This thesis focuses only on the 'electricity' sub-sector, although it can overlap with the 'transportation' sub-sector in the future with higher uptake of electric vehicles. Today, however, this overlap is negligible (SEC, 2022c). Finally, only the rooftop solar PV system technology is assessed amongst other potential renewable energy options. As described in Section 1.1.3, other renewable energy technologies are either suboptimal, for example, onshore wind energy (EDP International, 2019; SEC, 2022c), or currently at infant development stages for the Seychellois context, for example, WtE and biodiesel plants (SEC, 2022c).

Figure 1 also illustrates that the structure of the thesis encompasses three distinct but interconnected parts (innermost rectangle). In the first part, an analysis of the current state of the electricity sector along with the historical development of rooftop PV systems in Seychelles is conducted. This includes a survey of existing institutional, legal, and policy frameworks concerning electricity and renewable technologies, with a particular focus on rooftop PV technology. This part also identifies the important actors/stakeholders involved in the process of increasing the deployment of rooftop solar systems on Mahé.

With a clear understanding of the status-quo regarding the electricity and rooftop PV sector in Seychelles and with the most relevant stakeholders involved in its development identified, the second part conducts a deeper analysis of the risks and opportunities perceived by each of these actors/stakeholders. This information is solicited through interviews, organised, and analysed qualitatively to produce stakeholder-specific risk perception matrices. Divergences in risk perceptions between the stakeholders are unearthed to investigate the possibility of having stakeholder-specific rooftop PV deployment policies in the future. This second part is directly associated with the first research question (RQ1, Section 1.2).

Finally, in the third part, results from the first two parts are utilised to perform a quantitative economic analysis concerning the adoption of rooftop PV systems in the domestic sector. Furthermore, the effect that existing and potential policy and incentive frameworks would have on the deployment rates amongst residential property owners is analysed using a simplified, economic-based ABM. This third part is directly associated with the second research question (RQ2, Section 1.2).

2.2 Data Collection

Achieving the objectives of the thesis demanded different types of data, which were collected through four data collection methods. Their contribution to the different parts of the thesis, and data flows between these parts are illustrated in Figure 2. A large amount of the data needed was collected through in-person interviews in Seychelles, for which a two-month field study was conducted between the 1st of February 2022 and the 31st of March 2022. This was planned and conducted in close collaboration with the Seychelles Energy Commission, under MACCE.

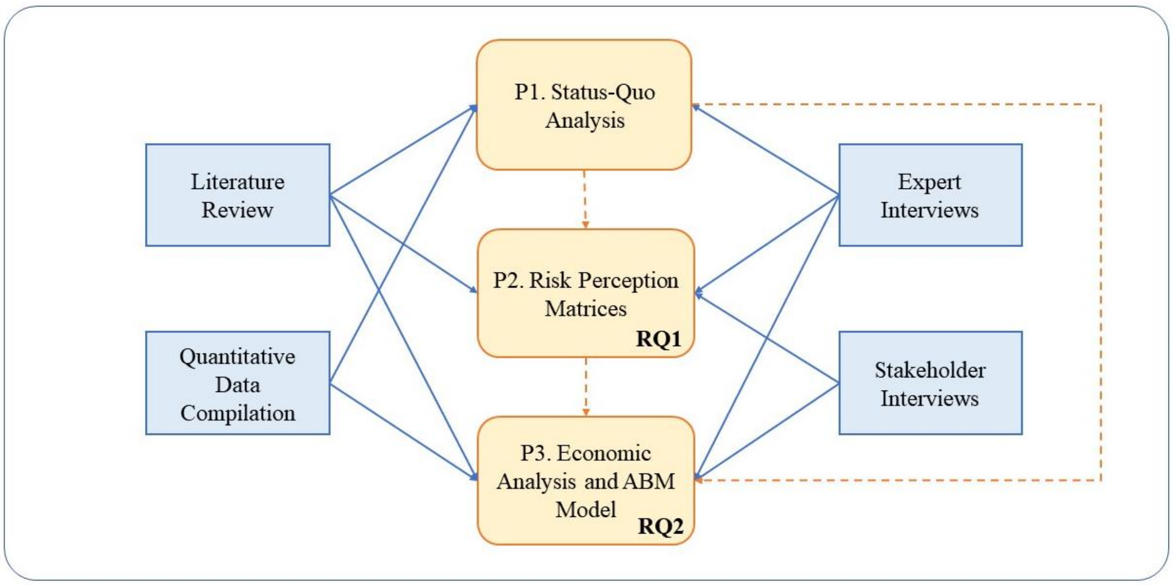

Figure 2: Data Collection methods and their contribution to the different parts of the thesis (solid blue arrows), along with contributions of one part of the thesis to another (dashed orange arrows).

The four data collection methods are illustrated in Figure 2 (blue boxes). Namely, literature review, expert interviews, stakeholder interviews, and quantitative data compilation directly from governmental departments. They are detailed further in the following subsections. As the different parts of the thesis are interconnected, there exists data flow between them. The findings from the first part, the status-quo analysis, were used in the other two parts. Similarly, the findings from the second part, the risk perception matrices, were utilised in the third part while performing the economic analysis and were also integrated into the ABM to simulate the rooftop solar PV deployment rates for different policy scenarios.

2.2.1 Literature Review

A comprehensive review of existing literature relevant to the different parts of the thesis (Figure 2) was conducted. The existing peer-reviewed published knowledge on renewable energy, and in particular, the solar power sector concerning Seychelles is limited (for example, Brown et al., 2016 and Gendron &

Kristoferson, 1983). However, several consultancies and intergovernmental bodies have conducted projects on different aspects of the renewable energy (and solar power) sector in Seychelles, which bridges this gap to a certain extent (for example, Cadmus Group, 2019; DNV.GL, 2018; EDP International, 2019; Energynautics, 2014; Macro Consulting, 2019; Okinawa Enetech, 2016; PSR, 2016; Quadran International, 2019). In addition to this, governmental authorities or departments concerned with the energy sector in Seychelles release annual technical reports and legal documents which proved useful (for example, PUC, 2021; SEC, 2014). Hence, the sources that were reviewed included, but were not limited to, scientific papers, legal documents, policy plans, technical reports, websites, and press releases. These sources were either consulted online or obtained from stakeholders directly.

2.2.2 Quantitative Data Compilation

Raw Quantitative data was needed to attain the objectives set for the first and third parts (RQ2) of the thesis. They were either concerned with (i) the historical and current deployment status of solar rooftop PV by different stakeholders, or (ii) the evolution of electricity tariff rates and production cost of electricity. Again, the sources for these data were either consulted online or obtained directly from governmental authorities. This included SEC, PUC, and the National Bureau of Statistics (NBS) (NBS, 2022a). All these authorities attended to requests promptly and provided datasets of good quality.

In the first part (P1, Figure 2), to establish and analyse the status quo of the rooftop solar PV sector, updated data regarding the installation of rooftop PV systems on Mahé was needed. SEC and PUC both individually maintain databases of all the applications they receive, together with the commissioned rooftop PV systems on Mahé, Praslin, and La Digue, for all stakeholder groups (residential and commercial). These databases were made available. To compute the stakeholder-specific historical deployment rates on Mahé, a comprehensive data frame was derived from the sourced databases. Statistical analysis was further performed on this data frame, and the results were used for the economic analysis and in the ABM model (P3, Figure 2).

In addition to this, the ABM needed an estimate of the number of homeowners and households on Mahé and the trend it was following historically. This was computed from data sourced from NBS' surveys (NBS, 2014, 2020a, 2020b, 2021a, 2021d, 2021c). Furthermore, data concerning the number of residential consumers of PUC, along with the consumption brackets they fall into, was acquired directly from PUC for the years 2011 and 2021. Similarly, electricity tariff data and the average production cost of electricity were also sourced from PUC.

2.2.3 Expert Interviews

To gain a holistic understanding of the renewable energy and rooftop solar PV sector in Seychelles, it is essential to consult relevant governmental authorities/organisations along with other “experts” in this field. This was particularly important as the amount of literature on this topic within the context of Seychelles is highly limited. Data from experts were collected through semi-structured interviews and e-mail correspondences.

A total of 10 participants from 8 institutions were selected in collaboration with SEC. After invitations, all the targeted experts took part in the interviews (see Appendix A.1). Three of these institutions were governmental, namely the MACCE, SEC, and PUC. The remaining five respondents were comprised of all the current “endorsed” installers/suppliers of rooftop PV systems in Seychelles. Only such installers/suppliers are permitted to operate in the PV market in Seychelles. SEC issues this endorsement to applicants each year, provided that their products and services comply with published standards. Therefore, the list of the currently endorsed installers/suppliers of PV was obtained from SEC following which each of them was invited to take part in the research activity.

Adams (2015) describes semi-structured interviews as those which are conducted conversationally and employ a blend of closed- and open-ended questions, often accompanied by follow-up why or how questions. Such interviews have several advantages, for example, it provides the mechanism for complex topics to be addressed through probes and clarifications, while also ensuring that particular aspects are covered even while participants have the freedom to raise additional concerns and issues (Wilson, 2014). However, the “interviewer effect”, where the background, sex, age, and other demographics influence how much information people are willing to reveal in an interview (Denscombe, 2010), should not be discounted.

In total, four questionnaires were prepared: one each for the experts from governmental institutions and a common one for the experts from the endorsed installers/suppliers list (see Appendix B.1 to B.4). All the questionnaires were prepared in collaboration with SEC, except for the one for SEC itself. They were shared with the targeted participants if requested before the interview, however, this happened rarely. On average, the interviews lasted 1 hour and 30 minutes. They were recorded, and simultaneously, notes were recorded on an electronic device.

2.2.4 Stakeholder Interviews

Here, “stakeholders” imply people or entities who are involved in the process of increasing the rooftop solar PV capacity on Mahé. Together with the Chief Executive Officer of SEC, “stakeholders” were framed as those people or entities who could, or had already, installed rooftop solar PV systems. In essence, they should have the capacity to participate in the rooftop solar sector on Mahé. Such stakeholders fell into three groups: “governmental”, “commercial” and “homeowner”.

2.2.4.1 Governmental Stakeholder

“Governmental” stakeholders entail decision-makers responsible for managing governmental buildings which can install rooftop PV systems. Incidentally, this responsibility lies with the MACCE and SEC (SEC, 2022c). It is also worth mentioning that most of the installations on governmental buildings have been made following grants from friendly foreign countries. For example, following a grant of USD 3.6 million from the Indian government, rooftop PV installations were made on several governmental buildings like the coastguard base, the Victoria Gymnasium, the National Assembly, and seven hospitals (Karapetyan, 2020; Pillay, 2019). The governmental stakeholders have already been covered as part of the expert interviews.

2.2.4.2 Commercial Stakeholders

Secondly, “commercial” stakeholders (see Table 1 and Appendix A.2) are privately-owned entities that can make rooftop solar PV installations or have already done so. This includes “auto-producers”, meaning licensees carrying out electricity production to meet their electricity requirements, without being connected to the grid (Energy Act, 2012). SEC maintains a list of such auto-producers in Seychelles, from which interview requests were sent to the three that are situated on Mahé following which all of them agreed to participate. They are all privately owned commercial entities, using diesel generators to meet their electricity needs. However, one of these auto-producers (CP5-AP, Table 1) had also installed a large rooftop PV system apart from diesel generators to meet their electricity needs.

Apart from the 3 auto-producers, 9 other commercial entities were interviewed. Five of them had not yet installed a rooftop solar PV system (henceforth abbreviated “CNP” followed by their number, see Table 1), and the remaining had (henceforth abbreviated “CP” followed by their number, see Table 1).

Table 1: List of commercial entities interviewed along with their type, abbreviation, and installation details. “CNP” is the abbreviation for a commercial entity that has not yet installed a rooftop solar PV system; “CP” is the abbreviation for a commercial entity that has already installed a rooftop solar PV system; the suffix “-AP” implies that the interviewed commercial entity was an auto-producer at the time of the interview.

Sl. No.	Type	Abbreviation	Installation Size (kW) and year
1	Grid-Connected – No rooftop PV system installed	CNP1	0
2	Grid-Connected – No rooftop PV system installed	CNP2	0
3	Grid-Connected – No rooftop PV system installed	CNP3	0
4	Grid-Connected – No rooftop PV system installed	CNP4	0
5	Grid-Connected – No rooftop PV installed	CNP5	0
6	Grid-Connected – Rooftop PV system installed	CP1	52.64, 2014
7	Grid-Connected – Rooftop PV system installed	CP2	139.302, 2013
8	Grid-Connected – Rooftop PV system installed	CP3	38.44, 2020
9	Grid-Connected – Rooftop PV system installed	CP4	198.32, 2020 (2 separate installations of 99.16 kW each)
10	Auto-Producer – No rooftop PV system installed	CNP6-AP	0
11	Auto-Producer – No rooftop PV system installed	CNP7-AP	0
12	Auto-Producer – Rooftop PV system installed	CP5-AP	800, 2021

Together with SEC, the target number of respondents for the entire commercial stakeholders’ group was set to 10, given the time constraints, and follows the approach of Reindl and Palm (2021). Table 1 shows that eventually, 12 stakeholders participated in the interviews. As mentioned in Section 2.2.2, a complete data frame of all the installations was derived from the databases maintained by SEC and PUC. Commercial stakeholders who had already installed a rooftop PV system (CP), were contacted in a randomized manner from this data frame and invited to participate in a semi-structured interview until the target number of interviews was reached. This process was also done in collaboration with SEC. As for the commercial stakeholder who had not yet installed a rooftop solar PV system (CNP), they needed to have basic knowledge about such systems for them to participate in the interview. To ensure this, a list of commercial entities who had contacted SEC regarding the possibility of making an installation was made available, from which potential participants were contacted in a randomized manner until the target number of interviews was reached. All the commercial stakeholders were subject to semi-structured interviews, for which questionnaires (Appendix B.5 to B.7) were prepared in collaboration with SEC.

2.2.4.3 Homeowners

Finally, "homeowners" imply residential property owners who can make rooftop solar PV installations or have already done so. Like the approach in Palm (2018), 31 homeowners were subject to semi-structured interviews in total (see Appendix A.3). About half (16) of these respondents had not yet installed a rooftop solar PV system and the other half had made such an installation. Furthermore, within each half, respondents were selected in such a way that they were distributed equally between 3 consumption bands: 0 to 300 kWh (low-consumption band), 301 to 600 kWh (mid-consumption band), and above 600 kWh (high-consumption band).

Table 2: List of homeowners interviewed along with their abbreviations and electricity consumption band. "HNP" is the abbreviation for a homeowner that has not yet installed a rooftop solar PV system; "HP" is the abbreviation for a homeowner that has already installed a rooftop solar PV system; the suffixes "-L", "-M" and "-H" implies that the interviewed homeowner belongs to the low-, mid- or high- consumption band respectively.

PV Installation Status	Electricity Consumption Band	Abbreviation	Number of respondents
PV Installation not yet made at the time of the interview - "HNP"	Low Consumption - 0 to 300 kWh - "L"	HNP-L (1 to 5)	5
	Mid Consumption - 301 to 600 kWh - "M"	HNP-M (1 to 6)	6
	High Consumption - above 600 kWh - "H"	HNP-H (1 to 5)	5
PV Installation already made at the time of the interview - "HP"	Low Consumption - 0 to 300 kWh - "L"	HP-L (1 to 5)	5
	Mid Consumption - 301 to 600 kWh - "M"	HP-M (1 to 5)	5
	High Consumption - above 600 kWh - "H"	HP-H (1 to 5)	5
The total number of homeowners interviewed			**31**

This rationale was adopted to ensure that all types of homeowners were included, both concerning energy consumption and whether they had already installed a rooftop PV system, to comprehensively understand their perceptions while also capturing any differences between them based on these criteria. Henceforth, they are abbreviated according to the scheme outlined in Table 2.

Again, HP participants (i.e, homeowners who already had installed rooftop PV systems) were contacted in a randomized manner from the data frame derived from the installation databases provided by SEC and PUC and were invited to participate in a semi-structured interview until the target number of interviews was reached. It had to be ensured, that HNP participants (i.e, homeowners who had not yet installed rooftop PV systems) have a basic awareness of rooftop solar PV systems. Therefore, they were sampled from a list of homeowners who had contacted SEC regarding the possibility of making an installation, in a randomized manner until the target number of interviews was reached. Care was taken to ensure that participants were distributed equally between the three consumption bands. Again, all the homeowners were subject to semi-structured interviews, for which questionnaires (Appendix B.8 to B.9) were prepared in collaboration with SEC.

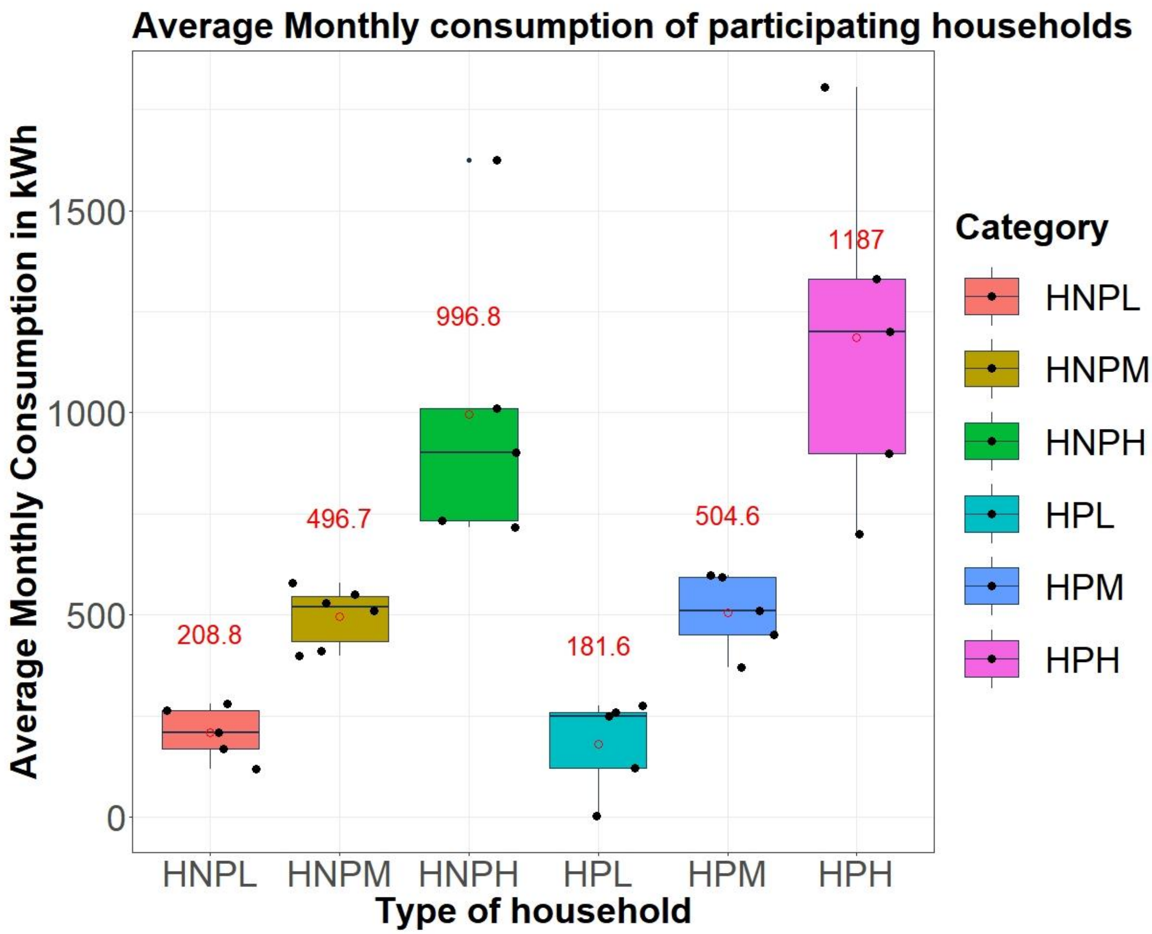

Figure 3: Average monthly consumption of interviewed households. The first three boxplots from the left represent HNP household groups and the remaining HP. Points in red, represent the mean within the respective group, which is also mentioned in red (kWh) over the boxplots. The solid black line within each boxplot represents the respective median values.

Figure 3 illustrates the distribution of the average monthly consumption of interviewed HNP and HP households, who are further segregated by their consumption bands.

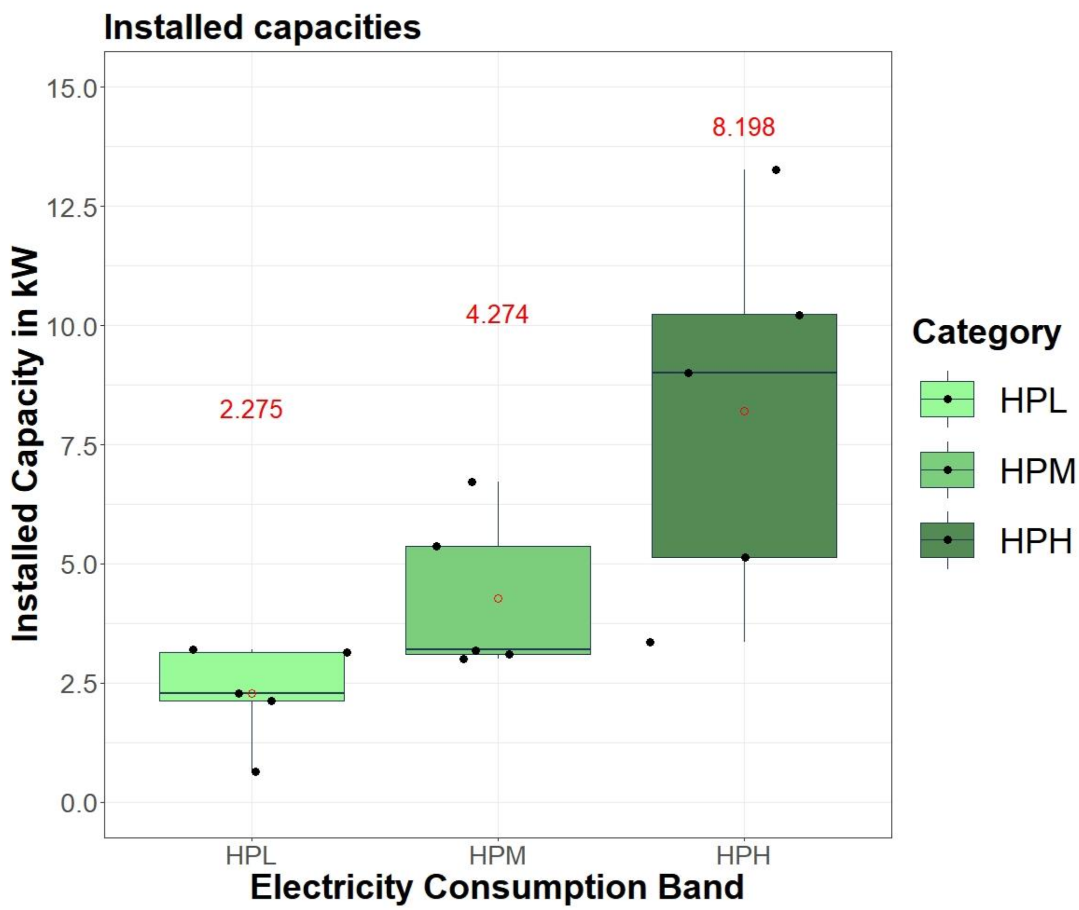

Figure 4: Installed capacity of interviewed households who had already installed solar PV systems. Points in red, represent the mean, which is also mentioned in red (kW) over the respective group. The solid black line within each boxplot represents the respective median values.

Figure 4 depicts the distribution of installed rooftop solar PV systems' capacities between the three types of HP households. The mean installed capacity (depicted by red points in the box plots and mentioned in red over them) varied with the consumption band.

The overall monthly household income was also collected from the homeowners, wherein they were asked to choose the income band that their household would fall into from 3 options: less than 10,000 SCR/month, between 10,001 and 30,000 SCR/month, and greater than 30,000 SCR/month (see Appendix B.8 and B.9). All the interviewed households fell in the highest income band (greater than 30,000 SCR/month), except for 5 cases: 3 HNP-L, 1 HNP-M, and 1 HP-M respondent, all in the middle-income band (between 10,001 and 30,000 SCR/month).

2.3 Approach and Data Analysis

The data analysis approaches varied between quantitative and qualitative techniques based on the part of the thesis for which it was being executed (see Figure 2).

2.3.1 Part 1 – Status Quo Analysis

The status quo analysis was conducted in five sub-parts as illustrated in Figure 5. The overall objective of Part 1 was to gain a comprehensive understanding of renewable energy and more specifically, the PV sector in Mahé. Therefore, each part is aimed at producing results focused on different aspects of this objective.

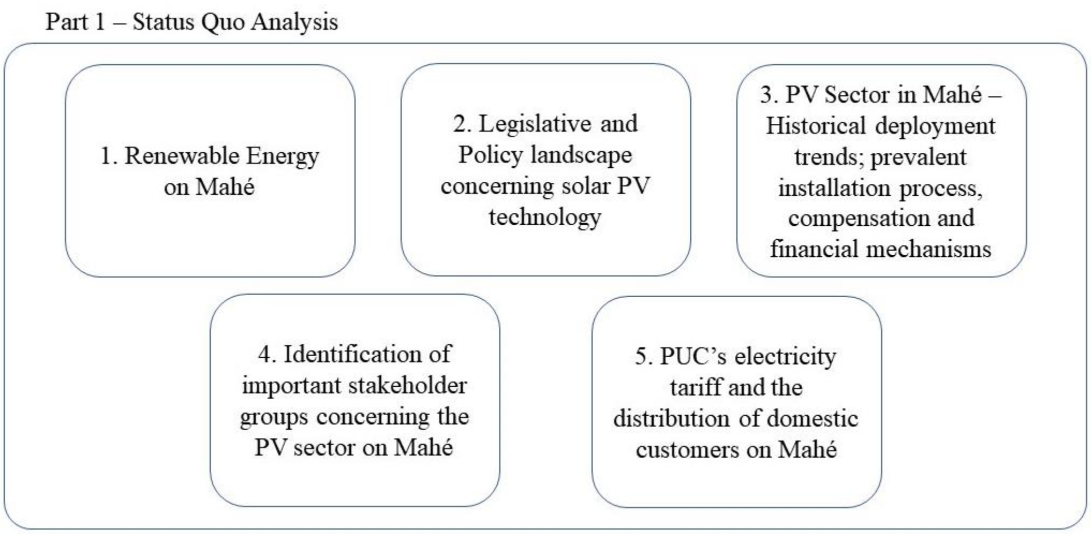

Figure 5: Subparts of Part 1 – Status quo analysis.

Firstly, underpinned by data collected from the literature review and expert interviews, an analysis of the renewable energy sector in Mahé was conducted. This includes information on the country's fossil fuel imports and electricity mix, apart from an analysis of the renewable energy generated on Mahé from 2018 to 2020. Secondly, the legislative & institutional framework and the policy & regulatory landscape concerning solar PV technology in Seychelles were detailed and assessed individually, again supported by information gathered through the literature review and expert interviews.

As mentioned in Section 2.2.2, a complete data frame of all the installations on Mahé was produced by combining the databases sourced from PUC and SEC. In the third subpart, this data frame was subject to statistical analysis using R to produce historical deployment trends and to unearth the current state of rooftop solar PV installations on Mahé. Consequently, information regarding the yearly distribution of these installations based on the sector (commercial or domestic), and the investment mode (bought or granted) were produced. Furthermore, the availability of monthly consumption data of domestic adopters on Mahé from 2017, enabled producing installation trends based on the consumption band that a household fell into. A household was classified as "high consumption" if their average monthly electricity consumption exceeded 601 kWh, "mid consumption" if it fell between 301 and 600 kWh and, "low consumption" if it was less than 301 kWh (see Section 2.2.4.3 and Table 2).

Additionally, by collecting information through expert interviews (Section 2.2.3), this subpart also presents details regarding the installation process in Mahé, the compensation mode for electricity generated, and the financial incentives available to aid potential adopters.

The fourth subpart identifies the different stakeholder groups involved in the process of increasing the deployment of rooftop solar PV systems on Mahé. This exercise was conducted in collaboration with SEC. It was ensured that the composition of each stakeholder group and the role they play in the process were clearly defined. Finally, in the fifth subpart, PUC's electricity tariff structure and the distribution of its domestic customers on Mahé are presented after this data was obtained directly from PUC.

2.3.2 Part 2 – Risk Perception Matrices

The energy sector can be conceptualized as a "socio-technical system" (Markard et al., 2012). Along the same lines, a socio-technical *transition* is a set of processes that lead to a fundamental shift in such systems, "involving far-reaching changes along different dimensions: technological, material, organizational, institutional, political, economic, and socio-cultural" (Geels, 2005; Markard et al., 2012). They differ from "technological transitions" in that they include changes in user practices and institutional structures, in addition to the technological dimension. Such transitions involve a broad range of actors and usually unfold over considerable periods (Markard et al., 2012).

In that sense, accelerating the deployment of rooftop solar PV installations on Mahé also implies a socio-technical transition. Here, the intended systemic transformation is the realization of a fossil-free electricity mix for Mahé (MACCE, 2022b; SEC, 2022c). It requires a broad set of actors, or stakeholder groups, to undergo sustained behavioural changes that will eventually result in transformation at the systemic level. This is accommodated by the Multi-Level Perspective on Transitions theory introduced in Geels (2005).

Therefore, understanding the perspectives of these multiple stakeholder groups, essentially their "*risk perception*" concerning the deployment of PV systems in Mahé, is crucial to designing transition pathways that are socially, economically, and environmentally compatible in the Seychellois context. In practice, however, risks are stakeholder-specific, depending on the point of view of the person experiencing or observing the risk (Glickman, 2013). What is negative for some stakeholders may be perceived as positive by others (Lieu et al., 2020b).

Stakeholder groups were identified during the status-quo analysis. Sample sizes were decided for each stakeholder group in collaboration with SEC, following which they were subject to semi-structured interviews to elicit the risks and opportunities they perceive concerning the adoption of rooftop solar PV systems (see Section 2.2). Consequently, this part conducts a deeper analysis of the risk perception of each stakeholder group by accumulating the responses of their participants. Thereby, stakeholder-group-specific *"risk perception matrices"* are constructed. Only with this knowledge, it would be possible to frame policies that address the concerns and aspirations of each stakeholder group to achieve the intended transition.

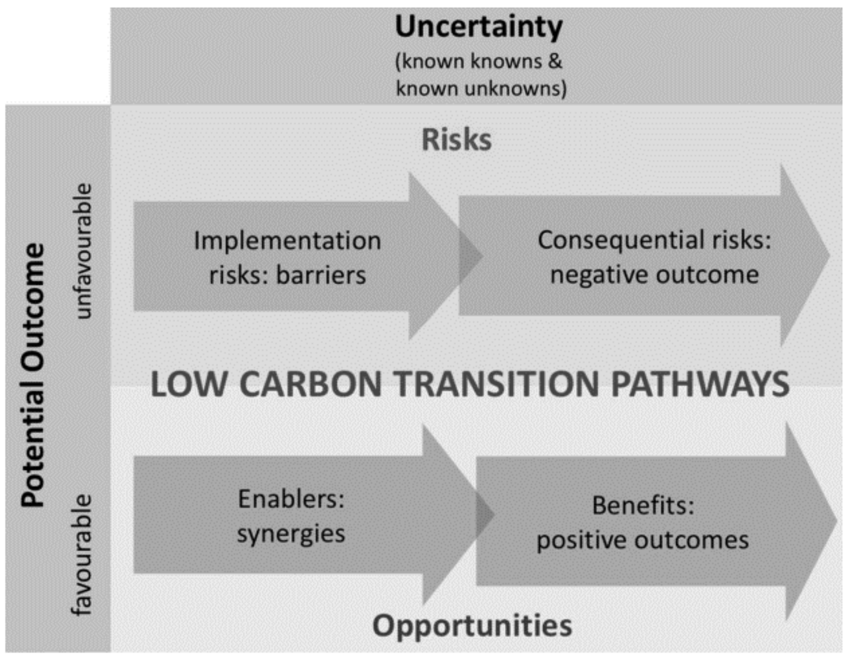

Figure 6: Risk and Opportunities framing, adapted from (Lieu et al., 2020b).

The perceived "risks" and "opportunities" from each stakeholder group are qualitatively derived based on the risk framing outlined in Lieu et al. (2020) and depicted in Figure 6. Here, "*uncertainties*" are considered "a state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable" (Kunreuther et al., 2014, p. 155). As such, uncertainties can result in positive outcomes, creating "*benefits*" (in this case, potential benefits for stakeholders after having installed rooftop PV systems), or negative outcomes, called "*consequential risks*" or simply "*risks*". These *consequential risks* are different from "*implementation risks*" or "*barriers*". *Implementation risk* is the potential for negative impact on the implementation of a low carbon pathway (in this case, barriers against the adoption and increase in deployment of rooftop PV installations), while *consequential risk* (here, the potential negative outcomes of installing PV systems perceived by different stakeholders) refers to the potential for negative impacts resulting from the implementation of a potential pathway (Lieu et al., 2020b).

Finally, "*enablers*" are factors that facilitate the implementation of a low carbon pathway (here, factors that are synergetic to increasing the deployment of rooftop PV).

However, the distinction between consequential risks and implementation risks is not always apparent, as the knowledge of consequential risk may function as a cognitive barrier during the decision-making process which also makes it an implementation risk (Lieu et al., 2020b). In this thesis, this cognitive decision-making barrier is ignored such that an "uncertainty" is classified as "consequential" if an *outcome* is negative *after* the adoption of a PV system, and as "implementation" if it creates *barriers prior* to the adoption of a PV system. This distinction extends to benefits and enablers based on whether the concerned "uncertainty" comes into effect after or before the adoption of a PV system respectively.

Consequently, stakeholder-group-specific "risk perception matrices" are constructed from their respective derived risks and opportunities. Importantly, while deriving and detailing the elements of the "risk perception matrices" for commercial and homeowner stakeholder groups, the experiences of individuals who had already adopted rooftop solar PV systems along with the uncertainties that they perceived before making the installation, were utilised. Although the *"experiences"* of those who had already adopted systems don't constitute *"uncertainties"*, juxtaposing these experiences against the uncertainties perceived by those that haven't, helps in clarifying differences between perceptions and reality. Furthermore, it helps derive a more comprehensive understanding of the issue from the point of view of these stakeholder groups.

In this process, the data collected through semi-structured interviews from each stakeholder group (Section 2.2) was subject to qualitative content analysis (Schreier, 2012). This was the practice in several similar research efforts (Nygrén et al., 2015b; J. Palm, 2018; Reindl & Palm, 2021a). Essentially, each recorded interview and transcript was analysed to procure uncertainties and experiences specific to each respondent. Following this, they were accumulated and categorized based on the risk framing (Figure 6) for each stakeholder group to produce their respective risk perception matrices.

The risk perception matrices were derived for the governmental, commercial and homeowners' stakeholder groups identified in Section 3.1.4. Governmental stakeholders are responsible for policies promoting rooftop solar PV systems, whereas the commercial and homeowners' stakeholder groups represent the targeted potential adopters. Although identified in Section 3.1.4, the PV industry in Mahé is excluded from the analysis in Part 2, as they only play a facilitative role in comparison to the decision-making role that the governmental, commercial or homeowners' stakeholder groups play. However, their inputs were important to gain a comprehensive understanding of the PV industry and application process in Mahé.

2.3.3 Part 3 – Economic Analysis and Agent-based modelling

While the previous part is devoted to unearthing the socio-economic risks and opportunities perceived by different stakeholders, this part attempts to simulate the effect that current and potential adoption policies would have on the deployment of rooftop solar PV systems within the domestic sector on Mahé. This analysis is conducted in 4 sequential subparts, as illustrated in Figure 7.

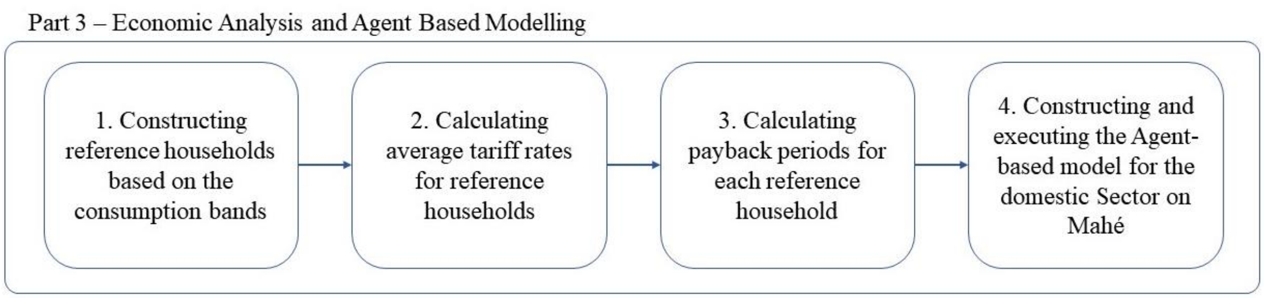

Figure 7: Sequential subparts of Part 3 – Economic Analysis and Agent-Based Modelling.

2.3.3.1 Constructing reference households

In the first subpart, "reference" households were constructed for each of the three consumption bands – low, mid, and high. A "reference" household is one which has not adopted a rooftop solar PV system yet but is considering doing so. The three reference households are constructed for each consumption band based on two parameters: their average monthly consumption, and the capacity of the rooftop solar PV system they will install. As the average monthly consumption data is available only from the beginning of 2017, the parameters for each consumption band are calculated from a subset of 193 installations on Mahé (see Section 3.1.3.1, Figures 13 and 14) from the beginning of 2017. Additionally, all these households "bought" their installation without being supported by governmental initiatives wherein they were installed for free.

2.3.3.2 Calculating Average Tariffs for each reference household

In the second subpart, the average tariffs applicable for each of the reference households based on their monthly electricity consumption were computed for tariff rates applicable in November 2011 and May 2022 (see Appendix D for the applicable tariff rates). The objective was to capture any changes in average tariff rates in the 10 years between late 2011 and early 2022. For this calculation, a fixed demand charge of 50 SCR/month, 50 SCR/month, and 100 SCR/month were assumed for the low, mid and high reference households respectively. This assumption was possible as the demand charge has been unchanged during this period (see Appendix D). Although the demand charge varies with the categorization of a household depending on its load, this assumption was based on the electricity bills shared by interviewed homeowners.

2.3.3.3 Calculating the payback period for each reference household

In the third subpart, the simple payback periods for each of the reference households were calculated as a function of two parameters: offered financial incentives and applicable average tariffs.

From the interviews with the homeowners (see Section 2.2.4.3, Table 2), it was apparent that they decide on the economic viability of investing in a rooftop solar PV system based on its payback period. The *simple payback* calculates the minimum number of years required for the sum of non-discounted annual cash flows to equal or exceed the non-discounted investment cost (Short et al., 1995). Homeowners calculate the payback based on this concept of *simple payback*, ignoring the time value of money. In essence, they do not account for a discount rate, as in a discounted payback period (Short et al., 1995).

This payback period was calculated according to the following formula (adapted from Rai & Robinson, 2015):

$$PB = \frac{TC - FI}{AC - OMC}$$

Where,

PB is the simple payback period in years,

TC is the total cost for a rooftop solar PV installation in SCR,

FI is the sum of financial incentives offered by the government to reduce the upfront cost, like the rebate scheme,

AC is the avoided cost per annum after making the installation in SCR/year and

OMC is the operational and maintenance cost of the system per annum in SCR/year.

Further, the avoided costs per annum depend on two factors: firstly, the compensation mechanism in place and secondly, the average yield per annum from the installed system. In Mahé, the applicable compensation mechanism today is the net billing system (see Section 3.1.3.2), wherein produced energy is directly offset in terms of electricity units. Additionally, the average yield per annum from the PV system may drop with time due to reduced panel efficiency. For the calculations here, the average yield per annum was calculated in units of electricity generated (kWh/annum) per installed kW (kW), as an average of the first 10 years of operation for a typical system in Seychelles.

In the net billing system, as the electricity units are directly offset, the avoided costs depend on the average tariff system (see Table 16) applicable during the system's operation. Homeowners usually calculated the payback period based on the tariff at the time of calculation, the same approach is followed, neglecting changes in tariff rates in the future.

Therefore, the avoided costs in the context of Mahé were calculated as:

$$AC = PM \times 12 \times AT \times SC$$

Where,

PM is the average yield of the system per month considering the first 10 years of operation in kWh/month,

AT is the average tariff during the time of calculation in SCR/kWh and

SC is the system capacity applicable to the respective reference household

The general system characteristics (cost per unit of installed capacity, average yield, lifespan, etc) for all reference households were assumed to be equal. The difference was only in the capacity of the system they would adopt, and the average tariff rate applicable to them (see Table 16). These system characteristics are depicted in Table 3.

Table 3: Common system characteristics for the PV modules that reference households will adopt.

System Characteristic	Details	Source/Justification
Total cost of installation including the VAT exemption	22,400 SCR/kW	On average, the installers reported charging between 1.2 and 1.4 EUR/W for a turnkey system, which was confirmed during the homeowners' interviews. The higher-end, 1.4 Euro/W is chosen. This includes fees to PUC for their commissioning services, the cost to install the new meter, along with any other miscellaneous expenses. Additionally, this also includes the VAT tax exemption for PV equipment (Value Added Tax (Amendment of Schedules) Regulations, 2014). The conversion rate used is 1 EUR = 16 SCR (CBS, 2022)
Maintenance cost	255 SCR/kW/year	17 USD/kW per year as reported by Wiser et al., 2020. The conversion rate used is 1 USD = 15 SCR (CBS, 2022)
Lifespan	25 years	Lifespans exceeding 30 years have been reported in literature (Wiser et al., 2020), however, most PV panel manufacturers claim 25 years of warrantied performance (Canadian Solar Inc., 2020; JA Solar, 2022)
Average Monthly Yield	114.6 kWh/kW/month	Installers usually claim 120 to 126 kWh/kW of monthly yield for a new system. 120 kWh/kW monthly yield is assumed for a new system which depreciates by 1% every year. The average monthly yield for the first 10 years is adopted. Corroborates with interviewed HP homeowners

Therefore, the payback periods vary with two policy instruments: the amount of rebate, and the average applicable tariff, and in essence, each variation represents a policy condition. These instruments were the incumbent tools which could be altered to increase or decrease the attractiveness of investing in a rooftop solar PV system.

Furthermore, these parameters are specific for each reference household. The rebate is varied from 0 to 25% of the total installation cost for a reference household, which was the maximum amount offered when the rebate scheme was active (Section 3.1.3.2) (the threshold of 25,200 SCR is ignored for the high consumption reference household). On the other hand, the average tariff is varied in 25 steps from its current rate (as of May 2022), in increments equal to its annual increments in the 10 years between late 2011 and early 2022. Effectively, this is meant to mimic the expected rise in average tariff for each of the reference households for the next 25 years (from 2022 to 2046).

2.3.3.4 Agent-based modelling of the domestic sector in Mahé

Finally, in the fourth subpart, a simplified Agent-based model was developed for the domestic sector in Mahé, which was utilised to simulate deployment rates for three constructed policy scenarios: BAU, conservative and optimistic. Agent-based modelling is a bottom-up simulation method, where the interaction of many components generates patterns on a higher system level. They allow for the testing of theories (of individual behaviour) leading to emergent phenomena (system behaviour). Hence, they may fill the gap between formal but restrictive models and wide-ranging but imprecise qualitative frameworks. In Agent-based Modelling, an "agent" is an entity that completes an action or takes a decision, by which it effectively interacts with its environment (Dam et al., 2013).

To achieve this, the open-source modelling tool NetLogo (Wilensky, 1999) was used. In the context of this thesis, an agent is one of the three reference households, that decides for or against the installation of a rooftop PV system each year. Their decision may be influenced by several factors: environmental awareness, the likelihood to imitate neighbours who have already installed rooftop PV systems, or also be driven by an economic analysis. The factors for this model were selected from the risk perception matrix derived for homeowners in Part 2 (Table 13), based on what risks and opportunities they considered to be most influential in their decision-making.

Constructing the policy scenarios:

The conservative and optimistic policy scenarios differ from the BAU policy scenario only based on variations in two policy instruments: information dissemination efforts and rebate schemes (Table 4). The policy instruments were selected for their ability to address the most important barriers that homeowners face concerning the prospect of adopting a system. From the risk perception matrices derived for the homeowners' and governmental stakeholders' groups in Section 3.2, it was clear that the information barrier and the high upfront cost constituted the biggest hurdles to the accelerated adoption of PV modules within the domestic sector (see Table 14 and Section 3.2.3.5). Therefore, policy instruments that directly focus on reducing these barriers, i.e, rebate schemes addressing the high upfront cost, and information dissemination efforts addressing the information barrier, were chosen.

The BAU scenario was constructed to replicate the current policy situation concerning the adoption of PV modules on Mahé. Consequently, the adoption of PV modules within each agent type in the future was modelled based on linear regression from historical installation figures. From when the installations began in 2013 to the end of 2021, 293 PV modules were adopted by the domestic sector on Mahé (installations made for free under governmental initiatives are neglected). However, consumption data of households (which enable the categorization of a household into one of the three consumption bands: low, mid, and high) were available for only 193 installations from the beginning of 2017 to the end of 2021. The remaining 100 installations made before 2017 were distributed between the three consumption bands in the same proportion they were found to be distributed amongst themselves between the years 2017 and 2021. The resultant distribution of installations between the three consumption bands is depicted in Appendix E.3. Consequently, the cumulative and the yearly number of adoptions were projected linearly for each of the consumption bands between the years 2022 and 2046, the period for which the model is run. This is detailed in Appendix E.4.

Since the conservative and optimistic policy scenarios vary from the BAU policy scenarios only based on the two policy instruments, they were tantamount in every other way. For example, the restriction on system capacity at 100% of average consumption, the geographical barriers and the lack of battery storage options would continue as it is currently. Importantly, the compensation mechanism, that is, the net billing system is assumed to continue for all scenarios from 2022 to 2046. The constructed policy scenarios are detailed in table 4.

Table 4: Scenarios constructed for the ABM.

Scenario	Rebate Scheme	Information dissemination
Business as Usual (BAU)	VAT exemption for PV equipment continues and 25% of the total cost of installation (including VAT exception on PV equipment; for high-consumption households, it continues to be SCR 25,200 which is the maximum threshold offered currently) continues from 2022 to 2046.	The current lack of availability of information or easy access to it which has resulted in a lack of awareness or understanding of the installation process and the financial incentives available (Section 3.1.3.2) continues from 2022 to 2046. No awareness generation campaigns are conducted. Interested potential adopters must try to find information independently.
Conservative	VAT exception on PV equipment continues from 2022 to 2046, but the Rebate scheme is stopped	The availability and access to information on the installation process, or financial incentives available are further constrained in comparison to BAU from 2022 to 2046. No awareness generation campaigns are conducted. Interested potential adopters must try to find information independently.
Optimistic	VAT exception for PV equipment continues and 25% of the total cost of installation (including VAT exception on PV equipment; for high-consumption households, it continues to be SCR 25,200 which is the maximum threshold offered currently) continues from 2022 to 2046	Aggressive information dissemination efforts are sustained from 2022 to 2046 which ensures the availability of and access to information, coupled with the active encouragement of the target group (agents who can adopt a PV system).

The assumptions made to model the domestic sector in Mahé and the theoretical foundations upon which the ABM works are described below.

Purpose:

To simulate the PV adoption by domestic households belonging to different consumption bands in Mahé for three scenarios: BAU, conservative and optimistic.

Types of agents, their state variables, their distribution, and time scales:

The model includes three types of agents: low-consumption, mid-consumption, and high-consumption reference households. These households were constructed according to two parameters: their average monthly electricity consumption and the system capacity of the PV module that they would adopt (Section 3.3.1). In essence, households of the same agent type (low, mid, or high-consumption reference households) always consume the same amount of electricity on average every month and would adopt the same system capacity of a PV module. The system characteristics as depicted in Table 3 were adopted for all three agent types.

The total number of households was fixed at the total number of domestic consumers PUC had for 2021: 31,682 (see Section 3.1.5.3). Although "consumers" may not always imply an independent "household", as the same household may have multiple connections, this consideration was ignored for the model. This is because currently an application for a new PV connection is made based on the consumption of a "consumer" and not a "household" (PUC, 2022d; SEC, 2022b, 2022c). Additionally, growth in the total number of domestic consumers of PUC has been reported over the years (PUC, 2021, 2022d). However, this growth was ignored to simplify the model, and the simulations were run only for the 31,682 connections reported in 2021.

Furthermore, the three types of agents were distributed within the total number of households in the same proportion as domestic consumers were distributed based on their consumption (low, mid, and high) for the year 2021 (see Section 3.1.5.3). Therefore, the model consists of 19,204 low-consumption reference households, 9,658 mid-consumption reference households, and 2,820 high-consumption reference households. Additionally, it was assumed that only 25% of each of the agent types could install PV systems. The rationale for this assumption follows the geographical and roof-related barriers identified by governmental and homeowners' stakeholder groups (Section 3.2). Essentially, a household may be incapable of installing a PV module owing to suboptimal roof inclination, insufficient roof structural strength or inconvenient location.

Of the households capable of installing a PV module, since 2013 several of them have already made the installations. Table 5 details how many such installations were made within each consumption band until 2021. Importantly, it was assumed that the 137 free installations made under governmental initiatives were all installed in low-consumption households. Consequently, Table 5 details the number of possible PV connections within each agent type from 2022.

Table 5: Number of reference households (here, the 154 low-consumption reference households who had already installed a PV module by 2021 include 137 free installations made under governmental initiatives).

Agent Types/Reference household	Total number	25% of the total number	Already installed until 2021	Capable of installing from 2022
Low	19204	4801	154	4647
Mid	9658	2415	73	2342
High	2820	705	192	513
Total	**31682**	**7921**	**419**	**7502**

The 31,682 households are distributed in an artificial square landscape of 252 "patches" on each side totalling 63,504 patches. The distribution was randomly made in such a manner that each household occupies one patch. In essence, slightly more than half the patches are vacant (see Appendix E.1). As Figure

35 (Appendix E.2) shows, only a narrow coastal strip along the foot of the granitic mountains on Mahé is suitable for development (Government of Seychelles, 2015). The rationale was to represent the distribution of households in these urban areas on Mahé.

Each of the households contains a logical state-variable 'PV' which is *true* if they have adopted a PV module, or *false* if they haven't. The model is run with a discrete-time step of 1 year for 25 years, from 2022 to 2046.

Model initialization:

The model was initialized with a random distribution of agents as explained. Additionally, the households who have already installed the PV modules by 2021 for each agent type are also randomly distributed within them. Therefore, before the beginning of the simulation, the number of households capable of adopting PV modules is 4647, 2342, and 513, low-consumption, mid-consumption, and high-consumption reference households respectively (see Table 5).

Process overview:

In each time step, a household that can install a PV module adopts a system according to a computed probability. This probability is specific for each agent type and the scenario for which it is calculated. However, generally, it can be expressed for an eligible household with the following equation:

$$p_i = pl_i \times pb_i \times ne \times k$$

Where,

i is the time step in years,

p_i is the probability that the household will adopt a PV module in time step i which is specific for each agent type and scenario,

pl_i is the probability that the eligible household would have adopted a PV module in time step i according to linear regression from historical installation figures (probability for BAU) which is specific for each agent type but common for all scenarios,

pb_i is a factor reflecting the increase or decrease in payback period computed for the conservative or optimistic scenario in comparison to BAU in time step i, which is specific for each agent type and scenario,

ne is the neighbourhood effect which is specific for each agent type but common for all scenarios, and

k is the effect of awareness and information dissemination campaigns which varies with the scenario.

In essence, the probability that an eligible household would adopt a PV module in year i, in the scenario for which it is computed, is the probability a household belonging to the concerned agent type would adopt a system in BAU in year i (pl_i) multiplied by three factors: first, pb_i reflecting the increase or decrease in the payback period for the concerned scenario in comparison to BAU in year i and for that agent type; secondly, ne reflects the neighbourhood effect on the household which varies with the agent type but is consistent across scenarios; finally, k which reflect the effect of awareness and information dissemination campaigns which vary with the scenarios but are consistent across agent types.

The probability pl_i is specific for each agent type and is calculated as:

$$pl_i = \frac{Projected\ installations\ in\ time\ step\ i\ according\ to\ BAU}{Total\ number\ of\ installations\ until\ timestep\ (i-1)}$$

The projected number of installations was calculated for each agent type calculated for the BAU for each time step and is listed in Appendix E.4.

As the compensation mechanism is assumed to remain the current net billing system, the payback periods for each of the reference households were computed as described in Section 2.3.3.3. The rebate amount was equal in the BAU and optimistic scenarios, while it was not offered in the conservative scenario (see Table 4). Further, the average tariffs that the respective reference household would be subject to were assumed to increase with each time step with the same respective yearly increment for the 10 years between late 2011 and early 2022. The same exercise was carried out in Section 2.3.3.3 and the results are detailed in Section 3.3.3.

Once the payback periods were computed for each of the scenarios and each of the agent types (detailed in Appendix E.5, along with the applicable average tariff for each agent type from 2022 to 2046), the factor pb_i for an agent type is given by the following equation:

$$pb_i = 2 - \frac{payback\ period\ in\ time\ step\ i\ in\ the\ scenario}{payback\ period\ in\ time\ step\ i\ in\ BAU}$$

Naturally, pb_i was equal to 1 for the optimistic scenario at all time steps and agent types.

The neighbourhood effect factor, ne, varies with the agent type but is constant for all scenarios. It is triggered for an eligible household in time step i if within a certain vicinity (in this model, the vicinity radius is set to 8 patches) another household has already adopted a PV module (essentially, by time step $i - 1$). The magnitude of ne was set to 1, 1.5 and 2 for low-consumption, mid-consumption, and high-consumption reference households respectively. This was because a conflict in perception was unearthed between respondents from the three consumption bands during the interviews for the homeowners' risk perception matrix (see Section 32.3) when questioned whether they would be inspired to install a system if their neighbour had done so. Respondents from the low-consumption subgroup disagreed with such an influence, whereas it seemed to matter increasingly more for mid and high-consumption subgroups, which is reflected in ne.

Finally, the factor k represents the effect of awareness and information dissemination campaigns which varies with the scenario but is consistent across the agent types. It was set to 0.75, and 2 for the conservative and optimistic scenarios respectively. This was because the lack of and/or access to information regarding the installation process or financial incentives available was already identified to be a pronounced barrier by the governmental and homeowners' stakeholder groups in their respective risk perception matrices (see Section 3.2.1 and 3.2.3). Therefore, a further constriction in measures toward information dissemination in the conservative scenario would have a lesser effect on potential adopters compared to BAU. However, the presence of this information was perceived to have a significantly positive effect in comparison to BAU.

The variation in factors pb_i, ne and k are summarised for the conservative and optimistic scenarios and the respective agent types in Table 6.

Table 6: Variation in factors pb_i, ne and k for the conservative and optimistic scenarios and the respective agent types.

Scenario	Agent Type	Payback period factor (pb_i)	Neighbourhood Effect factor (ne)	Information dissemination factor (k)
Conservative	Low	Calculated for i	1	0.75
	Mid	Calculated for i	1.5	0.75
	High	Calculated for i	2	0.75
Optimistic	Low	1 for all i	1	2
	Mid	1 for all i	1.5	2
	High	1 for all i	2	2

Output:

In each run, the model simulated the yearly cumulative number of PV modules adopted within each agent type from 2022 to 2046. Consequently, the simulations were repeated for 50 runs for each scenario from which the average yearly cumulative number of PV modules adopted within each agent type from 2022 to 2046 was computed.

Following this, the yearly cumulative capacity of rooftop PV systems installed was computed. An agent adopted a PV module of capacity dictated by the type they fell into. In essence, low-consumption reference households always adopted a system of the capacity of 2.81 kW, mid-consumption reference households adopted a system of the capacity of 3.16 kW and high-consumption reference households always adopted a system of the capacity of 5.22 kW (see Table 15, Section 3.3.1). Furthermore, for this projection, the PV module lifespan was assumed as 25 years (as in Table 3). Additionally, a household that had installed a PV module, upon completion of its lifespan, install another one of the same capacities immediately.

3 Results and interpretation

This chapter is divided into three subsections according to the part of the thesis it addresses (Figure 2, Section 2.2). In the first subsection (Section 3.1), the status-quo of the energy and in particular rooftop solar PV sector in Mahé is detailed. The subsequent Section 3.2 addresses Part 2 (RQ1) and unveils the stakeholder-specific risk perception matrices along with their interpretation. Finally, Section 3.3 presents the results of the economic analysis and the ABM, again accompanied by their interpretation (RQ2). The results from the status-quo analysis are used in the remaining two parts, and similarly, the results from the semi-structured interviews conducted for part two (Section 3.2) are used in the final part (Section 3.3) (see Figure 2).

3.1 Status-Quo Analysis

3.1.1 Renewable energy on Mahé

Seychelles is almost completely dependent on fossil fuel imports to meet its energy requirements. For the year 2019, the country imported 392,364.6 tonnes of oil equivalents (TOE) of various types of fossil fuels, namely Gasoline, Gasoil, Fuel Oil, Jet A1, LPG, and Avgas (Seychelles Energy Commission, 2020). During the same period, only 1,222 TOE were accounted for as primary energy production, from fuelwood & charcoal, solar PV, solar thermal, and wind energy, essentially, renewable energy sources. This amounted to a contribution of 0.8% to the overall Primary Energy Consumption (PEC) (Seychelles Energy Commission, 2020).

Naturally, this has a direct effect on the country's Power Generation Mix (electricity mix, see Section 1.1.2). PUC operates two power stations on Mahé: Victoria B (capacity of 28.8 MW) and Victoria C (capacity of 75.8 MW) (PUC, 2021). Furthermore, the electricity generated by PUC increased at a rate of 4.5% per year between 2010 and 2019 to keep up with the rise in demand (Seychelles Energy Commission, 2020).

On Mahé, there are two sources of renewable energy that are used to generate electricity: solar PV technology and wind turbine technology. Here, "solar PV" technology includes both rooftop installations and solar farms. Currently, there exists a 5 MW solar farm on Ile de Romainville which is permanently tied to the national grid (Seychelles Energy Commission, 2020). Additionally, as part of the "Democratization of PV" project, following a grant from the Indian government, another 1 MW solar farm was installed on Ile de Romainville in 2020 (PUC, 2021). Apart from this, a 4 MW floating solar farm is planned to be constructed soon on the lagoon at Le Rocher. The project has been delayed due to supply chain restrictions caused by the COVID-19 pandemic (SEC, 2022c).

A 6 MW wind farm is also operational since 2013 at Ile du Port and Ile de Romainville. However, as Figure 8 shows, the amount of electricity generated from the farm decreased drastically in the year 2019 from 2018, before picking up again in 2020. The reason for the low efficiency of on-shore wind turbines is attributed to the unfavourable wind characteristics on the coastline where the current wind farm is situated (SEC, 2022c). Hence, there are no plans to construct further on-shore wind farms (EDP International, 2019; SEC, 2022c) (see Section 1.1.3). In contrast, a gradual rise in rooftop PV installations on Mahé has fuelled a consistent growth in the electricity they have produced (see Figure 8).

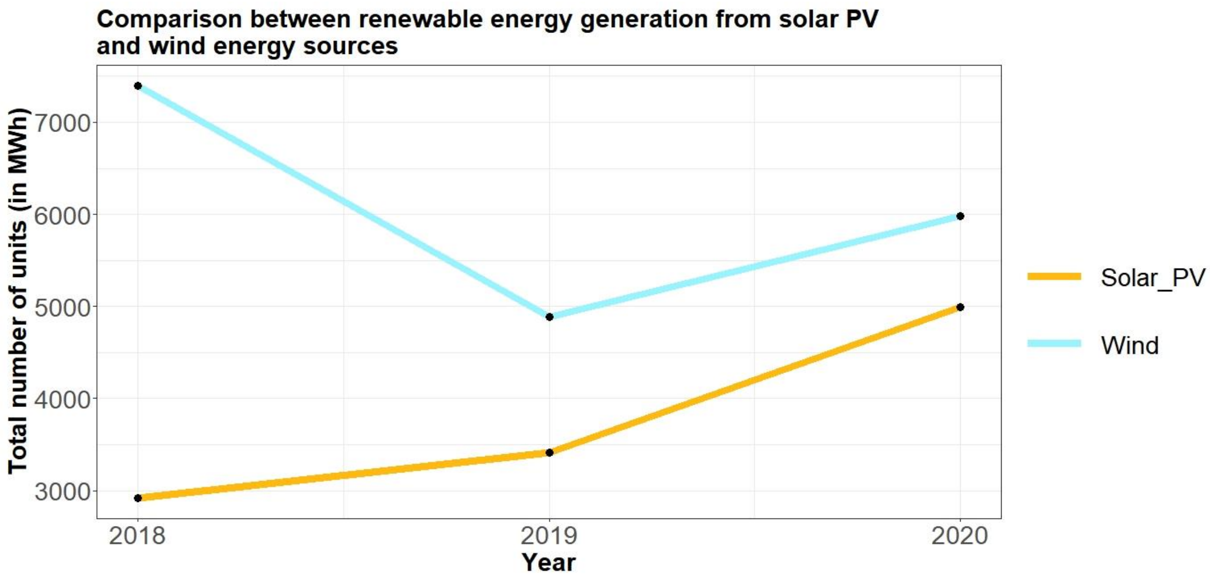

Figure 8: Evolution of electricity generated through renewable energy sources between the years 2018 and 2020 (adapted from PUC, 2021).

Apart from the rooftop solar installations on private commercial entities and households, PUC produced the rest of the electricity on Mahé, forming a monopoly. It is also important to note that PUC operates the 6 MW solar farm on Ile de Romainville, along with the 6 MW wind farm at Ile du Port and on Ile de Romainville (PUC, 2022d; SEC, 2022c). The solar farms were only commissioned in 2021, and hence, their annual electricity generation figures are not available yet.

3.1.2 Legislative & institutional framework and policy & regulatory landscape

3.1.2.1 Legislative & institutional framework

In this subsection, the legislative framework and the resulting institutional machinery related to solar PV technology in Seychelles are discussed. Three legislations are immediately relevant to this institutional arrangement: the Public Utilities Corporation Act, 1986, the Seychelles Energy Commission Act, 2010, and the Energy Act, 2012.

They are discussed chronologically beginning with the Public Utilities Corporation Act, 1986 which set up PUC. The Act lists “supply of electricity”, “supply of water”, and “the provision of sewerage” as the primary functions that PUC is entrusted with, apart from any “such other functions as may be conferred” by any other Act or “by any regulation made under” the Act (Public Utilities Corporation Act, 1986, p. 2). It also grants PUC the power to do “all things necessary” to supply electricity, water, and sewerage, but is also required to comply with any direction issued by the Ministry in the performance of its functions.

In 2010, efforts to regulate the energy sector in Seychelles by an independent body resulted in the enactment of the Seychelles Energy Commission Act, 2010, which established the SEC. It was entrusted with the objective of “ensuring the provision of adequate, reliable, cost-effective and affordable energy while protecting and conserving the environment” (Seychelles Energy Commission Act, 2010, p. 3).

In 2012, this Act was repealed and replaced by the more comprehensive Energy Act, 2012, which re-established SEC with the same objectives as in the Seychelles Energy Commission Act, 2010. In pursuit of achieving them, SEC is required to perform a wide variety of sixteen separate but interconnected “functions”(Energy Act, 2012, p. 88). The relevant “functions” for this analysis include “formulate the national energy plan and implement the national energy policy”, “promote energy efficiency and conservation of energy and the use of renewable energy”, and “periodically review the electricity tariffs of the Public Utilities Corporation, other transmission, distribution operators and network users” (Energy Act, 2012, p. 88-92).

Thereby, the Act allocates the responsibility of regulating the electricity sector and promoting renewable energy and energy efficiency initiatives to SEC. Regarding the electricity sector, the Act provides that SEC shall “regulate the generation, transmission, distribution, supply and use of electrical energy”, “oversee the efficient functioning and development of the electricity sector and security of electricity supply”, and “ensure efficient supply of electricity” (Energy Act, 2012, p. 90).

Similarly, as part of its renewable energy measures, SEC shall “create and promote public education and awareness programs on such issues” and “conduct research and provide recommendations to the Minister on ways to promote renewable energy and support options such as feed-in tariffs and power purchase agreements (PPAs)” (Energy Act, 2012, p. 90). Furthermore, the Act specifically permits the use of Independent Power producers (IPPs), competitive tender processes, and PPAs for the development of new electricity resources. In the performance of its duties, the Act provides that “the Commission shall not be subject to the direction or control of any authority in its day-to-day management” (Energy Act, 2012, p. 92).

Apart from the establishment of SEC, the Energy Act, 2012 also designates PUC as the “principal system operator” and is required to “coordinate power supply to obtain an instantaneous balance between generation and consumption” (Energy Act, 2012, p. 112). This is an important responsibility, especially considering the related technical eventualities that widespread adoption of distributed electricity generation systems, like rooftop solar PV systems, can create on the national common grid.

Therefore, the institutional arrangement consists of three separate entities: the Ministry of Agriculture, Climate Change and Environment (MACCE) which is led by a popularly elected Minister; the independent energy regulator Seychelles Energy Commission (SEC), which provides advice to MACCE; and finally, the principal system operator Public Utilities Corporation (PUC) which is responsible for most of the energy generation and transmission including maintaining and upgrading the national grid.

3.1.2.2 Policy and regulatory landscape

In this subsection, the policy and regulatory landscape concerning rooftop solar PV technology in Seychelles are detailed. The most important policy document concerning this field is the National Energy Policy, 2010 – 30 (NEP) (van Vreden et al., 2010) which seeks to guide the country’s sustainable development concerning its energy sector through to 2030. It sets out three “core elements”: land transportation, consumption of electricity, and production of electricity. For this thesis, “production of electricity” is the focus, wherein NEP set targets of 5% and 15% penetration of renewable energy in the country’s electricity mix by 2020 and 2030 respectively. These goals have been further amplified on the global stage in Seychelles’ recent submission under the Paris Agreement (UNFCCC, 2015): “Seychelles’ Updated national Determined Contribution” (Government of Seychelles, 2021).

Furthermore, NEP details a “strategic vision” for energy policy comprised of nine goals framed around the several challenges concerning Seychelles’ energy sector at that time, like the dependence on imported oil and the need to improve the energy security of the country. In the long term, NEP’s vision foresees that the energy supply will be diversified to such an extent that “100% of it will be based on renewables”, and that “both public and private participation” will play a part in this. Three other goals of this vision are important for this thesis: “energy supply must not give rise to pollution exceeding critical levels”, “energy will be priced to consumers at its true cost” and “investments will be made to reinforce the image of Seychelles as energy-conserving, GHG friendly and sustainable”.

As mandated by the Energy Act, 2012, SEC is responsible to “recommend standards related to renewable energy”. Consequently, SEC has defined the technical standards for grid-connected PV power systems (SEC, 2014) which must be adhered to if a company would like to earn the annual endorsement of SEC (SEC, 2022a). Only those companies who have procured such an endorsement are permitted to supply and/or install, PV systems in Seychelles, and PUC shall commission PV applications only by such companies. Ensuring the adherence to technical standards (SEC, 2014) and conducting the endorsement process (SEC, 2022a) by SEC takes place simultaneously with the enforcement of the Grid Code (DNV.GL, 2018) by PUC as the principal system operator (Energy Act, 2012).

3.1.2.3 Assessing the legislative framework and institutional setup

According to PUC, 2021, Seychelles' electricity mix for 2020 was: HFO at 86.9%, LFO at 10.4%, wind energy at 1.4%, and Solar at 1.3%. This amounts to an RE penetration of 2.7% against the target of 5% set in the NEP. Following this, SEC requested assistance from the consultancy firm Cadmus Group to conduct a review of the NEP and the legislative framework which led to the production of three analysis reports (Cadmus Group, 2019a, 2019c, 2019b).

They conclude that the implementation of the NEP faces several challenges, divided into three areas of concern: governance, incentives/programs, and capacity (Cadmus Group, 2019a). On the governance side, it has been pointed out that there are issues aligning the responsibilities, powers, and capacities of PUC and SEC. This was also apparent while conducting the expert interviews (see Section 2.2.3), with representatives from both organizations bringing up the lack of clarity in the separation of authority and responsibilities (PUC, 2022d; SEC, 2022c). This amounts to a challenge that needs to be addressed at the institutional level.

However, the genesis of the issue seems to be at the legislative level as pointed out in the Legislative Analysis (Cadmus Group, 2019b). It has been highlighted that the regulatory authority provided to PUC through the Public Utilities Corporation Act, 1986 is at odds with the provisions of the Energy Act, 2012, which establishes SEC as an independent regulatory body. Additionally, the extensive scope of the Energy Act may be prohibitive for SEC's proper execution of its regulatory role (Cadmus Group, 2019b).

3.1.3 PV Sector in Seychelles

This subsection contains two parts. In the first, the historical trends and the current status of rooftop solar PV installations in Mahé are presented systematically. In the second, the installation process, compensation mode for produced electricity and, financial incentives put in place to accelerate the adoption of such systems are detailed.

3.1.3.1 Historical trends and current status of rooftop solar PV installations in Mahé

A systemic analysis of the PV installations for the entirety of Seychelles can be found in Appendix C.2. Until March 2022, the cumulative capacity of installations in all of Seychelles was 6631.3 kW (660 installations in total) (Appendix C.2) of which 582 were in Mahé. These installations are analysed based on their sectorwise distribution (Figures 9 and 10) and based on the investment mode (Figures 11 and 12)

Countrywide patterns for sectorwise distribution (Appendix C.2) were replicated also on Mahé. Of the total installed capacity on Mahé (5660.8 kW), 65.1% (3630 kW) was accounted for by only 152 commercial installations (out of 582), resulting in an average commercial installed capacity of 23.9 kW. The remaining 430 domestic installations accounted for 2030.8 kW (35.9%) at an average installed capacity of 4.7 kW. These analyses also account for free installations.

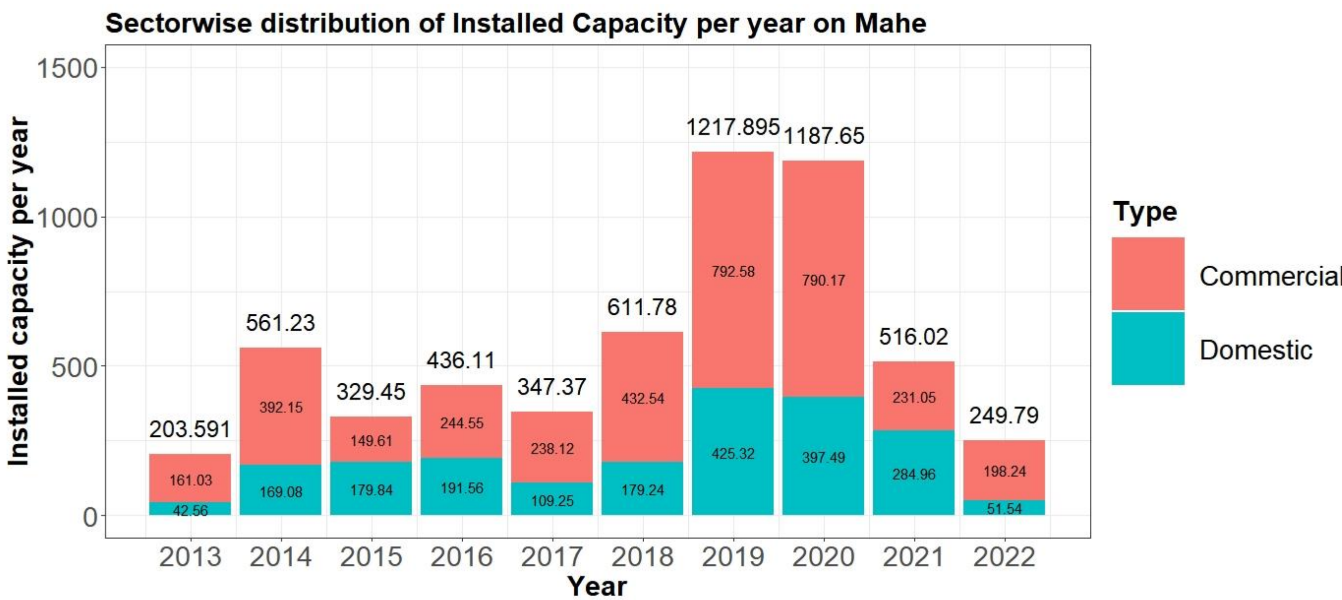

Figure 9: Yearly sector-wise distribution of installed PV capacity in kW on Mahé.

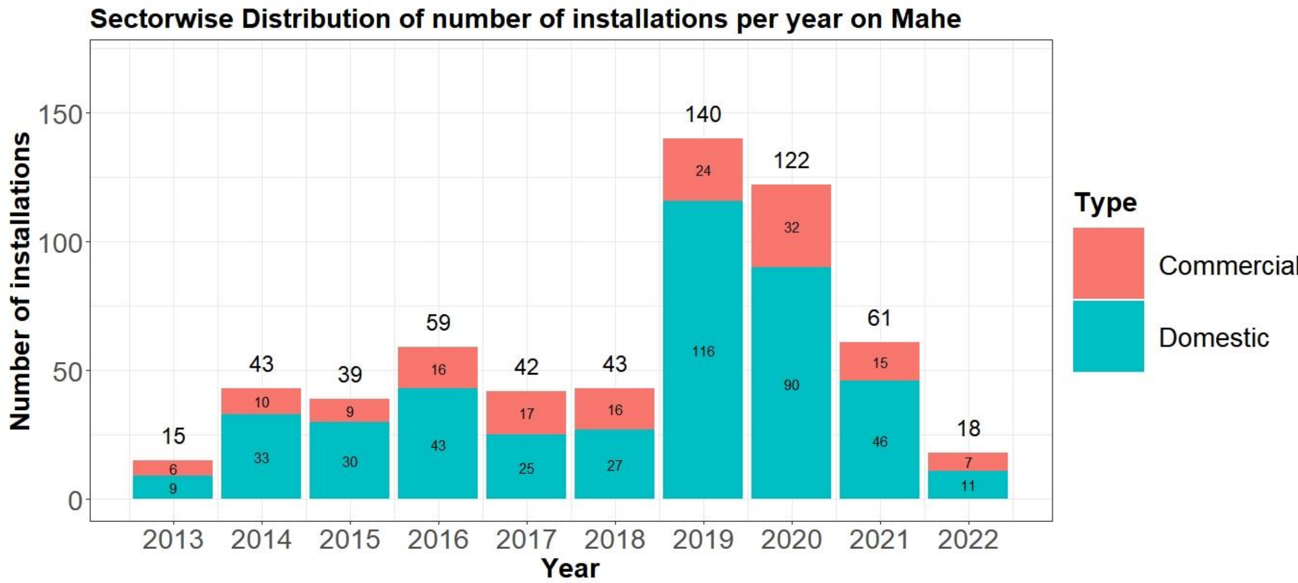

Figure 10: Sector-wise distribution of installation counts on Mahé.

Further, it is important to note two separate projects which made free installations in Seychelles. In Figure 11 and Figure 12, they are referred to as "grant" and are differentiated from privately financed installations (referred to as "bought"). The first project was an undertaking of the GoS, wherein free installations were made on 15 homes on Mahé in 2016. The second project was part of the Democratization of PV initiative (PUC, 2021; Seychelles Energy Commission, 2020) wherein 132 free installations were made, 122 in the domestic sector and the remaining 10 in the commercial sector (all on governmental buildings) between 2019 and 2020. In total, 147 such installations were commissioned. The remaining 435 installations (from a total of 582 installations on Mahé) were "bought" and accounted for 83.5% (4728.62 kW) of the installed capacity, against the 16.5% (932.3 kW) by "grant" installations. 2020 was the best year in terms of installed capacity of the "bought" category.

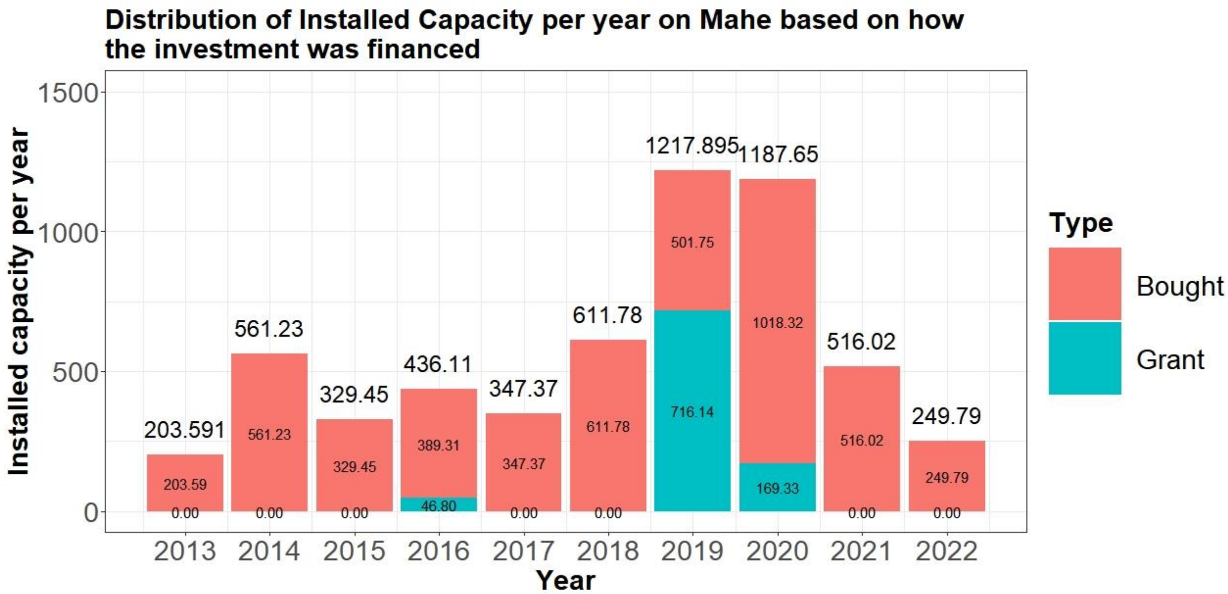

Figure 11: Distribution of installed yearly capacities on Mahé in kW based on how the investment was financed.

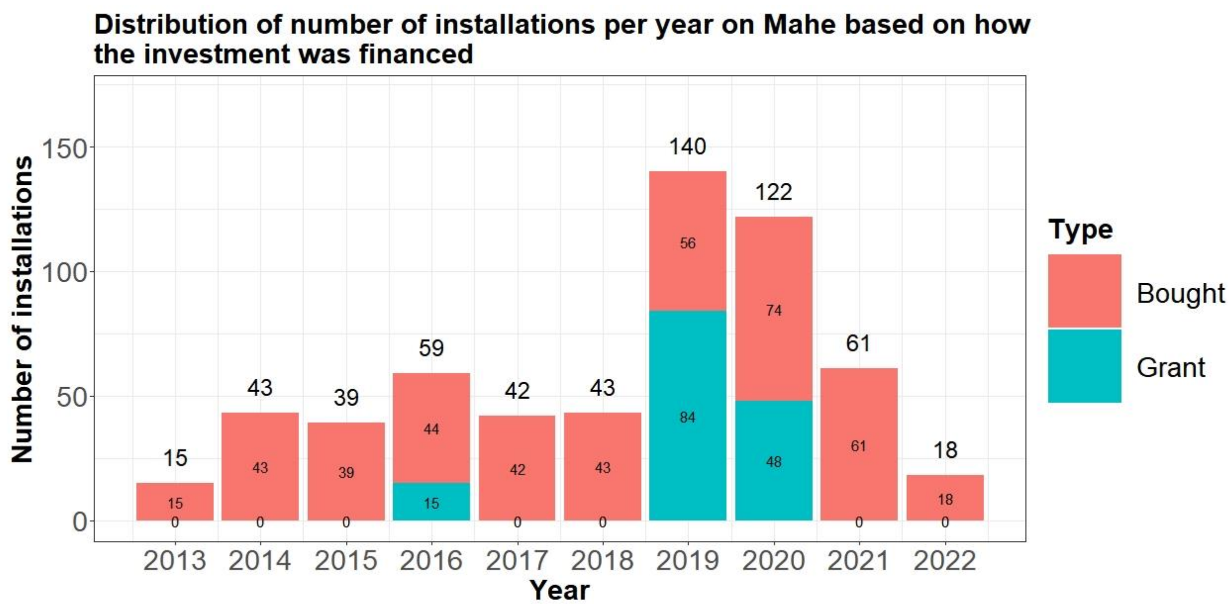

Figure 12: Distribution of yearly installation counts on Mahé based on how the investment was financed.

Finally, the distribution of yearly capacity and the number of installations made within the domestic sector on Mahé which were "bought" between 2017 and March 2022 are depicted in Figures 13 and 14 respectively.

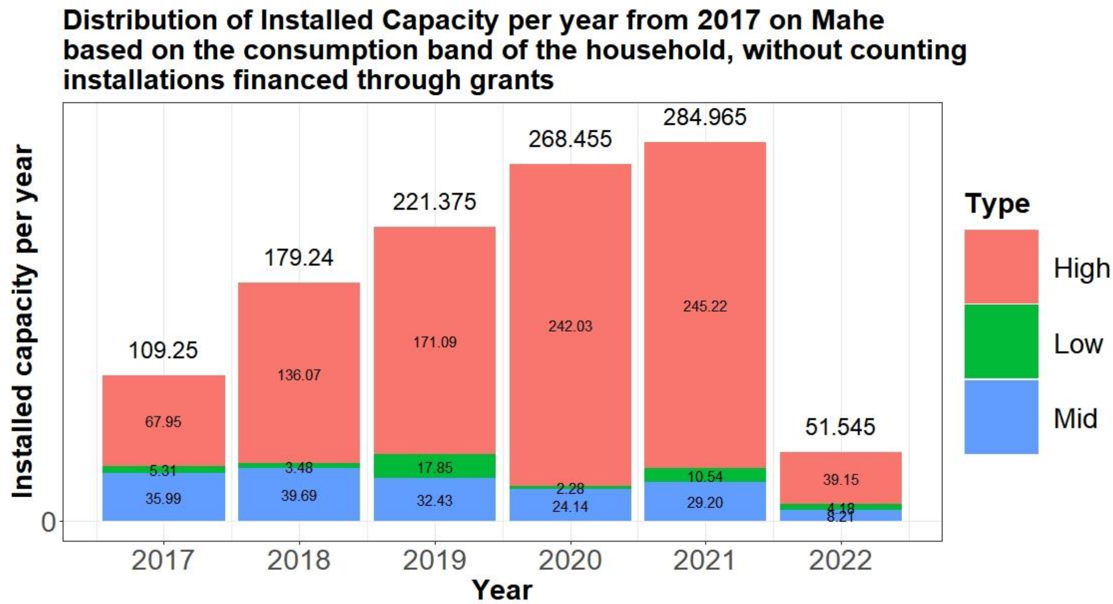

Figure 13: Distribution of installed capacities within the domestic sector on Mahé based on the electricity consumption band the household fell into from 2017 to March 2022.

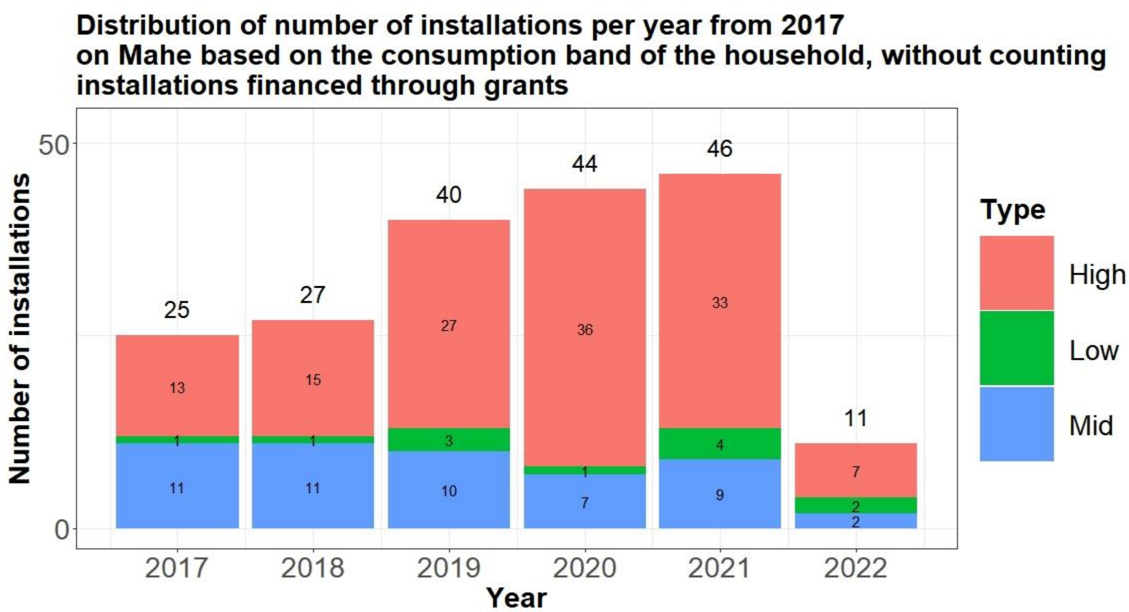

Figure 14: Distribution of installed yearly counts within the domestic sector on Mahé based on the electricity consumption band the household fell into from 2017 to March 2022.

From the beginning of 2017, 1114.8 kW of installed capacity was accounted for by 193 households: 67.9% (131) high consumption, 25.9% (50) mid consumption and, 6.2% (12) low consumption. It is clear from Figures 13 and 14, that there is a gradual growth both in the installed capacity and installation count amongst households in Mahé. Note that the numbers for 2022 account only up to the 22nd of March.

3.1.3.2 Installation Process, compensation, and financial mechanisms

The applications for rooftop solar PV installations are made to SEC, who subsequently forward it to PUC where its technical viability is scrutinised (SEC, 2022b). Among other factors, the location of the proposed system and its size can have an impact on the national grid for which PUC is responsible. Consequently, they conduct site visits before approving, advising size reduction, or rejecting a proposed system. In the latter two cases, they also provide reasons for their decision. Some of them include, but are not limited to (PUC, 2022c):

- Small transformers and rationing of their capacity: In the case of connecting multiple PV systems to a distribution transformer, the latter's rating may not be exceeded which can result in overloading. This problem is of particular concern in areas supplied by small transformers (sometimes with a rating of only 25 kVA). When a large system (greater than 5kW) is connected to a small transformer, it reduces the possibility of future connections by other customers connected to the same transformer.
- Reverse power flow during the peak production period and voltage rise: Often, a PV system's peak production period coincides with those of low energy consumption, resulting in reverse flow of power, which beyond certain thresholds, can lead to voltage rise beyond allowable limits (253V). This may damage consumers' electrical appliances or may result in the PV inverter shutting down. Low-voltage domestic grids and industrial/commercial grids during holidays are particularly susceptible to this impact.
- Distance from transformer: the further a consumer is from the transformer, the higher the voltage rise can be.
- Domestic System capacity cap: electricity generated by a domestic consumer per month may not exceed their average monthly consumption.
- Commercial System capacity cap: for systems with a capacity less than 10 kW, electricity generated by a commercial consumer per month may not exceed their average monthly electricity consumption; for over 10 kW, electricity generated by a commercial consumer per month may not exceed half their average monthly consumption.
- In any case, systems exceeding 100 kW are not permitted

Furthermore, the system capacity for domestic consumers is approved in such a way that electricity generated by a domestic consumer per month may not exceed their average monthly consumption. Similarly, for commercial consumers, electricity generated per month may not exceed half their average monthly consumption.

PUC's decision, along with a quote of the connection fees if applicable, is then communicated to the applicant by SEC, and they may choose to accept the decision or abandon the project. If they choose to accept it, SEC issues a "Registration Certificate" indicating the capacity of the system permitted to be installed along with a period within which it should be completed. Upon receipt of the connection fee, and after the installation is completed by an endorsed installer, PUC conducts another site visit to test the technical performance of the system before finally commissioning it. Usually, the installation companies process the applications on behalf of their clients.

Currently, both domestic and commercial consumers are compensated according to a Net Billing System for on-grid installations, wherein the units produced in a month are negated from the units they consume before calculating the bill for that month. Hence, the compensation is directly in terms of units of electricity (kWh) and not tariff rates.

To accelerate the deployment of rooftop PV systems, GoS has devised three financial mechanisms to help reduce the upfront cost or make its financing cheaper (SEC, 2022c). This includes:

- **Value Added taxes (VAT) Exemption:** The Value Added Tax Act, 2010 was amended in 2014 (Value Added Tax (Amendment of Schedules) Regulations, 2014) such that "goods imported to be used in the process of conservation, generation or production of renewable energy or environment-friendly energy sources as endorsed by the Seychelles Energy Commission" are exempt from VAT. Consequently, SEC has devised a process through which importers can apply for VAT exemption of such products, which include rooftop solar PV equipment (panels, inverters, wiring, etc). All the rooftop solar PV systems installed to date have benefitted from VAT exemption and continue to do so.
- **Seychelles Energy Efficiency and Renewable Energy Programme (SEEREP) subsidised loans:** As part of this program, households and Small-Medium Enterprises can purchase Rooftop solar PV equipment through loans of up to 150,000 SCR at 5% interest rates over 5 years. This scheme is still active (SEC, 2022b, 2022c).
- **Rebate Scheme as part of the implementation of the GoS-UNDP-GEF Grid connected rooftop PV systems in Seychelles program:** From 2014 until March 2022, both commercial and residential consumers could benefit from a rebate scheme which compensated a certain percentage of their upfront installation costs until a threshold. This rebate was transferred after their system had been commissioned by PUC. Residential benefactors were compensated 25% of the upfront cost until a threshold of SCR 25,200, and commercial benefactors 15% of the upfront cost until a threshold of SCR 86,400. The scheme was discontinued in March 2022, after running out of funds.

However, SEC and MACCE have expressed the intention to renew the funds given its success (MACCE, 2022b; SEC, 2022c).

3.1.4 Important stakeholders

Four distinct stakeholder groups were identified as listed in Table 7.

Table 7: Stakeholder groups involved in the effort to increase the solar rooftop PV installations on Mahé.

Stakeholder groups	Description
Governmental stakeholder	Include SEC, PUC and MACCE, representing the energy regulator, principal energy system operator, and the Ministry responsible for the energy sector.
Commercial stakeholders	Includes privately-owned entities who can install rooftop solar PV systems or have already done so, including “auto-producers”.
Homeowners/Residential Stakeholders	Imply residential property owners who can make rooftop solar PV installations or have already done so.
PV industry operating on Mahé	Includes the 6 currently “endorsed” PV installers/suppliers, who are responsible for importing and undertaking all the installations on Mahé (see Section 2.2.3).

In addition to rooftops of households and commercial entities, installations can also take place on governmental buildings. However, the decision-making responsibility regarding such installations lies with MACCE and SEC, who already comprise the “governmental stakeholder group”.

3.1.5 PUC’s Electricity Tariff and the distribution of domestic customers on Mahé

This subsection presents the current tariff rates of PUC’s electricity levied on its domestic and commercial customers, followed by the distribution of domestic customers on Mahé.

3.1.5.1 Domestic customers

In 2019, Macros Consulting released a report analysing PUC’s tariffs for the year 2018 based on data supplied by PUC (Macro Consulting, 2019). With 33,316 customers, the domestic sector amounted to 82.6% of PUC’s client base (out of a total of 40,337) but consumed only 32.8% of the total energy produced by PUC (which amounted to about 386.3 TWh) in 2018 for the entirety of Seychelles. Both PUC and SEC confirmed that these numbers are also proportionally true for Mahé today (PUC, 2022d; SEC, 2022c). Due to the cross-subsidisation, the tariffs are set in such a way that the average tariff across the domestic sector is maintained at 2 SCR/kWh and between 3.8 SCR/kWh and 4.6 SCR/kWh within the commercial sector (Macro Consulting, 2019; PUC, 2022d). Furthermore, the average consumption of a household in Seychelles for 2018 was 317 kWh/month.

The domestic electricity bill consists of two parts: demand charges and variable charges. Demand charges are levied based on the electrical load (in kVA) categorization of a household, which may be “Tariff-110”, “Tariff-120”, or “Tariff-130”. A household is categorized into “Tariff-110” if their electrical load is 2.4 kVA or less, into “Tariff-120” if it is above 2.4 kVA but less than 9.6 kVA, and into “Tariff-130” if it is greater than 9.6 kVA. Based on this categorization, separate power demand charges are levied per kVA as shown in Table 8.

Secondly, the variable charges are based on the electricity consumption of the household. As shown in Table 8, they increase in 5 “blocks”, with a major jump from the second to the third.

Table 8: Domestic Tariff, May 2022 (PUC, 2022b).

Consumption bracket	Tariff-110 (SCR/kWh)	Tariff-120 (SCR/kWh)	Tariff-130 (SCR/kWh)
Power Demand Charge in SCR/kVA	0	4.9	9.85
0 to 200 kWh	1.57	1.57	1.57
201 to 300 kWh	1.86	1.86	1.86
301 to 400 kWh	3.5	3.5	3.5
401 to 600 kWh	3.9	3.9	3.9
More than 600 kWh	4.55	4.55	4.55

PUC from time to time conducts tariff adjustments based on the impact of fuel prices (PUC, 2021). The last major electricity tariff revision happened between 2012-13.

3.1.5.2 Commercial customers

Similarly, commercial customers are categorized based on their electrical load demand and if they are serviced by a single or three-phase supply into “Tariff-210” (less than or equal to 200 kWh/month), Tariff-220 (more than 200 kWh/month), Tariff-310 (less than or equal to 200 kWh/month), Tariff-320 (more than 200 kWh/month). In Table 9, “Tariff-210” and “Tariff-310”, accounting for commercial customers consuming less than 200 kWh per month are omitted.

Table 9: Commercial Tariff, May 2022 (PUC, 2022b).

Consumption bracket	Tariff-220 - Single-Phase - (More than 200 kWh/month) (SCR/kWh)	Tariff-320 - Three-phase - (More than 200 kWh/month) (SCR/kWh)
Power Demand Charge in SCR/kVA	16.65	16.65
0 to 500 kWh	4.01	4.01
501 to 1000 kWh	4.37	4.37
More than 1000 kWh	4.94	4.94

3.1.5.3 Distribution of domestic customers on Mahé

Table 10 shows the distribution of PUC's domestic customers on Mahé according to the consumption bands (see Section 2.2.4.3).

Table 10: Distribution of domestic consumers in 2021 (Source: PUC).

Consumption band	Number of Customers	Share in percentage
Low - 0 to 300 kWh	19204	60.6
Mid - 301 to 600 kWh	9658	30.5
High - 601 kWh	2820	8.9
Total	**31682**	**100.0**

Over 60% of PUC's domestic customers on Mahé were from the low-consumption band, and the mid and high-consumption bands contributed about 30% and 9% respectively.

3.2 Risk Perception Matrices

3.2.1 Governmental Stakeholder Group

Here the individual perceptions of risks and opportunities were solicited from each stakeholder (MACCE, SEC, or PUC) regarding the process of increasing the deployment of rooftop solar PV systems for the entirety of Mahé, i.e., at the *systemic* level. However, stakeholders often cite issues at the micro or individual consumer level (either domestic or commercial) while justifying the uncertainties that they perceive. The derived uncertainties are further grouped into risks & barriers, and synergies & benefits, and, where possible, they are further classified into subgroups if they fall into the same context (for example, economical risk, social barriers, etc). Furthermore, if an "uncertainty" applies only to domestic or commercial consumers, this is indicated. Where feasible, the raised uncertainties are justified with literature or data analysis.

Apart from unearthing uncertainties at the systemic level, the matrix reveals how the governmental stakeholders currently associate these uncertainties with issues at the consumer level.

Table 11: Risk Perception Matrix for the governmental stakeholder group.

Risk Perception Matrix – Governmental Stakeholder Group – MACCE, SEC, and PUC	
Risks	
I. Implementation Risks - Barriers	**II. Consequential Risks – Negative Outcomes**
1. Information barrier 2. Economic barriers a. High upfront cost b. Difficult to obtain low-cost financing c. Perceived lack of tangible benefit d. Competing Investment options – Households e. Long pay-back period – Households f. Winding down the rebate program 3. Geographical and roof-related barriers a. Location and shade b. The structural strength of roofs and suboptimal inclination 4. Technical Barriers a. Limitations posed by the current state of the grid – Capacity caps b. Battery storage discouraged 5. Institutional Barriers a. Inertia to move away from the “old system” and PUC’s business model b. Subdued role of SEC	1. Technical Risks a. Increased urgency to overhaul the distribution network and generation capacity at high capital costs b. Incremental technological improvements – Lock-in of obsolete tech 2. Rise in safety risks for PUC grid workers 3. End-of-life management

Opportunities	
III. Synergies - Enablers	**IV. Benefits – Positive Outcomes**
1. Geographical Enablers 2. Environmental awareness – People do their bit	1. Economic benefit for adopters and PUC 2. Energy Security and reduction in forex lost to fuel imports 3. Reducing the environmental impact of electricity production and achieving stated commitments improves Seychelles' standing in international fora on climate action 4. Provide a boost to the tourism industry

The individual elements are further deliberated on below, in the order that they appear in the table.

3.2.1.1 Implementation Risks - Barriers

1. Information barrier

According to SEC, people are generally aware of renewable energy and PV technologies, but they don't fully comprehend the technical challenges that come due to its intermittency. Furthermore, most people are not aware of the application process and incentive programs available. Understanding the regulations, costs, and benefits of installing the system, and the pay-back period concept is often difficult during the initial stages. During this phase, successful adopters were usually assisted by the installation companies.

However, PUC believed this information barrier is reducing gradually:

"People are aware of it, definitely in the past two years, there's a growing awareness and it is growing especially amongst the youth."

Additionally, SEC is undergoing a restructuring (SEC, 2022c) due to which its website has not been functional. As SEC is responsible for information dissemination and promoting the adoption of renewable energy technologies (Energy Act, 2012), this creates a constraint on the *availability* of information itself. Hence to obtain information, adopters mostly rely on installation companies, friends or neighbours who have already made an installation, or contact SEC directly.

2. Economic barriers

a. High upfront cost

Today, on average PV module costs vary from 20,000 to 25,000 SCR per kW of installed peak capacity depending on the installation company. Governmental stakeholders believe that although people generally want to adopt these systems, this high upfront cost imposes the biggest barrier. This is especially the case for low- and middle-income households and less so for high-income households and large commercial entities.

b. Difficult to obtain low-cost financing

According to SEC, low- and middle-income households, along with Small and Medium Enterprises (SMEs) tend to seek low-cost financing to buy the systems. Identifying this, the SEEREP loan scheme was instituted (Section 3.1.3.2). However, the process to obtain the SEEREP loan is perceived to be difficult. The number of beneficiaries who installed PV systems is low. This may be because, in general, people don't like to take loans, especially potential residential adopters.

Furthermore, the banks limit the amount of loan one can take to 40% of one's earning capacity which may be insufficient to finance a complete system (SEC, 2022c). The banks mainly target SMEs and larger commercial entities.

c. Perceived lack of tangible benefit

In the Net Billing System that currently exists, the benefit of investing in a PV system is derived from the reduced electricity bill costs. In other words, one would save money by not having to spend it, and not by generating it. Furthermore, adopters do not experience tangible benefits, which SEC expressed as:

"Compare this investment to where one buys a car. They can immediately drive away and use it. This is not possible with PV. There is a somewhat hidden benefit to them but comes with a high upfront cost. This may discourage some people unless they realise that it makes a lot of sense in the long run."

d. Competing investment options - Households

Often for low- and middle-income households, there are competing investment options for the same amount of money. SEC believed that investment in PV systems for such households is not among the highest priority:

"They would rather buy a car than invest in PV."

e. Long pay-back period – Households generated by the cross-subsidized tariff system

The tariff system on Mahé reflects a cross-subsidization between the commercial and domestic sectors (see Tables 4 and 5; Macro Consulting, 2019). Additionally, for both sectors, variable charges are levied which increase in slabs based on the monthly consumption. For low-consumption (less than 300 kWh monthly) and mid-consumption (between 301 and 600 kWh monthly) households, the electricity bills are comparatively lower compared to high-consumption households (greater than 600 kWh) as they do not penetrate the higher and more expensive slabs (Section 3.1.5).

This combined with the capacity cap, wherein domestic consumers cannot adopt systems exceeding 100% of their monthly consumption and the net billing system (Section 3.1.3.2), implies that such households are forced to install small systems which entail long pay-back periods. Hence, the subsidized electricity tariffs which don't reflect the actual cost of electricity production from PUC (PUC, 2022d; SEC, 2022c) result in long pay-back periods that disincentivise low- and mid-consumption households from adopting the systems. For this reason, a tariff system that reflects the cost of electricity service is seen by SEC as the "biggest incentive" for accelerating PV adoption in Seychelles. This is particularly important as in 2021, 91% of PUC's domestic consumers fell either into the low- or mid-consumption bands. To abate this, SEC elaborated on the need for targeted subsidization:

"Right now, everyone, regardless of their economic situation, is getting a benefit for the first 300 units or so. We want any such subsidies in the future to be more targeted to people who really need them. If we get the tariff to reflect the cost of service, it would be the biggest incentive for accelerating PV adoption in Seychelles."

PUC also recognizes the issue:

"I think there is a lot of inertia, especially for households to make the extra effort to install PV when they are only paying 300 or 600 SCR per month. We want to move to a tariff system where everyone pays something that reflects the cost of production."

As high-consumption households and commercial entities already pay expensive bills, the net billing system facilitates a quick pay-back period, due to which they don't experience this barrier.

f. Winding down the Rebate program

In March 2022, the GoS-UNDP-GEF Rebate Program (Section 3.1.3.2) ran out of funds. The lack of rebate on the upfront cost is viewed by all governmental stakeholders to constitute a major barrier, which would further increase pay-back periods and reduce the affordability of PV systems. However, SEC emphasized the need to revise the terms on which the rebate would be offered in the future:

"Commercial people don't really need it as their payback is already only 2-3 years. But most residential customers will need it. I've requested that the funds be replenished soon."

The MACCE also showed cognisance of the issue and agreed that the program should continue:

"Right now, the only problem is finding the money. But the rebate program has worked, and it should continue if we can find the resources."

3. Geographical barriers

a. Location and shade

SEC stated that the location of the building also may pose a barrier to the feasibility of a proposed system. Several buildings are situated on higher altitudes with one or more of their walls facing the mountainsides, which could cast shadows on the roof for a part of the day. This reduces the yield of a PV system and hence the economic benefit to its adopter.

Furthermore, not all the buildings, even with a sound roof are suitable to install PV. There may be obstructing structures, buildings or trees in the vicinity which cause shade on the roof for a certain period during the day. This is further complicated by the fact that it is illegal to cut most trees in Seychelles, as they are protected by the (Breadfruit and Other Trees (Protection) Act, 1917). Permission must be obtained from the Department of Environment in some cases. Additionally, another challenge arises when shade on the roof of a property owner who is willing to adopt a system, is cast by a tree belonging to their neighbouring property.

SEC also stated that unique micro-climatic effects were observed higher up in the mountains (on Sans Soucis and La Misere roads) resulting in increased formation of clouds and precipitation (EDP International, 2019). Therefore, yields were measured to be lesser in these locations in comparison to buildings on the coast. Further, the yields are higher in the south of the island than in the north.

b. The structural strength of roofs and suboptimal inclination

SEC noted that some buildings on Mahé lacked the structural strength to accommodate solar panels. On average, a 300W solar panel weighs about 20 kg (JA Solar, 2022). Hence a 5kW rooftop system would weigh about 400 kg. The barrier is more significant when considering installations on commercial properties which function out of large warehouses requiring renovation before the installations. The urgency to renovate to install solar panels comes with an added cost which constitutes another barrier for potential adopters.

4. Technical Barriers

a. Limitations posed by the current state of the grid – Capacity caps

Currently, PUC imposes caps on the system capacities that domestic (maximum 100% of monthly consumption) and commercial entities (maximum 50% of monthly consumption) can install. Several reasons are provided for this: to operate within transformer limits on low-voltage transmission lines, to avoid voltage surges due to the distance of a proposed system from a transformer, to ration a transformer’s capacity given possible connections in the future, etc. These reasons are detailed in Section 3.1.3.2. Being the principal system operator, PUC has a monopoly on deciding how much capacity an applicant may be awarded.

SEC states that applicants however find the reasons hard to comprehend and many of them drop the project after their proposed system is downsized by PUC. The network will have to be upgraded in certain locations, especially those serviced by low-voltage lines, to accommodate new PV system connections. PUC acknowledges this matter:

"The network was designed for uni-direction flow from the power station. But now with solar panels, you have distributed energy, which brings issues for network management like voltage frequency fluctuations. To some extent, we can continue operating the grid as it is. But if the number of solar panels connected to the grid increases, then we must upgrade the grid. Like, such as increasing the transformers' capacity to allow more for feed-in of electricity from the other direction or consider batteries at the house and grid level."

b. Battery storage discouraged

In the current Net Billing System, all the electricity produced by an adopter is pumped back into the grid, without the option to store and use this energy. Essentially, the national grid behaves like a battery for individual customers. The governmental stakeholders agree that this reduces the appeal of PV systems to some consumers, as the lack of a storage option implies a lack of electricity during power outages despite "producing one's own electricity".

5. Institutional barriers

a. Inertia to move away from the "old system" and PUC's business model

SEC, as the energy regulator, is mandated to direct and manage the energy transition of the country (Energy Act, 2012). As the adoption of PV systems increases, PUC's role is expected to change from the principal electricity generator and system operator in the country to a more "pragmatic" role, in the eyes of SEC, as a network operator which can ensure the quality of electricity supply and bridging sudden supply shortages. This implies that if many PV systems suddenly default (say, due to a natural calamity) or suffer yield losses (say, due to sustained bad weather), PUC is expected to have the generating capacity to fill the shortages. SEC, therefore, envisages a transformation of PUC's current role:

"It needs to be an entirely new system. The utilities decide the pace and direction at which the energy transition flows. As the sole electricity provider to the country, PUC plays a major role in the country's power sector today and will continue to do so in the future. I firmly believe that their

role will be, sort of like a conductor, a network operator, to ensure that the system will be stable and reliable. For that, we are ready to provide them with all the help and support needed. But their "one leg dragged" approach affects the interests of the whole country."

To achieve this, SEC believes that there is an urgent need to rethink PUC's business model, wherein it is currently responsible for three functions: electricity supply, water supply, and sanitation (Public Utilities Corporation Act, 1986; PUC, 2021). In 2020, almost 83% of its revenue came from its electricity vertical, and the remaining 15% and 2% were generated from the water and sewerage verticals respectively (PUC, 2021). The latter two verticals are consistently loss-making (PUC, 2022d), hence PUC's profitability depends largely on the revenues from its electricity sale. Being a parastatal entity, PUC is a self-sufficient firm, at least in its operational expenses (MACCE, 2022b). However, it believes that as more people adopt PV systems, it would result in the erosion of its electricity revenues, which may explain its capacity caps:

"That's one of our main concerns. Some revenue loss is fine. But the cost of managing the network should be borne by the PV adopters, a fixed demand for instance."

However, PUC also expects some amount of revenue erosion to facilitate an energy transition in the country. Currently, efforts are being made to diversify PUC's revenue channels and they believe that they should be "capable of functioning with lower revenue".

MACCE is aware of the challenge but points out that PUC's amalgamated model, wherein it is responsible for electricity, water, and sewerage, has worked well for the country. But, given the urgency of the matter, foresees that a new model in line with the commitments of the nation must be worked out mutually:

"It works well for certain things but prohibits other things. We must work with them to figure out the optimum model that would work for Seychelles. Today, PUC is self-sufficient in its operations, they receive some support from the government for capital expenses. But we can't wait, we must push for things to happen."

b. Subdued role of SEC

Issues with aligning the responsibilities, powers, and capacities of PUC and SEC have been pointed out before (Cadmus Group, 2019b) and they continue to manifest today. The regulatory authority provided to PUC through the Public Utilities Corporation Act, 1986 is at odds with the provisions of the Energy Act, 2012, which establishes SEC as an independent regulatory body.

Although SEC is mandated to "regulate the generation, transmission, distribution, supply and use of electrical energy" (Energy Act, 2012) both SEC and MACCE agree that it currently lacks the capacity to exercise technical oversight over PUC. For example, SEC perceives that PUC has complete decision-making power while approving the capacity of proposed projects. Due to its lack of technical staff, SEC is unable to verify the downsizing or rejection of applications by PUC. MACCE highlights that the concept of an "energy regulator" is new to Seychelles and that it would "take some time to get an appreciation for the type, size, and structure" that SEC should evolve into, as the "capacity to do all the regulatory work isn't there yet". In line with this, SEC is currently in a restructuring process.

3.2.1.2 Consequential Risks – Negative Outcomes

1. **Technical Risks**

   a. Increased urgency to overhaul distribution network and generation capacity at high capital costs

The technical challenges and risk in the integration of a large amount of distributed intermittent renewable energy is well understood in the literature (Alshahrani et al., 2019; Hung et al., 2016; Nwaigwe et al., 2019). Mahé has a largely "passive" grid, as it is mostly unidirectional power flow from the source to loads (Hung et al., 2016; PUC, 2022d). With higher integration of distributed PV systems, the network becomes an "active" one that has bidirectional power flow, which happens between the load side and the substation (Hung et al., 2016). The consequent challenges include but are not limited to changes in standard load patterns, intermittency of generation, reverse power flow, voltage rise, reactive power support, power quality concerns, and distribution system stability (Hung et al., 2016).

PUC is aware of these challenges along with the solutions needed and foresees that controllable renewable energy generation technologies will play an important role:

"We believe that there are ways of us to reach a high penetration of renewables, but also manage the impacts it may have on the grid. The key is not to rely only on PV for our clean energy portfolio, but also more controllable energy sources like WtE."

The solutions include modern generators which can adapt to the changes in standard load patterns continuously (PUC, 2022d), the use of battery storage systems at the consumer level and at the utility-scale to abate the intermittency of generation (Hung et al., 2016), and energy management systems which coordinate the reactive capability of PV systems' inverters and battery energy storage (BES) to address voltage regulation problem (Alshahrani et al., 2019).

Several studies have also been conducted for Mahé exploring the limits of the current system, and the measures that need to be taken for higher integration of intermittent sources (EDP International, 2019; Okinawa Enetech, 2016; PUC, 2022c; Quadran International, 2019; SEC, 2014). Importantly, to cope with the 6 MW solar farm under PUC's management (Section 1.1.3), a utility-scale battery of 3.5 MWh capacity is operational to help smooth the fluctuation in energy output (Seychelles Energy Commission, 2020).

The implementation of these solutions translates to high capital costs which may have been avoided in a fossil-fuel-based system. PUC is unclear as to how these additional investments would factor into the tariff system:

"*There is the installation cost to buy the equipment, but also a question of how to generate revenue from them. Like battery storage, they ensure stable energy supply, but it does not factor in the calculation of the tariff directly. The main component we consider there currently is the fuel. Also, it shouldn't be that everybody pays for the battery whether they use it or not.*"

b. Incremental technological improvements – Lock-in of obsolete tech

SEC is responsible for the technical standard of PV equipment installed in the country (Energy Act, 2012) and noted that the efficiency of PV panels is improving every year. Additionally, breakthrough technologies in the solar sector are possible in the future. Aggressively deploying a large capacity of installations in a short time could result in a "lock-in" effect (Klitkou et al., 2015), especially given that PV panels have a lifetime exceeding 20 years (JA Solar, 2022). The lock-in refers to a situation wherein consumers are dependent on a single type or version of technology and cannot move to another type without incurring substantial costs or inconveniences. SEC stated that updating its regulations to manage such developments is challenging.

2. **Rise in safety risks for PUC grid workers**

PUC pointed out that higher penetration of PV systems can increase safety risks for its grid workers while working with the grid either during planned outages for maintenance, or unplanned outages due to breakdowns. Complete de-energization of the grid necessitates that PV systems are disconnected completely during such events. Otherwise, this could pose electrical shock risks for PUC's linesmen and technicians, if they unknowingly attempt to work on a live system (PUC, 2022c). Although such instances have not occurred on Mahé yet, a larger number of connected systems could increase the risk.

3. **End-of-life management**

All government stakeholders acknowledge a gap in the policy concerning end-of-life treatment of PV systems, including the panels, inverters, and other equipment. With the earliest installations dating from late 2013, Mahé may have to begin dealing with decommissioned systems as early as 2033 (assuming a lifetime of 20 years for the earliest systems). This is particularly concerning given the land scarcity and already documented difficulties with hazardous and e-waste management on Mahé (Krütli et al., 2018; Rapold, 2019).

3.2.1.3 Synergies – Enablers

1. Geographical enablers

All governmental stakeholders recognize that solar PV technology is the most mature and feasible renewable energy option today to diversify Mahé's electricity mix in the short- and long- term. This is justified by Mahé's proximity to the equator, resulting in an average of about 7 sunshine hours per day yielding about 5.8 Wh/m^2 received per day (EDP International, 2019). The average annual Full Load Hours (FLH) is calculated to be about 1,300 hours. Existing systems have produced an average of between 115 and 125 kWh per kW of installed capacity per month. This aligns with the solar resource maps published by the World Bank (Solargis, 2019). In addition, SEC also stated that the roofspace capable of installing rooftop PV systems was plentiful and cited the findings of the SolarCity tool, a simulator developed by IRENA (IRENA, 2022).

2. Environmental awareness of people

All governmental stakeholders agree that the increasing environmental awareness among the residents of Mahé is one of the contributing factors to the consistent amount of yearly capacity in Mahé (see "Bought" Type, Figure 11). SEC stated that apart from some adopters installing systems to appear environmentally friendly, others have solely done so to reduce their environmental impact:

"Going green looks "cool" and makes people feel like they are doing something for the environment."

This is corroborated by PUC:

"Some people have done it just to reduce their GHG emissions."

SEC also believes that some adopters may be tempted to invest in an installation given the knowledge that one of their neighbours has done so:

"It's a kind of "jealousy syndrome", if one has it, the other wants it as well."

3.2.1.4 Benefits – Positive Outcomes

Most of the listed benefits have already been addressed in Sections 1.1.2 and 1.1.3.

1. **Economic benefit for adopters and PUC**

   All governmental stakeholders agreed that the biggest factor motivating adopters today is the economic benefit they derive from it, especially for households in the high-consumption band and commercial entities due to the electricity tariff rates that they invoke (see Section 3.1.5). PUC put the investment into PV systems in context for homeowners and commercial entities:

   "Even for residents, it is one of the better investments that they can make. It pays back within 5 to 6 years at between 16% and 17% rates. For commercial customers, it is more than 20%."

   SEC also highlighted that the country strives to implement the recommendations of the International Monetary Fund (IMF) (IMF, 2022), which advises against sustained subsidisation of electricity prices for the domestic sector. Over the years, this has resulted in tariff hikes across the electricity sectors (EDP International, 2019; SEC, 2022c). Adopters are also perceived to be motivated by the desire to protect themselves against future price hikes.

   PUC also acknowledged that a sufficient penetration of solar PV in Mahé's electricity mix may reduce the pressure to install new generators:

   "It may help us delay the investment in generation and transmission infrastructure in the future. But at the moment, the impact is negligible on the generation capacity."

2. **Energy Security and reduction in forex lost to fuel imports**

   All governmental stakeholders stated that moving away from a fossil-fuel-based electricity generation system was a high priority. This has reflected amply in the country's National Energy Policy 2010-30 (Cadmus Group, 2019a; van Vreden et al., 2010). Further, energy security offers protection from aberrations in the international fossil fuel market, which SEC recognized:

   "Less exposed to risks involving fluctuations in international crude oil prices which affects our whole economy as we are an importing nation."

   SEC also stated that the economy of the country is pegged to fossil-fuel rates, as increased fuel imports deplete the country's foreign currency reserve. Hence, increased energy independence is perceived to offer firmer ground for economic development.

3. Reducing the environmental impact of electricity production and achieving stated commitments improves Seychelles' standing in international fora on climate action

All governmental stakeholders affirmed that increasing the deployment of rooftop PV systems is an important component of achieving the 15% renewable energy penetration target in Seychelles electricity mix by 2030 (Cadmus Group, 2019a; van Vreden et al., 2010). This commitment has been enshrined in the National Energy Policy 2010-30 and echoed in the country's submission under the Paris Agreement (Government of Seychelles, 2021). MACCE even opened the possibility of further improving this ambition:

"The 15% renewable energy penetration by 2030 target was set based on current limitations experiences, but there is scope to review those numbers. PV is the most promising option currently."

Importantly, they believe that fulfilling this endeavour would give the country an edge to hold bigger polluters accountable at global fora.

4. Provide a boost to the tourism industry

Since the country's economy is dominated by the tourism sector, SEC believes that increasing the deployment of rooftop PV systems would be directly in line with sustainable tourism, which is also high on the government's agenda. SEC and MACCE agreed that the tourism sector is increasingly being driven by a sustainable approach, and travellers are beginning to prefer options with low environmental impacts. This could be facilitated by the higher penetration of renewable energy sources in Mahé's electricity mix.

3.2.1.5 Main takeaways

There were three major risks (including implementation risks and consequential risks) highlighted by the governmental stakeholder group. Firstly, the technical barriers (I.4, Table 11) posed by the current state of the grid have resulted in capacity caps being implemented by PUC in both the domestic and commercial sectors. Although these caps may protect the stability of the grid from the high injection of intermittent electricity from PV modules, they were recognized by governmental stakeholders to also dampen the uptake of such modules. Secondly, the institutional barriers (I.5, Table 11) arising out of the legislative and policy framework (Section 3.1.2.3) have been acknowledged by MACCE and SEC to create a suboptimal institutional setup, which constraints SEC's capacity to perform its mandate as an independent energy regulator. Finally, the gap in policy and capacity to deal with the potentially large amount of e-waste arising from obsolete PV equipment in the future had earned ample attention from the respondents (II.3, Table 11). This concern could exacerbate if the use of batteries is allowed at the consumer level.

On the other hand, two opportunities were considered particularly important by the governmental stakeholder group. Firstly, a persistent and accelerated adoption of rooftop solar PV systems was recognised for its potential to provide energy security while reducing the country's expenses on imported oil (IV.2, Table 11), resulting in an overall positive effect on the economy. Secondly, the large-scale uptake of PV modules was seen as a measure to reduce the current environmental impact of electricity production (IV.3, Table 11). Consequently, increasing the share of renewables in Seychelles' electricity mix has been highlighted as an important goal in both national legislation (van Vreden et al., 2010) and international commitments (Government of Seychelles, 2021).

3.2.2 Commercial Stakeholder

The perceptions of risks and opportunities were solicited from each commercial stakeholder (Section 2.2.4.2 and Table 1) regarding the adoption of rooftop solar PV systems at the *individual* level. As detailed in Section 2.2.4.2 and Table 1, two subgroups constitute the commercial stakeholder group - commercial stakeholders who had not yet installed PV systems (CNP; individually CNP1-7, Table 1) and those who had already invested in these systems (CP, individually CP1-5, Table 1).

While the "risks" (both implementation – barriers and consequential – negative outcomes, according to Figure 6) were largely gathered from CNP, CP also reported "risks" which they perceived before making the installation. CP "risks" were admitted into the risk perception matrix if they were also perceived by a CNP stakeholder. In essence, the "risks" CP stakeholders perceived before making their investment in the past, should still be relevant for today's scenario. As the policy and incentives landscape has not changed much since the first commissioned rooftop solar PV system in Mahé (October 2013, Section 3.1.3.1) and especially since the beginning of the rebate scheme in 2014 (Section 3.1.3.2), most of the CP "risks" reported were relevant. Furthermore, these risks are juxtaposed against the *experiences* of CP stakeholders since their installation. Similarly, "opportunities" denote both *uncertainties* perceived by CNP stakeholders and CP stakeholders before making their installation, juxtaposed against the *experiences* of CP stakeholders. In this way, the risk perception matrix includes both *perceived uncertainties* by CNP and CP stakeholders before they adopted a system. And while explaining these uncertainties, they are juxtaposed against the experience of CP stakeholders.

Respondents often cited issues at the *systemic* level (country-level) while justifying the uncertainties that they perceived. The derived uncertainties are further grouped into risks & barriers, and synergies & benefits. Where possible, they are further classified into subgroups if they fall into the same context (for example, economic benefits, technical barriers, etc). If an "uncertainty" applies only to auto-producers, this is indicated with the suffix “-AP” in Table 12. Furthermore, the raised uncertainties are referenced to those identified by governmental stakeholders (Table 11) if possible, to avoid redundancy.

Table 12: Risk Perception Matrix for the commercial stakeholder group.

<table>
<tr><th colspan="2">Risk Perception Matrix – Commercial Stakeholder Group (including auto producers)</th></tr>
<tr><th colspan="2">Risks</th></tr>
<tr><th>I. Implementation Risks - Barriers</th><th>II. Consequential Risks – Negative Outcomes</th></tr>
<tr><td>1. Information barrier – Lack of awareness/understanding of the installation process and/or financial incentives available
2. Economic barriers
a. High upfront cost
b. Removal of the rebate scheme
c. Change in the compensation system
d. Competing investments
3. Technical barriers
a. 50% capacity cap and 100 kW limit
b. Newly constructed buildings cannot pre-install systems
c. Arduous shift to privately-owned hybrid systems - AP
4. Structural barrier – Need to renovate the roof before installation
5. Visual Pollution</td><td>1. Lock-in of less efficient technology
2. End-of-life management
3. Components breaking down</td></tr>
</table>

Opportunities	
III. Synergies - Enablers	**IV. Benefits – Positive Outcomes**
1. Environmental concern a. Good for the country b. Sustainability Commitments 2. Knowing people who have already installed PV 3. Presence of decision-makers in the firm who have a strong interest or knowledge of sustainability and PV technology	1. Economic benefits a. Reduced electricity bills and protection against tariff hikes b. Cheaper cost of production – AP 2. Security of supply – AP 3. Enhances business competitiveness 4. Cooling effect on buildings 5. Reduced air and sound pollution - AP

The individual elements are further deliberated on below, in the order that they appear in the table.

3.2.2.1 Implementation risks – Barriers

1. Information barrier – Lack of awareness/understanding of the installation process and/or financial incentives available

Information barriers manifesting from lack of awareness of the installation process and/or financial incentives (see Section 3.1.3.2) were evident. For example, CP1 didn't know about the rebate scheme before deciding to invest in a PV system. They imported the equipment independently and only found out later that the systems can be installed only by "endorsed" installers. Respondents further reported that knowledge of the rebate scheme would constitute another motivating factor.

Several respondents stated that this barrier was encountered as they didn't make the effort to actively seek this kind of information, which isn't available readily. CNP1, who hadn't yet installed a system remarked:

"We will research before investing obviously. There is an information gap from the government. We did briefly google suppliers but felt their online presence is limited. There needs to be more ads and publicity. We need the right information before making such investments."

CNP2 echoed a similar concern:

"I heard that the equipment is VAT-free, but not about the rebate program. This information is not easily available."

This barrier has also been identified by governmental stakeholders (I.1, Table 11).

2. Economic barriers

a. High upfront cost

The cost of the system was viewed by the respondents as more of an investment decision that has to make economic sense, than as a burden. It was perceived that this barrier would be especially significant for SMEs. To abate this, some respondents suggested instituting a delayed payment scheme.

This barrier has been identified by governmental stakeholders (I.2a and I.2b, Table 11).

b. Removal of the rebate scheme

The respondents generally noted that the removal of the rebate scheme (Section 3.1.3.2) would be discouraging but wouldn't stop them from investing as long as their investment is economically viable. With a pay-back period ranging from 3 to 4 years depending on the size of the system and without the rebate (PUC, 2022d; SEC, 2022c), the investment already makes economic sense. The rebate scheme seems to decide how quickly the investment is made and not if it will be made. For example, CNP3 who was in the process of making the installation:

"The removal of the rebate is definitely a disincentive. It's not a barrier in the sense that we would not go ahead with the project, but SEC should tell us well in advance so that we can plan out the budget better. The installation is going on right now and should be commissioned in 2 weeks or so. Following that, we would have received the rebate. Yesterday, I got a mail stating that the rebate has run out. This is disappointing. We had made our calculations for the payback period while considering the rebate. If the rebate is replenished in the future, they must make sure that people who had already installed PV systems benefit from it first. With the rebate, the pay-back period was 3 years, now it's 4."

Additionally, several respondents who had already made the installation were not aware of the rebate scheme before they invested.

This barrier has been identified by governmental stakeholders (I.2f, Table 11).

c. Change in the compensation system

Respondents were asked what they felt about moving from the current net billing system to a feed-in-tariff system (FiT) (Jacobs & Sovacool, 2012), wherein consumers would pay PUC for their consumption as they normally would but be compensated for the electricity that they inject into the grid at a fixed "feed-in-tariff". Currently, the net billing system offers a direct offset in terms of units of electricity, and not its monetary value like FiT would.

Some respondents believed that it may discourage potential adopters but understood why the government would consider it given PUC's revenue erosion due to the adoption of commercial PV systems. It would constitute another element to be considered before making an investment, which would have to be economically viable. But in shifting to FiT, respondents believed that the capacity cap should be removed to make it fair:

CNP3 – "We will not mind paying something to keep PUC running, but it should make sense. Otherwise, we'll go off-grid. If they move to such a system, they should also allow us to generate more electricity and remove the capacity cap. They gave us only 40%."

d. Competing investments

SME respondents stated that there are other expenses that they would rather meet first. For example, CNP1 which operated in the food industry:

"Investing in such a system ranks maybe 4th or 5th on our agenda, it isn't immediate. We are a company which is growing, other things need attention first. For example, to invest in a packaging machine for our snack products."

3. Technical barriers

a. 50% capacity cap and 100 kW limit

Respondents reported the biggest barrier to be the 50% capacity cap (for systems over 10 kW) and the overall 100 kW limit. For several respondents, the 100 kW system limit was meagre in comparison to their consumption. Given the lucrative nature of the investment, respondents who had already made installations expressed the desire to increase their:

CP1 – "We wanted to reduce our energy cost to 0, but PUC does not allow that. We tasked PUC with that question, and we got a very point-blank answer that they cannot have their generators just sitting for a rainy day. Who's going to pay for all the maintenance and infrastructure we invested in? It was a reasonable answer, so we had to accept that."

CP2 – "We'll go for 100% if it's possible."

Respondents who hadn't yet made installations felt that such measures reduce their economic attractiveness and counter the country's effort to decouple from fossil fuels. Several have contemplated going off-grid:

CNP3 – "If we could, we would have installed much more. They gave us only 40% of our consumption citing technical issues. But there must be solutions to these if we want to reduce fossil fuel dependence. Right now, batteries are expensive, otherwise, we would have gone off-grid."

CNP4 – "We want to go 100% green while still connected to PUC. But they told us if this happens, we would be disconnected from their supply. Batteries are not good enough right now to go off-grid."

This barrier has been identified by governmental stakeholders (I.4a, Table 11).

b. Newly constructed buildings cannot pre-install systems

One of the respondents, CNP3, had constructed a new commercial warehouse where they sought to make the installation already during the construction phase. However, as PUC has no consumption data, CNP3 had to delay the installation for a few months. This came at an extra cost which could've been avoided if the installation was made immediately after the construction of the warehouse:

CNP3 – "We wanted to install it during the building process itself. PUC did not allow this as they weren't sure what our energy consumption would be. For the last 4 months, we have been running on PUC's electricity completely and after that, they allowed only 40% of this. To install the systems, I have to spend more now, which could have been done already during the building phase. We've had to reinstall scaffoldings, which is an unnecessary cost."

c. Arduous shift to privately-owned hybrid systems – AP

CP5-AP is the only auto-producer in Mahé that has installed a rooftop-top solar system (see Table 1). It was commissioned in 2021 and is part of a privately managed hybrid system. Before this, there were no such precursors:

"We had to depend on theoretical analysis and trust the ability of the installation company, but it has worked out well."

Other auto-producers have also expressed the intent to adopt solar PV systems in addition to the diesel generators they currently operate but note that the task is technically arduous. For example, CNP6AP remarked:

"Moving from a diesel generator only to a hybrid system is a technically arduous task. What would be easier is if PUC produced clean energy which we can buy from them. They have a lot of government roof spaces that are conducive for this."

4. Structural barrier – Need to renovate the roof before installation and lack of sufficient roof-space

Commercial entities typically install large systems (over 20 kW on average, see Section 3.1.3.1) which require considerable space and structural strength concerning the roof. CNP5-AP, for instance, stated that the lack of sufficient roof space appropriate for the installation was a major barrier for them.

Structural strength is important as the installations would remain operational for at least 25 years (JA Solar, 2022) and a structurally poor roof could result in mishaps after installation. In some cases, respondents, like CNP5, have abandoned projects on being advised to renovate their roof by installers:

"We were highly interested in PV and released a tender. When potential installers did the site visit, they reported that the roof is not structurally sound to accommodate the panels. This poses the risk of it falling off. We are considering other areas now, like building a structure for shade in the parking

area and installing the PV systems on top of that. Or design new warehouses that are capable of accommodating them."

CP2 had to construct a supporting structure above their flat roof to accommodate the panels, which came at a huge cost:

"This building is almost 40 years old but was built on very strong structural principles. But we still had to build a structure that was raised about 7 ft above the roof, to install the solar panels. This added to the installation costs."

This barrier has also been identified by governmental stakeholders (I.3b, Table 11).

5. Visual Pollution

Respondents were asked whether the aesthetics of rooftop solar PV systems would affect their decision to invest in them. While the majority of them disagree that the rooftop PV system will improve the aesthetics of their property, they state that the economic benefit they derive from it is the overriding decision factor. For instance, CNP5 stated:

"Don't think it improves the aesthetics, but it won't stop us from installing them to reduce operational costs. But if there was some option like the Solar Roof by Tesla, it would also look good."

The relevance of aesthetics depends on their type of business. It is considered irrelevant when the business is operating out of offices/warehouses in industrial areas but is assigned more importance in the tourism sector. For example, CNP4 who operates in the luxury tourism sector stated:

"It's a question of finding the right roof space. It makes a lot of sense to install it on our garages, back-office, and staff quarters. Of course, we won't install it on the guest cottages."

3.2.2.2 Consequential risks – Negative outcomes

1. Lock-in of less efficient technology

Some respondents expressed the risk of investing heavily into a large system which may become less efficient with future technological innovations. For example, CNP4 noted this while also remarking that advanced technology might take time before its available in Seychelles in comparison to the global market:

"PV systems are only about 16-17% efficient today, there might soon be a radically new technology tomorrow that is far more efficient. So, there is a kind of incentive for us to wait. But cutting-edge technology usually takes time to come to Seychelles."

Some of the early adopters like CP1 (in 2014) reported that they had experienced this risk:

"When we invested in this system in 2014, they were very expensive and the payback period we calculated was 10 years. Today that's not the case. It would have made more economic sense to wait all these years, especially given the improvement also in energy-efficient technologies."

This risk has also been identified by governmental stakeholders (II.1b, Table 11).

2. End-of-life management

Respondents often brought up the environmental risk of dealing with obsolete equipment at the end of their service period. As Seychelles is a land-scarce country, creating the space to accommodate obsolete systems could become difficult. The issue is perceived to grow in magnitude if battery usage at the consumer level is permitted. Some respondents pointed out a lack of clarity regarding the recyclability of obsolete PV equipment and batteries. For instance, CNP2:

"Are these panels and batteries recyclable? Is there already some policy on this? Because right now everyone is installing these, in 20 years, what will we do with them? If we dispose them in the landfills, that is a huge problem in itself."

This risk has also been identified by governmental stakeholders (II.3, Table 11).

3. Components breaking down

Some respondents are apprehensive about components, like the solar panels and inverters, breaking down, necessitating their replacement. CNP respondents are unsure how long this replacement process will take place, and if their business operations would be adversely affected by it. They also perceive that this will add to their administrative hassle of dealing with warranty issues. Typically, the installers/suppliers handle such issues, but if a commercial entity imported the PV equipment independently, this liability falls on them.

Among CP respondents, only CP1 had faced such an issue where they had to replace an inverter. As they imported the equipment independently, they had to deal with its replacement on their own.

3.2.2.3 Synergies – Enablers

1. Environmental concern

a. Good for the country

All respondents perceived the adoption of PV systems to be "good for the country", in that it contributes to reduced pollution, increases environmental awareness amongst people, and can help achieve the nation's climate commitments. Adopting PV systems is seen as protecting the environment, which is perceived as pivotal for the country's tourism sector. This is indicated to be one of the motivating factors for commercial entities to make an installation, as they feel like they are "doing their bit".

Responders reported that another motivating factor was that adopting more PV systems would help "make the country more energy secure" and "reduce spending on oil imports".

This enabler has also been identified by governmental stakeholders (III.2, Table 11).

b. Sustainability Commitments

Several respondents represented companies which had committed to company-wide climate goals or had a "sustainable" approach to the way it operates. Several of these companies were part of international parent firms with globally declared sustainability commitments. For instance, in the case of CNP3, the motivation stemmed from the highest managerial level:

"Some of our board members are avid environmentalists, and as a company, we have sustainability firmly pinned in our thinking. We're doing our bit to protect the environment and reduce our carbon footprint."

Similarly, CNP4, which was part of a global chain of luxury resorts cited company-wide sustainability commitments:

"Our company is owned by an international holding, and sustainability is very important for us. We have annual sustainability and energy reports wherein we review our energy consumption and in the following year implement energy efficiency and clean technology measures. PV is a priority for us in that sense and we are actively considering it."

CP respondents also had a strong sustainability approach which motivated them to invest in the installations:

CP3 – "We discussed how to reduce our carbon footprint in our board meeting where one of the members pitched the PV idea."

CP4 – "Sustainability is very important for us. Participating in the renewable energy culture also helps in sensitizing people to create a better future."

2. Knowing people who have already installed PV

Almost all CP respondents knew somebody who had already made an installation (domestic or commercial), from whom they learnt about its costs and benefits. Without this, respondents reported having encountered information barriers that demand considerable time and effort to overcome. However, despite learning from the experience of previous adopters, respondents stated that the investment will still have to pass the test of economic viability before they consider the installation. CNP1 put this as:

"Would influence us in the sense that we would be interested about the system and will enquire about it and their experience of it. But we will still do our calculation to see if it makes sense for us."

CNP3, who at the time of the interview was in the process of installing a system stated:

"We did a lot of research and compared quotes from local installers before making the choice. We also consulted people who had already installed it to get their experience with it. This was important."

3. Presence of decision-makers in the firm who have a strong interest or knowledge of sustainability and PV technology

CP respondents often credited their decision to invest in a rooftop PV system to a person within the firm who had a strong interest or knowledge of sustainability. This enabler was especially influential for early adopters, for example, CP2:

"As I'm an engineer and the building manager here, I understood that PV was a good option to reduce our bill, made a presentation to the board and was able to push them towards it. We were one of the earliest adopters in 2013."

Similarly, for CP5-AP who commissioned their system in 2021:

"Our General Manager is an engineer from Europe who pushed the idea to be self-sufficient in energy with renewable energy as a strong component."

3.2.2.4 Benefits – Positive Outcomes

1. Economic benefits

a. Reduced electricity bills and protection against tariff hikes

The potential of a PV system to reduce a commercial entity's electricity bill is perceived as the most important motivator by the respondents. Along these lines, CP1 stated:

"It's business at the end of the day. PVs help us reduce operational costs and increase profits."

Furthermore, SME respondents stated that PV systems could facilitate the installation of new electrical appliances cost-effectively. Higher consumption from new electrical appliances would result in higher tariff bands being breached (see Table 5), which is avoided in the presence of a PV system operating under the current net billing system. CNP1 pointed this out as:

"As we grow, we will need more machines which would consume more electricity. At some point, PVs will start making more economic sense."

Given that the electricity tariff has grown consistently for the commercial sector (EDP International, 2019; Seychelles Energy Commission, 2020), respondents also view PV systems as a hedge against that risk. A dynamic electricity tariff also makes a company's budgetary planning difficult, while the installation of PV systems offers more predictability, as CP2 stated:

"The PV system provides us protection against the rise in electricity prices in the future. Before PUC was revising their tariffs often and our electricity budget was running out quickly."

This benefit has also been identified by governmental stakeholders (IV.1, Table 11).

b. Cheaper cost of production – AP

CP5-AP is an auto producer which manages a portion of its energy needs through an 800 kW rooftop solar installation. The rest of it is met by diesel generators. They calculated that it is cheaper, in the long run, to produce their electricity, even considering the expensive energy storage system required, in comparison to buying an equivalent amount of electricity from PUC.

Other auto producers perceived the reduced spending on diesel for their generators and the avoidance of their heavy maintenance costs, as huge benefits that solar systems of sufficient size can offer.

2. Security of supply – AP

Auto producers stated that the principal reason why they choose to remain off-grid is concerns regarding the security of electricity supply from PUC. Many of them are located in parts of Mahé that were difficult to service in the past, owing to which they chose to manage their energy needs independently. PV systems allow auto producers to retain control over managing their energy needs through a predictable supply source which they perceive as a benefit.

3. Enhances business competitiveness

Depending on the kind of business, respondents reported that if all their operations are run on clean energy through PV systems, it would give a "sustainability" tag to their products and/or services, which can be leveraged to increase their marketability. Along those lines, CNP1 stated:

"It can improve the marketability of our products. On social media, we already market our sustainable packaging. This would add value in that direction."

CNP3 also commented on this benefit, calling it a "marketing tool":

"It's becoming more and more a marketing tool! But it would only make sense if we can go 100% and reduce the carbon footprint of our energy consumption side to 0."

CNP4 which operates in the luxury resort business stated that it would increase its competitiveness, especially as there is growing pressure from tourists globally on resorts to adopt sustainable practices:

"In the resort business. Of course, it gives us a big advantage and we can market our hotel to be more sustainable. I would want to do it before my competitor. Some tourists already check for sustainability credentials before booking."

4. Cooling effect on buildings

CP2 reported a discernible cooling effect on the building over which their rooftop system is installed. Consequently, this leads to lesser consumption especially during summer, due to the reduced tendency to use air conditioning systems.

5. Easy maintenance and reduced air and sound pollution - AP

Auto producers also cited the low maintenance nature of solar systems to have a solid advantage over diesel generators. In this direction, CNP7-AP stated:

"The maintenance for diesel generators is very expensive. Sometimes, we have to wait for parts and plan for such situations. In comparison, a large solar PV system is much lesser maintenance."

Further, auto producers in the luxury resort business identified reduced air and sound pollution, which is otherwise caused by their diesel generators within their premises, due to the installation of PV systems as being an important benefit. This allows them to further improve the "quality of their service".

3.2.2.5 Main takeaways

The commercial stakeholders' group underlined 3 major risks (both implementation risks and consequential risks). Firstly, the 50% capacity cap and overall 100 kW system limit (I.3a, Table 12) were perceived to be the largest deterrents to higher adoption of rooftop PV systems within the commercial sector. Respondents saw the prospect of buying such a system as an investment toward reducing their operational costs in the long run. The capacity cap and system limit were seen to reduce the attractiveness of this prospect. Secondly, newly constructed buildings are currently unable to make an installation (I.3b, Table 12) due to the lack of consumption data which would enable PUC to allocate a system capacity to the applicant. Respondents perceived this restriction to be inhibitive, due to the additional costs of installation which could have been avoided if it took place in parallel to the construction of the buildings. Finally, some respondents perceived structural barriers (I.4, Table 12), in that their roof either lacks the strength required to support the panels or were considered suboptimal for high yields.

Despite these risks, the respondents highlighted 3 opportunities that accompany the adoption of a rooftop solar PV system. Firstly, due to the current cross-subsidisation and the commercial tariff rates (see Section 3.1.5.2), the sector benefits from relatively lower payback periods in comparison to the domestic sector. Therefore, the apparent economic benefit (IV.1, Table 12) was perceived as the biggest driver to make an installation. Secondly, in the case of most CP respondents, a decision-maker within the firm possessing a strong interest in sustainability or PV technology inspired the investment into such a system (III.3, Table 12). Lastly, it was also seen to enhance the business competitiveness of certain firms (IV.4, Table 12), wherein the “sustainability tag” could be utilised to market the offered goods or services (for example, sustainable tourism for luxury resorts).

3.2.3 Homeowners

The perceptions of risks and opportunities were solicited from each homeowner (Section 2.2.4.3 and Table 2) regarding the adoption of rooftop solar PV systems at the *individual* level. As Section 2.2.4.3 details, the interviews within the homeowner's stakeholder group were distributed equally between the three consumption bands: low, mid and high. Furthermore, within each of these consumption bands, an equal number of interviews were sought among homeowners who had already installed PV systems (HP) and those who hadn’t yet (HNP). As a result, 6 subgroups of homeowners formed the overall stakeholder group as explained in Table 2. Hereafter, they are abbreviated as defined in Table 2.

While the “risks” (both implementation – barriers and consequential – negative outcomes, according to Figure 6) were largely gathered from HNP, HP also reported “risks” which they perceived before making the installation. HP “risks” were admitted into the risk perception matrix if they were also perceived by an

HNP stakeholder. In essence, the "risks" HP stakeholders perceived before making their investment in the past, should still be relevant for today's scenario. As the policy and incentives landscape has not changed much since the first commissioned rooftop solar PV system in Mahé (October 2013, Section 3.1.3.1) and especially since the beginning of the rebate scheme in 2014 (Section 3.1.3.2), most such HP "risks" reported were relevant. Furthermore, these risks (from both HNP and HP) are juxtaposed against the *experiences* of HP stakeholders since their installation. Similarly, "opportunities" denote both *uncertainties* perceived by HNP stakeholders and HP stakeholders before making their installation, juxtaposed against the *experiences* of HP stakeholders. In this way, the risk perception matrix includes both *perceived uncertainties* by HNP and HP stakeholders. And while explaining these uncertainties, they are juxtaposed against the experience of HP stakeholders.

Respondents often cited issues at the *systemic* level (country-level) while justifying the uncertainties that they perceived at their *individual* level. The derived "risks" and "opportunities" are further grouped into risks & barriers, and synergies & benefits respectively as illustrated in Figure 6. Where possible, they are further classified into subgroups if they fall into the same context (for example, economic barriers, technical barriers, etc). Furthermore, the raised uncertainties are referenced to those identified by governmental stakeholders (Table 11) if possible, to avoid redundancy.

Table 13: Risk Perception Matrix for the homeowners.

Risk Perception Matrix – Homeowners Stakeholder Group	
Risks	
I. Implementation Risks - Barriers	**II. Consequential Risks – Negative Outcomes**
1. Information barrier - Lack of awareness/understanding of the installation process and/or financial incentives available - LMH 2. Economic barriers **a. High upfront cost - LMH** b. Difficult to obtain low-cost financing - LMH **c. Perceived lack of tangible benefit - LM** d. Competing Investment options - LMH **e. Long pay-back period – electricity bill already low due to subsidization - LM** 3. Geographical Barriers a. Location and shade - LMH b. The structural strength of roofs and suboptimal inclination - LMH 4. Technical Barriers **a. Capacity caps and difficulty with upgrades – MH** b. Battery storage discouraged - LMH	1. Technology improvement risk - H 2. End-of-life management - LMH 3. Maintenance-related risk and cost - LH

Opportunities	
III. Synergies - Enablers	**IV. Benefits – Positive Outcomes**
1. Environmental awareness a. Good for the country – Energy security and saving forex - LMH b. Individual carbon offsetting - LMH 2. Financial incentives – SEEREP loan and rebate scheme - LMH 3. Innovators or early adopters fascinated with technology – LMH 4. Ownership of Electric Vehicles – LMH **5. Social effect – inspiration from a neighbour or somebody known who has installed a system – MH**	**1. Economic benefits - Reduced electricity bills and protection against future tariff hikes - LMH** 2. Allows consumption of more electricity – LMH 3. Self-sufficiency in energy consumption

In Table 13, towards the end of each uncertainty, it is indicated in which consumption band-related sub-stakeholder group it was raised. For example, in I.1. "Information barrier - Lack of awareness/understanding of the installation process and/or financial incentives available – LMH", "LMH" denotes that the uncertainty was raised in all three, low, mid-, and high-consumption bands sub-stakeholder groups. If for an element, there are distinct differences between the two or more consumption bands, they are highlighted in bold and detailed accordingly. The individual elements are further deliberated on below, in the order that they appear in the table.

3.2.3.1 Implementation Risks - Barriers

1. Information barrier - Lack of awareness/understanding of the installation process and/or financial incentives available – LMH

Respondents from all consumption bands reported a lack of awareness or understanding of the installation process or the financial incentives available, which they perceived as an information barrier. A common remark amongst HNP respondents (homeowners who hadn't adopted systems yet) was that the information was available, but one had to go in pursuit of it. As they had not yet decided to install these systems, they hadn't made an active effort to do so. Some respondents who made an independent effort to search for information without the help of installation companies, found the process to be overwhelming. For example, HNP-M5 stated:

"The schemes should be in simple language which common people can understand. Whom should I contact to install? What is the application process exactly? How much time and money will it take? How and where to get the rebate? Will I get the money before or after making the purchase? Initially, it all sounds very complicated."

Given this knowledge, respondents, like HP-L4, believed that a lot more people would adopt these systems:

"The system cost us about 55 thousand rupees with the rebate. I'm sure a lot of households can afford this. I'm not sure if they actually know how cheap it is and what benefits they get from it. PUC and SEC should really work to create awareness to help a lot more people adopt it. I'm doing my bit, and if more people do it, it would really help the country reduce its dependence on oil."

This barrier has also been identified by governmental stakeholders (I.1, Table 11).

2. Economic barriers

a. High upfront cost – LMH (conflict in perceptions)

The high upfront cost was raised as the biggest barrier by the low- and mid-consumption sub-stakeholder groups, whereas the high-consumption sub-stakeholder group viewed the expense as more of an investment that bears immediate benefit. Along similar lines, the barrier was a bigger concern for low-consumption homeowners than mid-consumption homeowners. Low-consumption homeowners like HNP-L3 responded with straightforward statements like:

"It is still quite expensive. Normal people do not go for solar PV."

Contrastingly, high-consumption homeowners, like HNP-H2, had a more calculative approach:

"For my consumption, I'll probably need a big system which will come with a big upfront cost. It's a deterrent, although I see the benefits in the long run. Finding the resources to finance this cost may take time, but it will happen."

This barrier has also been identified by governmental stakeholders (I.2a, Table 11).

b. Difficult to obtain low-cost financing – LMH

The barrier was raised in all sub-stakeholder groups, wherein there was general agreement that the respondents perceived the collateral requirements and borrowing limits as hindrances in obtaining the SEEREP loan (Section 3.1.3.2). For example, HNP-H1 attempted to find more information about the loan process but found the rigid rules difficult:

"The access to loans has to be improved. We are trying to do something good for the country and they still have very rigid rules regarding the collateral. This has to be relaxed a little so that more people can benefit from it."

HNP-L3 also pointed out that not all the banks on Mahé offer the SEEREP loan. HP-L5 who took the SEEREP loan to finance their PV system along with other energy-efficient electrical appliances stated that the entire process was cumbersome:

"There is a lot of going back and forth, between the energy commission, bank and the shop. And there are a lot of conditions to be met, for example after coming back from the shop, the energy commission told me the loan cannot be availed for some of the products. These things if made clearer before could have saved a lot of time and effort."

This barrier has also been identified by governmental stakeholders (I.2b, Table 11).

c. Perceived lack of tangible benefit – LM (conflict in perceptions)

This barrier was raised only in the low- and mid-consumption HNP sub-groups. They perceived a lack of tangible benefits accruing from PV systems makes investing in one less attractive. PV systems were perceived as investments that "don't generate money", but benefit adopters "only through savings on the electricity bills". HNP-M4 was even under the impression that *"not paying as much money due to reduced electricity bill is not equivalent to saving"*. HP respondents did not find this to be a barrier.

This barrier has also been identified by governmental stakeholders (I.2c, Table 11).

d. Competing Investment options – LMH

Respondents from all consumption bands perceived that a PV system was not amongst their highest investment priorities and that there were other needs that they would like to tend to first. This priority seemed to be lowest for low-consumption homeowners, followed by mid- and high-consumption homeowners. For example, HNP-L1 stated:

"Not sure if it'll make it to the top 10 of our essential purchases. A car is a more pressing need right now."

HNP-H1 highlighted that the urgency was reduced owing to the already reliable supply from PUC, and was waiting for the right moment to invest:

"Well, we have PUC power anyway. Investing so much in PV is something of a luxury. I'll certainly do it, but I'm waiting for the right moment. Other products are more necessary right now."

This barrier has also been identified by governmental stakeholders (I.2d, Table 11).

e. Long pay-back period – electricity bill already low due to subsidization – LM (conflict in perception)

The pay-back period is heavily dependent on the consumption of a household considering the current incremental tariff structure (see Section 3.1.5). Accordingly, low-consumption households encountered the longest payback period and followed by mid- and high-consumption households, the latter of whom did not even raise the concern. For example, HNP-L1 stated:

"My consumption is only about 150 units per month, and I pay between 200 and 300 rupees. It just doesn't make sense to spend so much money on a PV system economically. If I were to install ACs or other appliances, it would start making sense."

The HP-L respondents who adopted a system seemed to assign more importance to long-term benefits. HP-L5 was even discouraged from investing:

"Initially I was discouraged from installing the system after they looked at my bill. But I really wanted to do it as it would save money in the long term. And I wanted to install it with the other energy-efficient appliances I bought with the SEEREP loan right after my house was built."

Similarly, mid-consumption homeowners, like HNP-M2, highlighted that the economic benefit was not attractive enough:

"I'm consuming only around 400 units per month. My bill is not a lot. It doesn't create a big enough incentive. If PUC stops subsidizing electricity, it will make a lot more sense."

This barrier has also been identified by governmental stakeholders (I.2e, Table 11).

3. Geographical Barriers

a. Location and shade – LMH

Some respondents in each consumption band had pointed out a barrier regarding the location of their property or the difficulty in removing objects, like trees, that cast a shadow on their roof. In some cases, like for HPL-5, objects present within a neighbour's property cast shadows on a potential adopter's roof:

"I got my neighbour to trim his tree before installing the system. This caused a delay."

In their case, they were able to convince their neighbour to trim their tree, but this is not always possible, especially given Seychelles' strict laws against the felling of trees (Breadfruit and Other Trees (Protection) Act, 1917).

This barrier has also been identified by governmental stakeholders (I.3a, Table 11).

b. The structural strength of roofs and suboptimal inclination – LMH

HNP respondents from all the consumption bands reported issues that dealt with structural strength or suboptimal inclination of their roofs, to install rooftop solar PV systems. This concern was heavier for low-consumption households, like in the case of HNP-L1:

"We live in a semi-detached house and although we have ownership over our part of the roof, it is now over 25 years old. Already, it's leaking in a few places if there is heavy rainfall. It must be renovated first before installing such systems."

Some respondents, like HNP-M6, pointed out that if their roof needs to be renovated to accommodate the PV systems, which they otherwise would have delayed, they would be forced to incur considerable expenses which are perceived to be a barrier:

"If I have to redo my roof, that's a big hassle and cost I wouldn't want to attempt now."

Some respondents also highlighted that the orientation and steepness of their roofs are not conducive to high yields from rooftop solar PV systems. Further, other respondents, like HP-H4, owned tall buildings wherein it was perceived to be inherently difficult to make the installation, however, the installer was able to find a solution:

"You can see that the roof is facing all directions and it is pretty tall. But the installer helped in finding a solution. Additional structures were needed to be constructed to ensure that mishaps do not occur."

This barrier has also been identified by governmental stakeholders (I.3b, Table 11).

4. Technical Barriers

a. Capacity caps and difficulty with upgrades – MH (conflict in perception)

Only respondents from mid and high-consumption groups perceived the cap on the maximum capacity as a barrier. They believed that the approach of limiting capacities lacks foresight on the government's side, as it ignores the potential increase in electricity consumption of their household in the future. HNP-M5 also stated that it makes much more economic sense to install a large system keeping in mind future consumption needs from a financial point of view:

"PUC does not allow for long-term planning. I know in the future that my family will be bigger. This will result in more electrical appliances and AC units being bought, which will maybe double or triple my current electricity consumption. So, if I'm ready with the money now, I would like to buy a PV system also keeping in mind my future electricity demand. But PUC does not allow this."

HNP-H3 perceived the lack of transparency concerning the awarding of capacities as strange:

"There needs to be more transparency. As things stand, PUC has the sole power in how much we get, without anybody else checking on them. It discourages a lot of people when they are downsized for reasons they don't understand. There are other ways for PUC to generate profit."

Several respondents also raised the issue of upgrading the capacity of their systems which stemmed from a requirement imposed by PUC that an inverter greater than the system size cannot be installed. HP-M4, who faced this barrier, stated:

"I wanted a 5 kW by the way, and they refused. I know other friends who have 5kW, I don't understand why I didn't get it too. Obviously, for a 4-bedroom house, they can estimate what the energy demand will be and of course, it will go up in the future! And another barrier is, that once you install a 3kW, it's difficult to upgrade to a 5 kW. The inverter must be changed, and infrastructural upgrades are needed on the roof. It's a lot of work and an unnecessary cost, instead of doing everything once and for all. They're putting a cart in front of the horse. They must always give the possibility of upgrading. It shouldn't be that the old system must always be replaced by a new one."

This barrier has also been identified by governmental stakeholders (I.4a, Table 11).

b. Battery storage discouraged – LMH

Respondents from each consumption band perceived the lack of a battery storage option to be a barrier as it negates the possibility of using the energy they produce, especially during power cuts. For some respondents, like HNP-L2, this was a decision-making factor:

"If battery storage is allowed, I'll think about it. That way, I will have electricity when the power cuts out. Also, I can't be self-sufficient without batteries."

Others, like HNP-M3, felt that they wouldn't be getting the most for their investment if battery storage wasn't allowed:

"If there is a power cut from PUC, and I'm not able to use the electricity I produced, I feel like I'm not getting full benefit for my investment."

HP respondents, like HP-L5, are facing the adverse effects:

"I liked the idea and enquired the installer about it. But he told me that they are not allowed by PUC. I need electricity 24/7 as I work from home and it's a pity that we can't store energy and use it for 1 or 2 hours during power cut-offs."

This barrier has also been identified by governmental stakeholders (I.4b, Table 11).

3.2.3.2 Consequential Risks – Negative Outcomes

1. Technology improvement risk – H

Only HNP respondents from the high-consumption band brought up the risk of investing in a technology that may become less efficient with time. HNP-H1 was apprehensive about investing a large sum of money in a long term-solution whose technology is continuously improving:

"It's a lot of investment and it's kind of long term. That means if there are improvements in panel technology in the future, I'm stuck with less efficient panels. That's a small risk though, I guess panel technology has somewhat matured, no? But technology always keeps changing."

Similarly, HNP-H5 stated:

"The panel prices keep dropping and battery technology keeps improving. It's like the later you invest in it, the better. It's difficult to time it."

This risk has also been identified by governmental stakeholders (II.1b, Table 11).

2. End-of-life management – LMH

Respondents from all consumption bands raised common concerns regarding the risk of e-waste mismanagement soon when the PV systems become obsolete. At the moment, there is no policy from the GoS to deal with such systems at the end of their life (SEC, 2022c). Currently, e-wastes end up in the landfill at Providence on Mahé, with very few components extracted and sold as scrap (Rapold, 2019; Simeon, 2022). Further, respondents, like HNP-L4, perceived that the risk would exacerbate when battery storage is allowed:

"Right now, e-waste is beginning to create a problem in Seychelles. PV could add to that problem if they aren't properly managed. Of course, if batteries are finally allowed, recycling them also needs a proper plan, otherwise, it could end up being hazardous and cause damage to the environment."

This risk has also been identified by governmental stakeholders (II.3, Table 11).

3. Maintenance-related risk and cost – LMH

Respondents from all stakeholder groups singled out the safety risk to a person carrying out maintenance-related work on the rooftop system. This risk was perceived to be more pronounced in the low-consumption band, wherein respondents perceived the maintenance service cost charge by installation companies to be expensive and hence chose to carry out the maintenance work independently. This was the case for HP-L1:

"The maintenance service from the installer is high. I just do it myself. The roof is high, and some might be scared but I manage."

HNP-L1 owned a house with a high roof, due to which they believed that attempting to install and maintain the system could constitute a safety hazard.

3.2.3.3 Synergies – Enablers

1. Environmental awareness

a. Good for the country – Energy security and saving forex – LMH

Stakeholders from all the consumption bands stated that one of the factors that would motivate them to adopt rooftop solar PV systems is the fact that it is "good for the country". The reasoning for this statement varied. Several respondents referred to Seychelles' geographical position and the solar irradiation it receives due to this. For example, HP-H1 stated:

"We have a lot of sun year-round, we must be doing more solar systems instead of wind turbines. They are an eye-soar."

Others highlighted that it would help protect Seychelles' environment and achieve its climate ambitions. HNP-M5 opined:

"We have a big mouth when it comes to climate action and installing more PVs helps us "walk the talk". Climate change is affecting us all."

Adding to this, HNP-H4 shed light on the sound and visual pollution caused by PUC's power stations in Victoria. As they live on a cliff-side with a direct view of the power station, they stated that the "black smoke" being emitted creates smog during the early hours of the day, advancing health issues. Due to this, they are motivated to invest in a PV system to contribute their bit to the country's transition away from fossil fuels:

"If we can make a small impact on the power produced, we will do it. Every little help matters."

Additionally, all respondents displayed awareness of how the electricity was generated on Mahé and perceived that it was an important advantage of solar that it helps in reducing fuel imports for the country. For instance, HNP-M1 cited recent global events and the effect they had on the fuel prices on Mahé:

"The foreign exchange we utilize to buy oil will reduce. This is more important now. The price of oil fluctuates, for example with the current war."

This enabler has also been identified by governmental stakeholders (III.2, Table 11).

b. Individual carbon offsetting – LMH

HNP respondents from all subgroups indicated a strong desire to reduce their carbon footprint and they perceived the adoption of a rooftop solar PV system as a means of doing so. Several of them reported that they would consider it even when the economic benefit is not pronounced. For example, in HNP-M2's case, they didn't view the high cost of the system as a major deterrent, as "environmental" and "moral" reasons were more important for them. Similarly, HNP-H2 stated:

"Keen on it because we care about sustainability and want to reduce our carbon footprint."

HP respondents brought attention to the fact that several of them made an installation more out of environmental concerns than perceived economic benefits. For instance, HP-L1 took a very methodological approach:

"I assessed my total carbon footprint, including flights and fuel consumption for transport and calculated the size of the system I would need to offset this. I always felt guilty about it and did

it for relief. My footprint is now negative! The installation cost was 80,000 but my bill was only 150 a month. So it is not a good investment at all. But I wanted to offset my carbon."

HP-M3 highlighted that the investment was much less economically viable in the past:

"I spent over 200,000 rupees on my system in 2015, it was not a small amount back then. Probably it is much cheaper now and there is better technology, and if I invested today, my returns would have been higher probably. So my investment back then was not only to make money but also to reduce my family's carbon footprint."

Furthermore, some respondents stated that they perceive having installed PV systems creates a positive image to others, concerning making a positive effect on the environment. For instance, HNP-H3 stated:

"Yes, having a solar panel sounds majestic. It makes you look good to others."

HP-H4 confirmed this with their experience:

"It makes you look like you're doing something for the environment. It is a good feeling."

This enabler has also been identified by governmental stakeholders (III.2, Table 11).

2. Financial incentives – SEEREP loan and rebate scheme – LMH

HNP respondents from all subgroups, who were aware of the financial mechanisms, perceived them to be important in deciding to invest. HNP-H4, who had already decided to adopt a system at the time of the interview, stated that the rebate scheme was a "deal-maker":

"It affected the timing of the investment, otherwise, I would have done it much later."

Several HP respondents, like HP-M4, also recalled similar experiences:

"The rebate made it easier to decide for me to go for it. If the rebate was not there, probably I would still be on the fence. And the cost of fuel was not that high then."

3. Innovators or early adopters fascinated with technology – LMH

Respondents, like HNP-L3, state that they are interested in adopting a system as they are fascinated by the technology. While some view it as a means of becoming self-sufficient in their energy consumption, others, like HNP-L5, see it as a natural progression after having implemented energy-efficient solutions in their homes.

Three of five HP-L respondents adopted the system early due to this reason. HP-L4 who had done so stated:

"I'm a big fan of it. I'm fascinated by the idea that the sun can produce the electricity I need."

Similarly, several HP-H respondents adopted the system driven by a curiosity about the technology and an ambition to become one of the few people in the country who possessed it. For example, HP-H1 stated:

"We were aware of renewables and the technology as we stayed in Hong Kong for some time. When we learnt that the technology was also available here, we were excited to try it."

4. Ownership of Electric Vehicles – LMH

Given Seychelles' electricity mix (see Section 3.1.1), respondents were aware that using an electric car powered by electricity from PUC would be counterproductive. Therefore, they perceived that a PV system of sufficient size could power their electric vehicle and produce two distinct benefits: reduced environmental impact from their transportation needs, and reduced costs accruing from decreased fuel consumption. Several HNP respondents perceive a synergetic relationship between the two technologies. For example, HNP-L4 observed:

"The investment would certainly start to make sense if I also bought an electric car. This is my plan."

Many HP respondents were driven by this synergetic relationship during their decision-making phase and reported positive experiences. For instance, HP-L2 stated:

"The PV system would never make sense without my new electric car. I installed my PV system only after I bought the car."

Similarly, HP-L4 is happy that they don't have to make trips to the petrol station anymore:

"I like the idea that my PV system is now charging my car. I don't have to go to the petrol station anymore. When I talk to my friends, they also like this PV plus EV idea, one of them is going to install a PV system now to power his car."

Furthermore, respondents reported that they would not have bought an electric car if they did not have the option to install a rooftop solar PV system in their homes.

5. Social effect – inspiration from a neighbour or somebody known who has installed a system – MH (conflict in perceptions)

Respondents were questioned whether they would be more inclined to install a system if one of their neighbours or a family member or a friend had already done so. A conflict in perception between the subgroups was unearthed, wherein respondents from the low-consumption subgroup disagreed with such an influence, whereas it seemed to matter increasingly more for mid and high-consumption subgroups. Especially, HNP-L respondents, like HNP-L1, stated that the investment decision depends solely on their financial capacity and not whether someone they knew had made an installation:

"I strongly disagree with this. It depends on my finances. This is not a competition."

HP-M respondents took a more cautious approach. For example, HNP-M1 admitted the existence of such an influence, but qualified its effect to the benefit they would derive from making the installation:

"Yes, it can have an effect. But normally what works for you need not work for me."

However, several HP-M and HP-H respondents had adopted their system precisely after such an influence. This was the case for HP-M2 and HP-M3:

HP-M2 – "A friend of mine had PV on his house for a long time. After I asked him about it, he referred me to an installer. It made the process of choosing very simple, as the feedback on his products was good."

HP-M3 – "When I wanted to install the system back in 2015, I started to look at various options and it certainly helped that some of my friends had already invested in them for their homes. In recent years, I have motivated some friends of mine to install them too."

The influence seemed to have the strongest effect on high-consumption households, like HNP-H1:

"Yes, of course! It's a Seychellois thing. The neighbours will think: "He is getting something more than me." They will definitely ask about it and want to put it too."

For HP-H2, this influence was the reason they made the installation:

"Well, this was exactly the case for me. I had 1 friend and 3 family members who had made the installation before me. I consulted them of course and got positive feedback. Now, I've inspired 4 of my friends and they are going ahead with it as well."

3.2.3.4 Benefits – Positive Outcomes

1. Economic benefits - Reduced electricity bills and protection against future tariff hikes – LMH (conflict in perception)

Respondents from all the subgroups perceived that the economic benefit one would derive from installing a PV system would constitute the biggest motivating factor. This economic benefit was tied to reduced electricity bills and hedging against future tariff hikes. However, HNP respondents from the low-consumption band perceived the investment to be unviable as their electricity consumption and hence system capacity was low. Low monthly returns, due to the subsidized electricity tariffs, translate to long payback periods. HP respondents from the low-consumption band seemed to be more motivated by other factors like reducing their carbon footprint or powering their electric vehicle while deciding whether to invest in a PV system.

The economic benefit factor played an increasingly bigger role for HP respondents from the mid and high-consumption households respectively. For example, HP-M2 stated:

"I was looking at ways to reduce the energy cost and PV was the solution. The bill used to be 1500 before, now we hardly pay anything. The prices are going up every year, so we're happy about this investment."

HNP-H respondents, like HNP-H1, pointed out that the benefit increases with higher consumption:

"Price we pay for electricity is very expensive, especially beyond the first 400 units. It's good protection for any future tariff hikes."

For HP-H3, it was a straightforward decision:

"I was paying between 8 and 9k SCR every month. Now I pay around 200. The economic benefit is clear. I was paid back within 3.5 years. It's a no-brainer. And you're free from PUC's electricity tariff, which is a relief."

This benefit has also been identified by governmental stakeholders (IV.1, Table 11).

2. Allows consumption of more electricity – LMH

Respondents from all subgroups perceived that installing a PV system would facilitate an improvement in their "standard of living". This improvement was perceived to come from increased electricity consumption either through installing new electrical appliances or by increasing the usage of incumbent appliances. For HNP respondents from the low-consumption band, it was perceived as a means to buy new electrical appliances that would "make their lives easier", which they had delayed in the apprehension of increasing their electricity bills. Further, for mid and high-consumption households, respondents perceived that they would likely increase their consumption. For instance, HNP-H5 stated:

"It's only natural. If I know that my AC units will run on solar, I may keep it running for longer."

And HP respondents, like HP-H2, seemed to confirm this with their experience:

"Well frankly, I wanted to use more AC without feeling guilty. We can use more energy as we are producing it now."

3. Self-sufficiency in energy consumption

Several respondents perceived that in the future, PV systems with batteries would allow them to go off-grid and be self-sufficient in their energy consumption. Some respondents, like HP-H5, had already discussed the possibility:

"We are waiting for efficient battery systems to become cheaper and available in Seychelles. We want to do it at some point. Absolutely!"

Other respondents, like HNP-L3, were fascinated with the idea from the technological point of view:

"I would like to meet all my energy needs from solar once batteries get better. Really want to experiment with this."

3.2.3.5 Main takeaways

The homeowners' stakeholder group identified 3 risks (both implementation risks and consequential risks) as particularly important. Firstly, the information barrier (I.1, Table 13) was construed to be the biggest hindrance to the adoption of a rooftop solar PV system. Respondents often reported being unaware or misinformed about the installation process and/or financial incentives available. This was perceived to stem from the lack of, or access to credible information, which was exacerbated by insufficient dissemination efforts. Secondly, the respondents who belonged to the low-consumption band perceived the upfront cost of the investment to be excessive (I.2, Table 13). This, combined with the applicable tariff rates resulted in payback periods that were considered to be too long (see Section 3.3.3). Finally, the respondents (especially, mid-consumption and high-consumption households) perceived the capacity cap imposed by PUC to be inhibitive (I.4, Table 13). If an applied system was downsized, respondents perceived this to be unfair and often abandoned their investment. Furthermore, the capacity cap was also perceived to make system upgrades more difficult in the future.

Nevertheless, two opportunities were highlighted as the biggest motivators by the respondents. Firstly, the potential economic benefit of installing the system was perceived to be the most convincing driver (IV.1, Table 13), especially for mid and high-consumption households. Their payback periods were considered to be increasingly more profitable in comparison to low-consumption households (see Section 3.3.3). Secondly, several HP respondents reported having installed a system driven more out of concern for the environment than for the economic benefits (III.1, Table 13). This trend continued also into HNP respondents, several of whom reiterated the same prioritisation. The motivation arose from the perception of investment in a rooftop solar PV system as being "good for the country", in addition, to facilitating the adopter in offsetting their carbon footprint.

3.2.4 Interpretation of results

The risk perception matrices (Tables 11, 12 and 13) directly address RQ1 (Section 1.2) by systematically unearthing the risks and opportunities perceived by three stakeholder groups: governmental, commercial and homeowners. Of these, the latter two comprise the targeted adopters of rooftop solar PV systems in Mahé.

While the barriers and drivers to PV adoption (either residential or non-residential sectors) have been discussed in literature extensively for western countries (Balcombe et al., 2013; J. Palm & Tengvard, 2011; Wittenberg & Matthies, 2016), such efforts are limited for SIDS. Furthermore, most of these works focus on the aggregated "barriers" and "drivers" that adopters experience before making an investment decision. However, in this thesis, an effort is made to demarcate the elements within these "barriers" into implementation and consequential risks, and the "drivers" into enablers and benefits according to the risk and opportunities framing outlined in Figure 6. The intention of differentiating between these elements is to develop a keener understanding of exactly where gaps exist currently so that more targeted and efficient policy instruments may be developed.

For example, from Sections 3.2.2 and 3.2.3, it was clear that the financial incentives were perceived to be a dealmaker for low and mid-consumption households, while it was considered to be a "bonus" for the commercial property owners and high-consumption households due to the already low payback periods they experience. Therefore, a revamped rebate scheme could target more low and mid-consumption households.

The major risks and opportunities (according to the framing illustrated in Figure 6) highlighted by the three stakeholder groups in Sections 3.2.1.5, 3.2.2.5, and 3.2.3.5, are summarised in Table 14.

Table 14: Summary of risk perception between the three stakeholder groups.

Type	Stakeholder Group		
	Governmental (Table 11)	Commercial (Table 12)	Homeowners (Table 13)
Risks	• Technical barriers (I.4) • Institutional barriers (I.5) • End-of-life management (II.3)	• 50% capacity cap and 100 kW limit (I.3a) • Newly constructed buildings cannot install systems (I.3b) • Roof needs to be renovated (I.4)	• Information barrier (I.1) • Economic barriers (I.2) • Technical barriers (I.4)
Opportunities	• Energy security and improved forex reserves (IV.2) • Reducing the environmental impact of electricity production (IV.3)	• Economic benefits (IV.1) • Presence of decision-makers in the firm with a strong interest or knowledge of sustainability (III.3) • Enhances business competitiveness (IV.4)	• Economic benefits (IV.1) • Environmental awareness (III.1)

A direct comparison between the risk perception of the stakeholder groups is inhibited by the difference in scope for which these risks and opportunities were elicited from each group. In essence, the risk perception matrix for the governmental stakeholder (Table 11) was constructed from perceptions regarding the process of increasing the deployment of rooftop solar PV systems for the entirety of Mahé at the *systemic* level. In contrast, the risk perception matrices for the commercial stakeholders' (Table 12) and homeowners (Table 13) were constructed from perceptions regarding the prospect of them adopting a system at the *individual* level.

However, governmental stakeholders often cited issues at the *individual* level (either domestic or commercial) while justifying issues at the *systemic* level. Similarly, commercial stakeholders and homeowners cited issues at the *systemic* level to justify issues at their *individual* level. In such cases, a difference in perception could be deciphered.

For example, although the governmental stakeholders rightly perceived environmental awareness to be a factor (III.2, Table 11) that motivates people to adopt rooftop solar PV systems, their assessment of its contribution seemed to be qualified in comparison to those reported by the commercial stakeholders (III.1, Table 12) and homeowners (III.1, Table 13). Particularly, several homeowners stated that they installed a system driven more by environmental awareness than the potential economic benefit.

In most cases, the rationale behind citing issues at the individual level by governmental stakeholders is corroborated by responses from the commercial stakeholders and homeowners. For instance, technical barriers being highlighted as a major risk by the governmental stakeholder group were reiterated by the other two groups (see Risks, Table 14). Unsurprisingly, the biggest motivation for the target groups was the economic benefit of adopting rooftop solar PV systems.

3.3 Economic Analysis and Agent-Based Modelling

3.3.1 Reference households

Figure 15 shows the distribution of installed capacities within each consumption band, where it is apparent that they vary considerably, especially for high and low consumption bands. The boxplots also depict the median installed capacity for each consumption band, wherein there is a general increase with higher consumption. In Table 15, these median installed capacities are compared to their respective average installed capacities. Due to the high variability in data points with significant outliers, the averages don't reflect an accurate representation of the respective consumption band. Therefore, for the reference households, the installation capacities are chosen to be the median value of installed capacities from the beginning of 2017, as highlighted in green in Table 15.

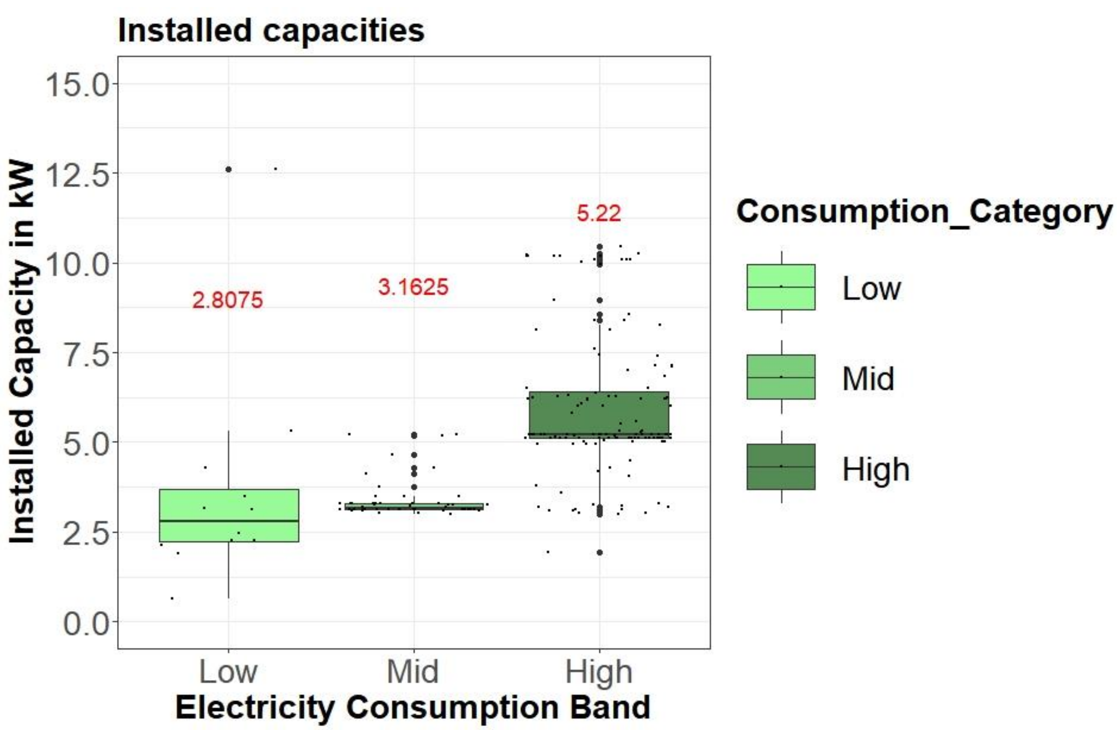

Figure 15: Distribution of installed capacities within each consumption band, with the median represented by the black line within the boxplots and mentioned in red over the respective box plots.

Table 15: Reference household parameters: comparison between average and median installed capacities, and monthly consumptions for each consumption band. Additionally, the average monthly consumption per invoice for each consumption band in the year 2018 is provided for reference (from Macro Consulting, 2019).

Consumption Band	Number of installations	Average Installed capacity (kW)	Median of Installed Capacity (kW)	Average Monthly Consumption (kWh)	Median Monthly Consumption (kWh)	Average Monthly Consumption per invoice in 2018 (kWh)
Low	12	3.64	**2.81**	230.89	**250**	171.54
Mid	50	3.39	**3.16**	468.82	**483.21**	408.54
High	131	6.88	**5.22**	1392.80	**970**	1040.48
All bands	193	5.78	**5.13**	1081.18	**791.13**	NA

Similarly, Figure 16 illustrates the distribution of average monthly consumption for households, before installing a rooftop PV system, belonging to each consumption band.

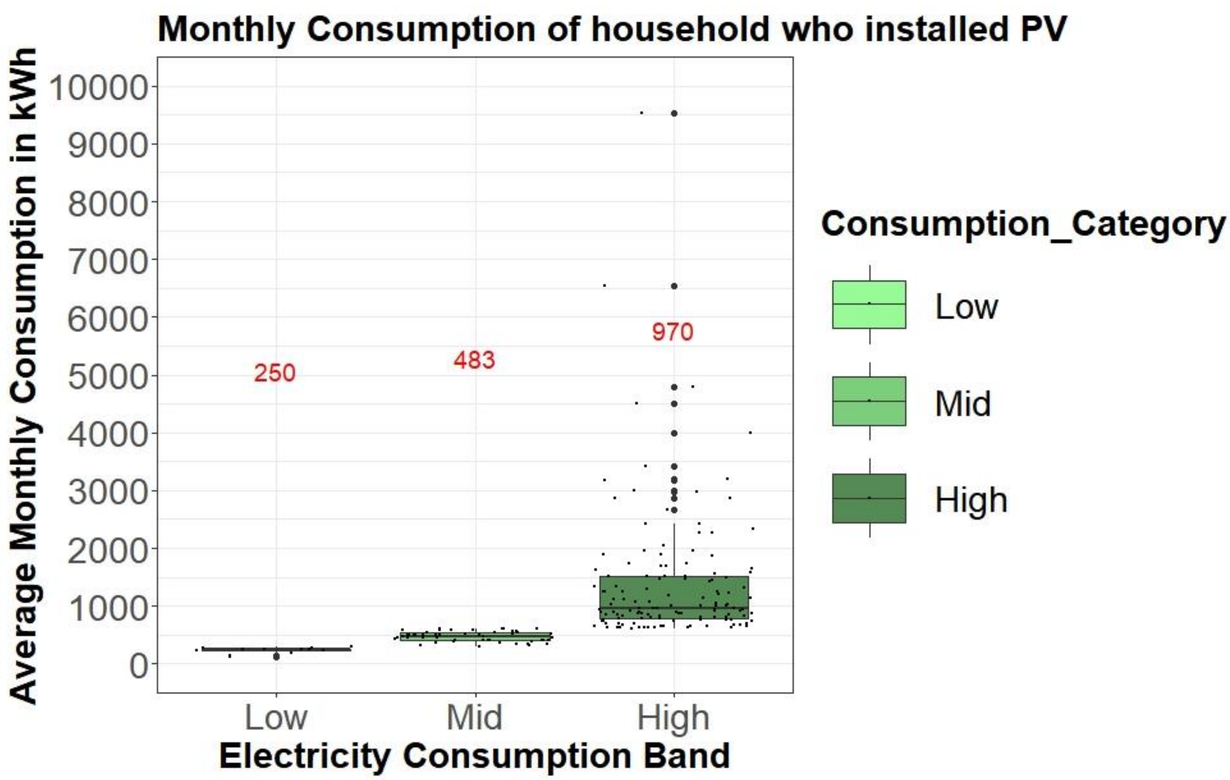

Figure 16: Distribution of average monthly consumption within each consumption band, with the median represented by the black line within the boxplots and mentioned in red over the respective box plots.

Distribution across a wide margin was observed for the high consumption band due to its definition (household with average monthly consumption greater than 600 kWh). Again, to avoid misrepresentation of the dataset (Table 15 compares the average and median values for each band), the median values of average monthly consumption of each band were adopted as the representative values for their respective reference households (highlighted in yellow in Table 15). Additionally, Table 15 also includes the average monthly consumption per issued invoice in the year 2018 for each consumption band, to provide context.

3.3.2 Average tariff rates for reference households

The average tariff applicable for the reference households' monthly consumption, calculated according to the tariff rates as of Nov 2011 and May 2022 is stated in Table 16. As the tariffs in both Nov 2011 and May 2022 were devised to become more expensive with higher consumption (see Section 3.1.5.1, and Appendix D), the average tariffs in both cases increased from the low to high consumption reference households. Furthermore, all reference households experienced an increase in average tariff from late 2011 to early 2022. The resulting annual increase in average tariff rates in the 10 years between were calculated for each reference household and listed in Table 16.

Table 16: Installation capacity, average consumptions for each reference household, along with the applicable average tariff based on the tariff rates in November 2011 and May 2022, including the annual increase in average tariff in the 10 years between 2012 and 2022.

Reference Household	Installation Capacity (kW)	Average Monthly Consumption (kWh)	Average tariff (SCR/kWh) according to rates in Nov 2011	Average tariff (SCR/kWh) according to the latest rates (May 2022)	Annual Increase in Average Tariff (SCR/kWh) between Nov 2011 and May 2022
Low	2.81	250	1.5460	**1.8280**	0.028
Mid	3.16	483.21	2.1752	**2.5341**	0.036
High	5.22	970	3.1115	**3.5191**	0.041

3.3.3 Payback period

Low consumption reference household

The parameters required to compute the payback period for the low consumption household are listed in Table 17, along with the ranges for the rebate and average tariff.

Table 17: Parameters needed to calculate the payback period for the low-consumption reference household.

Parameter	Value/Range
Total Cost – TC	62,944 SCR
Operational and Maintenance cost per annum – OMC	716.55 SCR / year
Rebate – FI	FI – Varies from 0 to 15,736 SCR in 10% increments (maximum is 25% of TC)
Avoided cost per annum – AC	3864.312 × AT
Average Tariff – AT	AT – Varies from the Average Tariff according to the latest rates (May 2022, Table 16), **1.8280 to 2.5048 SCR/kWh in increments of 0.028**, which was the average annual increment from 2012 to 2022

Based on these parameters, the payback period as a function of the average tariff (AT) and the rebate (FI) for the low consumption reference household is:

$$PB = \frac{62944 - FI}{((3864.312 \times AT) - 716.55)} \; years$$

The resulting payback period ranges from 5.27 years to 9.92 years, a window of 4.65 years. Its variation with the offered rebate and applicable average tariff is illustrated in Figure 17 as a contour plot. Naturally, the higher the rebate and the average tariff a low consumption reference household is subject to, the lower the payback period. Therefore, the lowest and highest payback periods are concentrated on the top-right and bottom-left parts of the contour plot in Figure 17. The current applicable payback period is represented by the top-left corner of the contour plot (average tariff of 1.828 SCR/kWh, and rebate of 25% of total installation cost), with a **value of 7.44 years**.

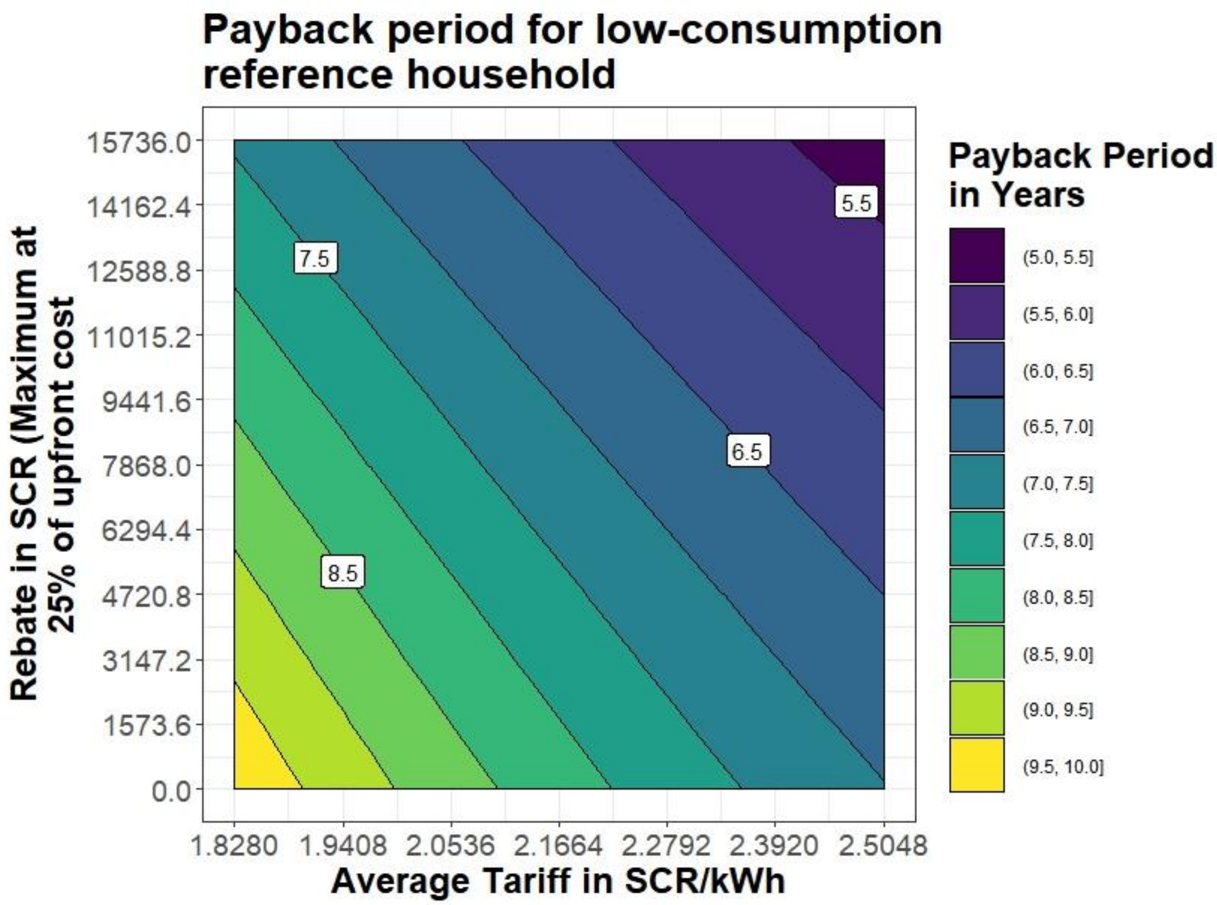

Figure 17: Payback period for the low-consumption reference household.

Mid consumption reference household

Similarly, the parameters required to compute the payback period for the mid consumption household are listed in Table 18, along with the ranges for the rebate and average tariff.

Table 18: Parameters needed to calculate the payback period for the mid consumption reference household.

Parameter	Value
Total Cost – TC	70,784 SCR
Operational and Maintenance cost per year – OMC	805.8 SCR
Rebate – FI	FI – Varies from 0 to 17,696 (in 10% increments) (maximum is 25% of TC)
Avoided cost per annum – AC	4345.632× AT
Average Tariff – AT	AT – Varies from the Average Tariff according to the latest rates (May 2022, Table 16): **2.5341 to 3.3955 SCR/kWh in increments of 0.0359**, which was the average annual increment from 2012 to 2022

Based on these parameters, the payback period as a function of the average tariff (AT) and the rebate (FI) is:

$$PB = \frac{70784 - FI}{((4345.632 \times AT) - 805.8)} \; years$$

The resulting payback period for the mid-consumption reference household ranges from 3.81 years to 6.94 years, a window of 3.13 years. The variation is illustrated in Figure 18. Like the low-consumption reference households, mid-consumption reference households also experienced their lowest (top-right corner in Figure 18) or highest (bottom left corner in Figure 18) payback periods based on when the rebate and the average tariff that they were subjected to were both at their highest or lowest extremes respectively. Again, the current applicable payback period (as of May 2022) is represented by the top-left corner of the contour plot (average tariff of 2.534 SCR/kWh, and rebate of 25% of total installation cost), with a **value of 5.20 years**.

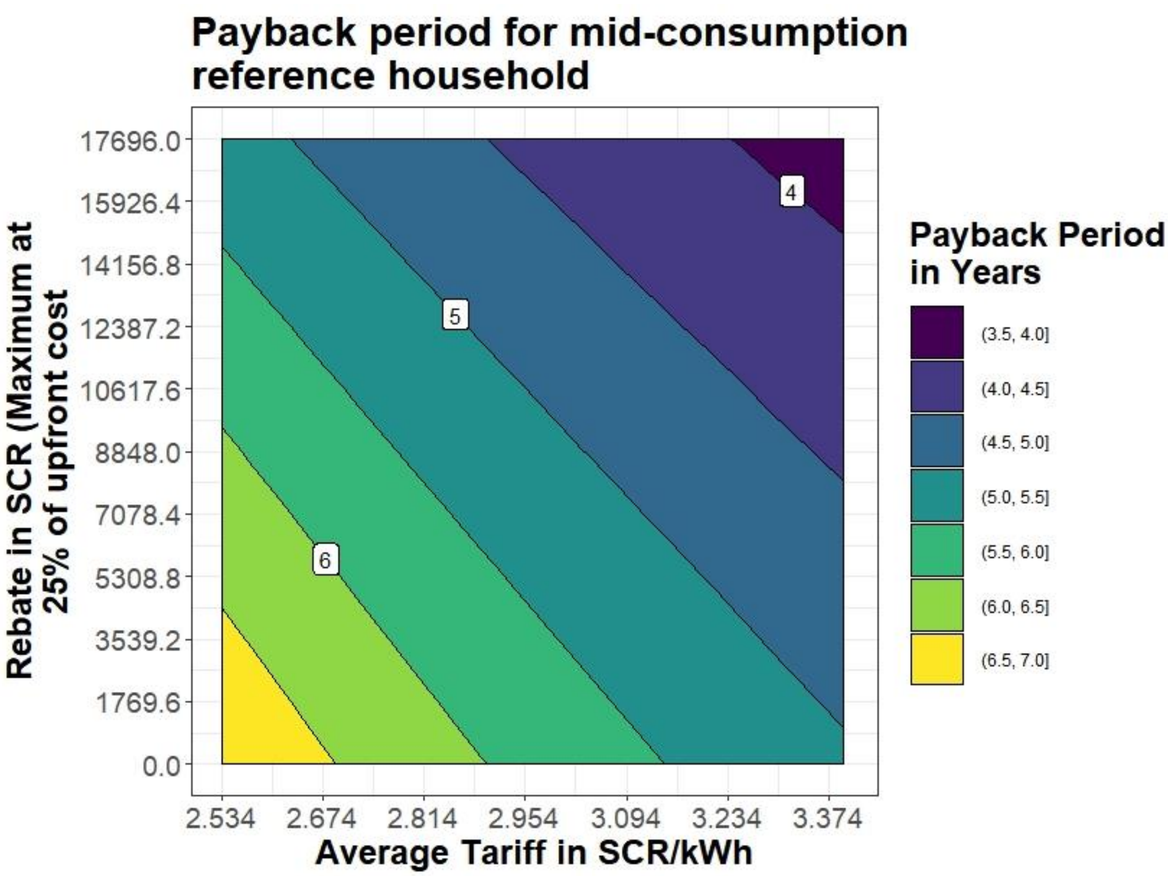

Figure 18: Payback period for mid-consumption reference household.

High consumption reference household

Along the same lines, the parameters needed to calculate the payback period for the high consumption reference household are detailed in Table 19.

Table 19: Parameters needed to calculate the payback period for the high consumption reference household.

Parameter	Value
Total Cost – TC	116,928 SCR
Operational and Maintenance cost per annum – OMC	1,331.1 SCR
Rebate – FI	FI – Varies from 0 to 29,232 (in 10% increments) (maximum is 25% of TC)
Avoided cost per annum – AC	7178.544 × AT
Average Tariff – AT	AT – Varies from the Average Tariff according to the latest rates (May 2022, Table 16): **3.5190 to 4.4971 SCR/kWh in increments of 0.0408**, which was the average annual increment from 2012 to 2022

Therefore, the payback period is calculated as:

$$PB = \frac{116928 - FI}{((7178.544 \times AT) - 1331.1)} \ years$$

The resulting payback period for the high-consumption reference household ranges from 2.83 years to 4.89 years, a window of 2.06 years. The variation is illustrated in Figure 19. Like in the low and mid-consumption reference households, the lowest and highest payback periods are concentrated in the top-right and bottom-left parts of the contour plot in Figure 19. However, unlike in Figures 17 and 18, the current payback period for the high consumption reference household is not represented by the top-left corner. This is because the rebate offered currently has a threshold of SCR 25,200 (see Section 3.1.3.2), whereas the top-left corner in the contour plot is calculated for a rebate of SCR 29,232. However, the **current payback period is calculated as 3.83 years**, which is situated in the vicinity of the top-left corner in Figure 19.

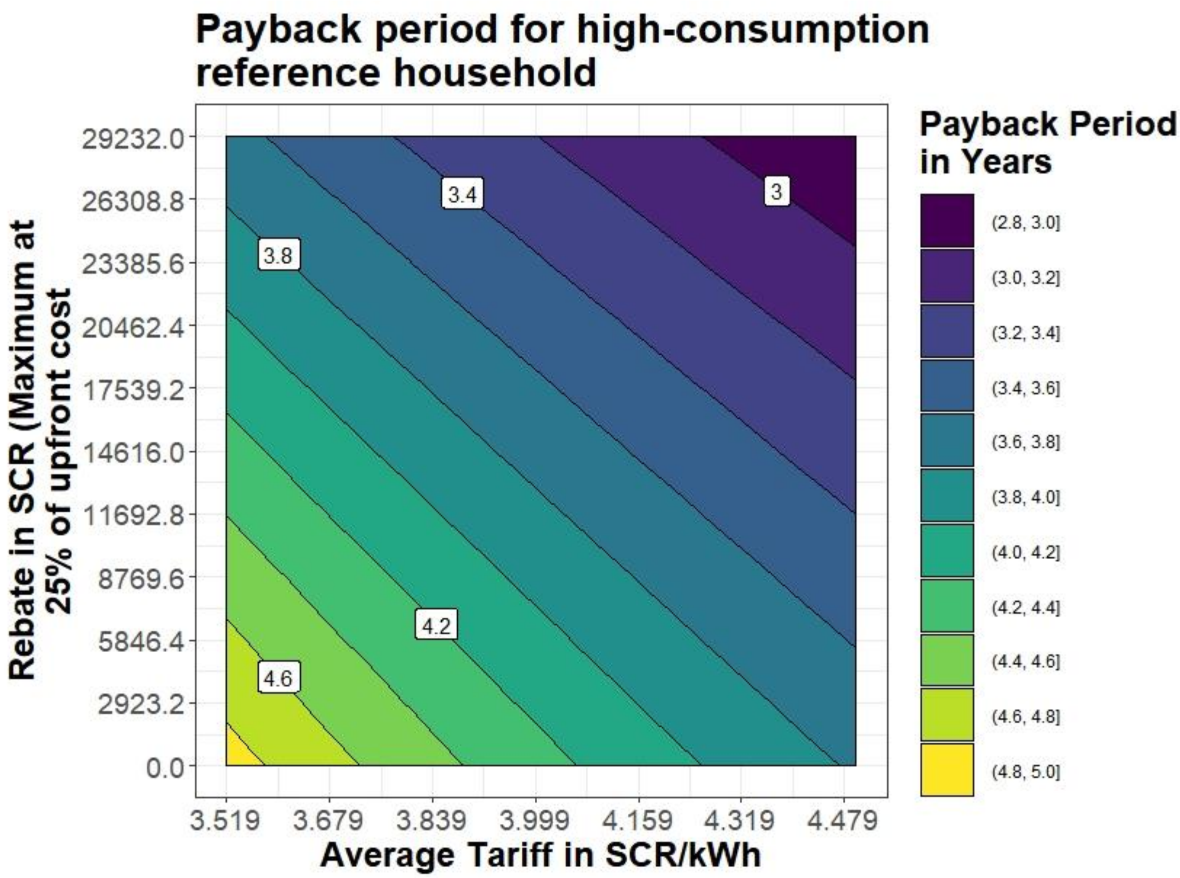

Figure 19: Payback period for high-consumption reference households.

3.3.4 Agent-based model for the domestic sector in Mahé

The projected cumulative number of installations for low, mid, and high-consumption reference households from 2021 to 2046 for each policy scenario is depicted in Figures 20, 21 and 22 respectively (the data is presented in Appendix E.6).

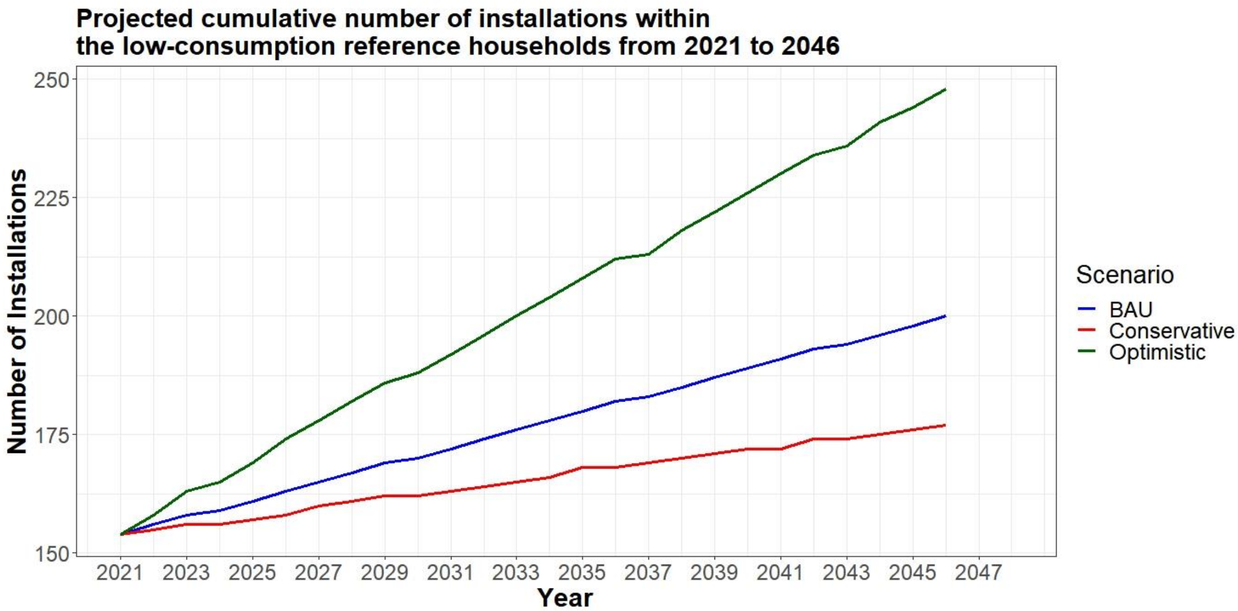

Figure 20: Projected cumulative number of installations for low-consumption reference households from 2021 to 2046 for each scenario.

From Figure 20, it is projected that low-consumption reference households would adopt systems more aggressively in the Optimistic scenario in comparison to BAU. This underlines the importance of adequate and sustained information dissemination campaigns, especially since such households are assumed to be unaffected by the neighbourhood effect (see Table 6). This trend carries through to the other two agent types: mid and high consumption reference households as apparent in Figures 21 and 22 respectively. Furthermore, it is important to note that compared to the 4647 low-consumption households eligible to install a rooftop solar PV system from 2022 (Table 5), less than 250 households do so until 2046. This can be pegged to the relatively high payback period that low-consumption reference households experience throughout this period (see Appendix E.5).

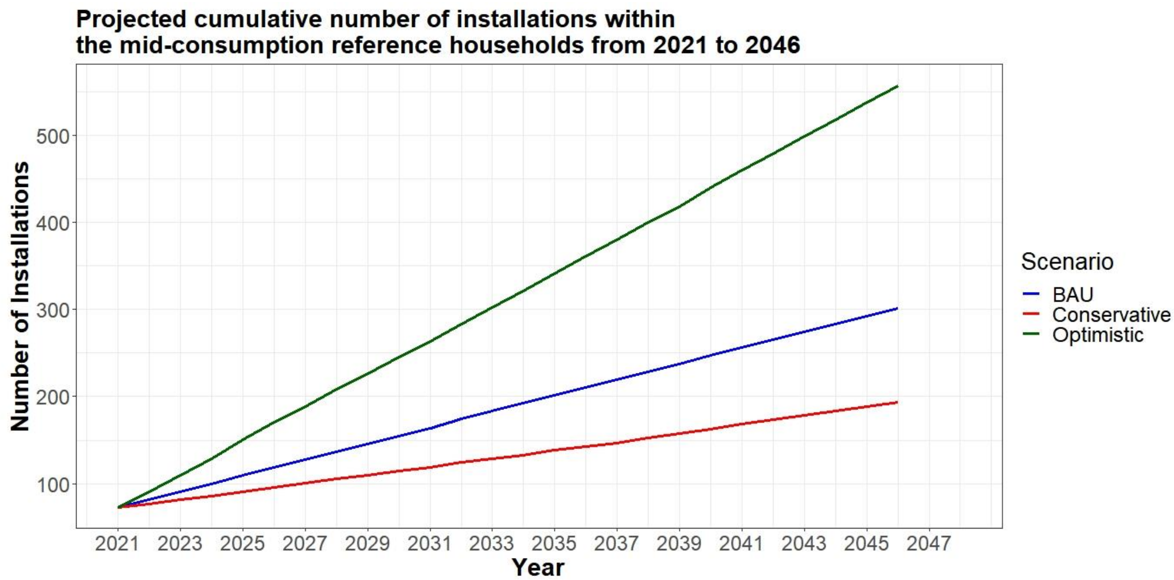

Figure 21: Projected cumulative number of installations for mid-consumption reference households from 2021 to 2046 for each scenario.

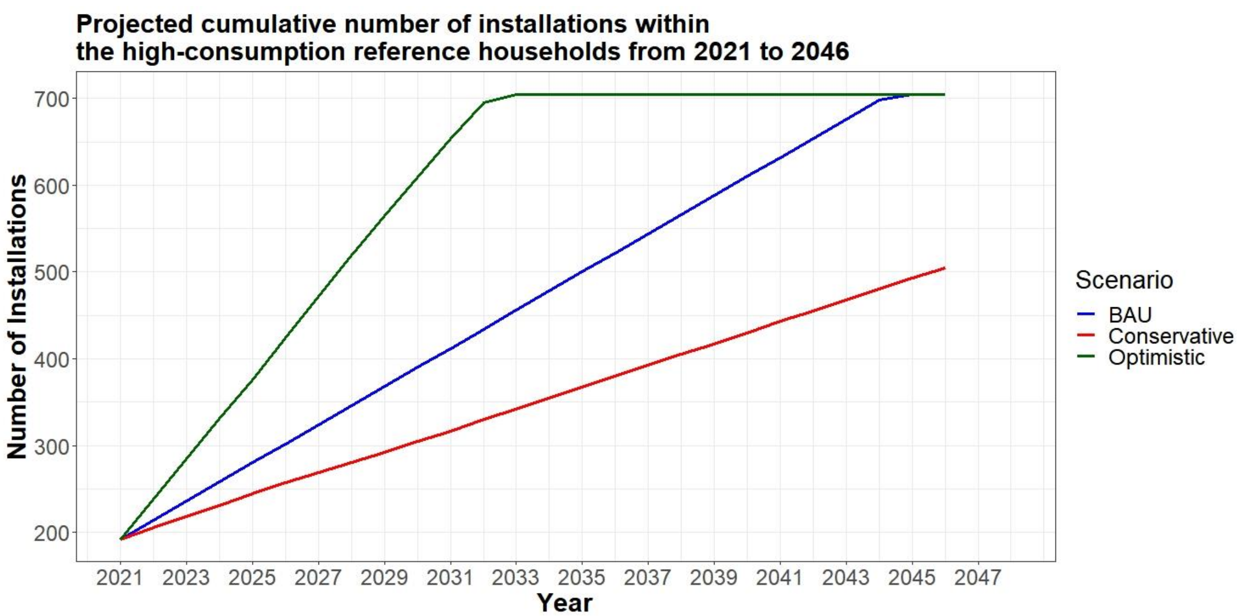

Figure 22: Projected cumulative number of installations for high-consumption reference households from 2021 to 2046 for each scenario.

In contrast, a higher proportion of eligible mid (2342) and high-consumption (513) reference households adopt the system (see Table 5), especially in the optimistic and business as usual scenarios. For high consumption reference households, all those eligible to adopt a system do so before 2046 for the BAU (by 2045) and optimistic (by 2033) scenarios (see Appendix E.6). However, only 505 high consumption reference households (from a total of 705, Table 5) adopt a system by the end of 2046 in the Conservative scenario. This can be attributed to the combined adverse effects of poor information dissemination efforts by the government and private companies, along with unattractive payback periods.

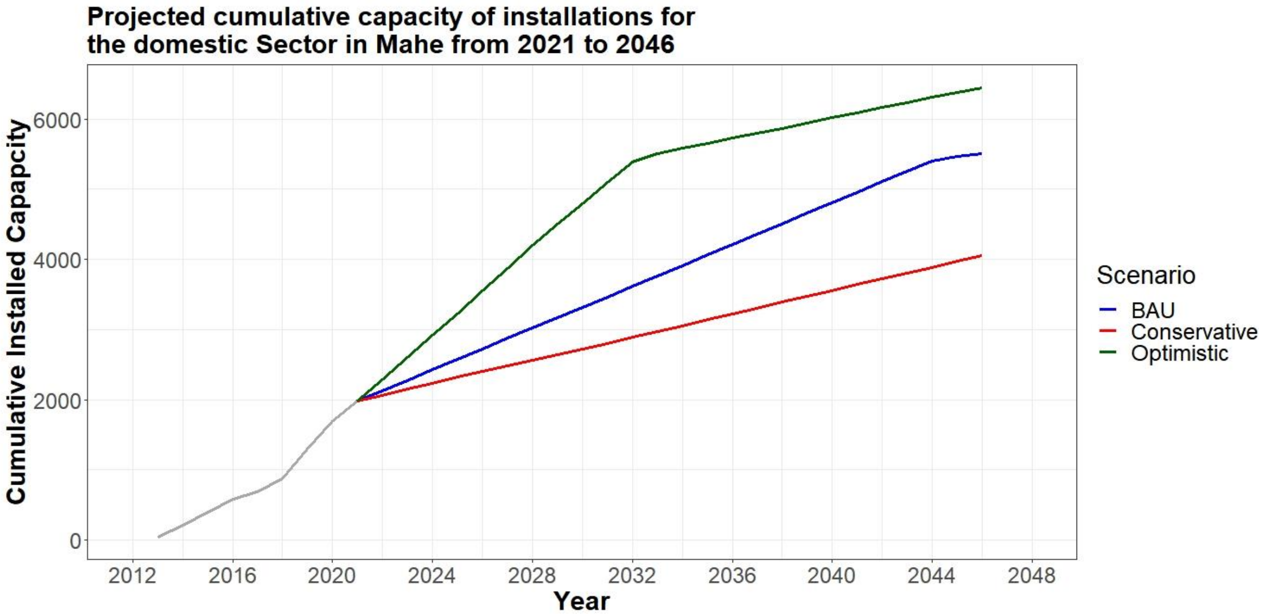

Figure 23: Projected cumulative capacity of installations in kW for the domestic sector on Mahé from 2021 to 2046 for the three scenarios, including the historical trend in the grey line from 2013 to 2021.

The projections for cumulative installed capacities between 2022 and 2046 for the three scenarios, along with the historical cumulative installed capacities from 2013 to 2021 are plotted in Figure 23. Predictably, the BAU scenario falls within the margin created by the Optimistic and Conservative scenarios on the higher and lower ends each year. Since these two scenarios are derived from the BAU scenario, which is projected using historical trends, it is reasonable to expect that actual deployment rates would lie in between their predictions (between the green and red curves in Figure 23).

3.3.5 Interpretation of results

This third part of the thesis directly addresses RQ2 (Section 1.2) in two steps.

Firstly, the attractiveness of investing in a rooftop solar PV system for homeowners belonging to different consumption bands was computed in terms of payback periods as a function of two policy instruments: rebate and applicable tariff.

From Figures 17, 18, and 19, the payback period, in general, decreased from the low to mid to high consumption reference households respectively. This is reflected in the current payback periods: 7.44, 5.21, and 3.83 years respectively for the low, mid, and high consumption reference households. This is primarily due to the incremental tariff structure followed in Mahé (see Section 3.1.5.1), wherein the applicable tariff rate increases as consumption increases. Therefore, a higher consumer of electricity saves more each month by avoiding or reducing the effect of higher tariffs at higher consumption levels. As the net billing system allows for produced electricity units to be directly offset from those consumed, the highest consumption slabs for the mid and high-consumption reference households are offset first which results in considerable savings.

Secondly, the ABM predicts the growth in deployment rates for the domestic sector on Mahé for 3 policy scenarios. Importantly, the payback period calculation is a significant component of the model.

The year 2030 is an important reference year for Seychelles' climate targets, by when it aims to achieve 15% renewable energy penetration in the country's electricity mix (Government of Seychelles, 2020, 2021; MACCE, 2022b). The model predicted 3316.935 kW, 2724.355 kW, and 4795.095 kW cumulative installed capacities for the BAU, Conservative and Optimistic scenarios respectively in 2030(see Appendix E.7).

In the projections for the optimistic scenarios (Figure 23), the growth slows down in 2032, which coincides with the year by which almost all eligible high-consumption households adopt PV modules (see Figure 22 and Appendix E.6). This is pegged to the assumption that only 25% of the households in each consumption band would be eligible to install PV. In reality, these assumptions may not be adhered to and a larger number of high-consumption households may become eligible in the future. Therefore, the growth within the optimistic scenario may be even higher, which would propel the overall deployment rates.

It is also clear that efforts to reduce the information barrier could be a low-cost high-dividends policy measure, especially because "environmental awareness" was identified to be an important driver for the homeowners (Section 3.2.3.5). Given the comparison to the payback periods for solar rooftop PV systems in Europe at 8-10 years (Whitlock, 2019), a higher deployment rate is expected from even the low-consumption households. The absence of this indicates that the non-economic barriers (as identified in the risk perception matrix for homeowners) dominate the decision-making process, especially for low and mid-consumption households. Aggressive and sustained information dissemination efforts and awareness creation campaigns could reduce these non-economic barriers drastically.

Given the proposal to shift away from the net billing system into another kind of compensation system (for example, a feed-in tariff system) (PUC, 2022d; SEC, 2022c) the payback period would need to be computed again for those conditions. However, since the net billing system offers a direct offset in terms of electricity units, it's unlikely that other systems would be able to replicate the low payback periods, and hence attractiveness of investment, for the mid and high consumption households.

Furthermore, an update to the tariff system was recommended by Macro Consulting (2019), such that the average tariff for the domestic sector increases from its current value of almost 2 SCR/kWh by about 80% to remove the cross-subsidization from the non-domestic to domestic sectors. The intention is to translate the average cost of production of electricity into a new tariff system. It’s unclear how this may evolve and whether it would continue to implement incremental bands (Section 3.1.5.1). However, any such decision would have an impact on the payback periods.

Small decreases in their current payback period may be tolerated by high-consumption households such that the current growth in their adoptions is sustained (BAU, Figure 22). This is because the investment is already quite attractive to them. However, decreases in the payback periods for low and mid-consumption households could further demotivate them. New policy instruments, which may take the form of rebate schemes, updated tariffs, or new compensation mechanisms like the FiT, may ensure that the payback for these households is adequately decreased from their current values to spur growth in deployment rates in them.

4 General discussion

In this thesis, an analysis of the different aspects which determine the development of the rooftop solar PV sector in Mahé was conducted. In pursuance of this, the risk perceptions of major stakeholders concerning the prospect of increasing the deployment of such systems were unearthed (answering RQ1, Section 1.2), and the economic aspects that the domestic sector may consider before investing were explored, culminating in the simulation of their adoption (answering RQ2, Section 1.2).

The major results from these constituent parts have already been individually discussed in the results section (Sections 3.2.4 and 3.3.5). Therefore, this section draws from these results to identify and discuss the most important challenges to increased adoption of rooftop solar PV systems while also discussing potential points of action to overcome them (4.1). Furthermore, limitations in the methods and the scope for further research are addressed (4.2).

4.1 Challenges and potential points of action

The challenges are discussed under three themes: institutional challenges, economic challenges, and non-economic challenges.

4.1.1 Institutional challenges

In 2010, SEC was instituted as an independent body to perform the role of an energy regulator. Consequently, the Energy Act, 2012, charged SEC with a wide variety of functions to help achieve its mandate. Therefore, the institutional arrangement comprising SEC, PUC and MACCE is expected to work collaboratively to achieve the energy goals of the country. However, from the results of the risk perception matrix derived for the governmental stakeholder group (Section 3.2.1), it is clear that this institutional setup has performed sub-optimally. This stems from two reasons.

Firstly, the lack of clarity in aligning the responsibilities, powers and capacities of PUC and SEC in legislation, as pointed out in Cadmus Group (2019b), continues to persist today. The regulatory authority provided to PUC in the Public Utilities Corporation Act, 1986 interferes with the SEC's role as an independent energy regulator. Furthermore, SEC currently lacks personnel with the appropriate capacity to exercise technical oversight on PUC. Therefore, for all technical aspects, SEC is completely dependent on PUC, which can manifest adverse outcomes. For instance, during the application process to install a rooftop solar PV system, PUC holds the sole authority to determine the system capacity that may be awarded. Often, the system may be downsized or rejected on several grounds (see Section 3.1.3.2), which applicants are obliged to accept without the possibility of verification. This verification process could've been facilitated by SEC if they had the technical staff to do so.

To overcome this challenge an important point of action may be to harmonize the Public Utilities Corporation Act, 1986 and Energy Act, 2012 by making amendments to them or by creating a new consolidated legislative framework. Cadmus Group (2019b) already contains several recommendations as to how this can be conducted. Another point of action could be to restructure SEC with personnel possessing suitable competencies that will enable it to execute its full scope of powers and responsibilities. Such revamping efforts are already underway, seeking to increase the number of staff within SEC and to expand the overall role it would play in the future (SEC, 2022c).

The second reason stems from PUC's expansive role as the principal system operator and its underlying business model (Section 3.2.1). PUC currently plays a delicate function in balancing the security of the energy supply with the country's energy transition ambitions. Due to technical restrictions posed by the prevalent state of the grid, PUC is often forced to favour the former. Additionally, PUC is currently responsible for two other services: water supply and sanitation. With the categorical majority of its revenues coming from the electricity supply (in 2020, 83%, PUC (2021)) and considering that the other two verticals are consistently loss-making, PUC's profitability largely depends on its electricity sale. Being a parastatal entity, PUC is responsible for its revenues. Hence, the loss of revenues that PUC may incur from the large deployment of rooftop solar PV systems was often brought up as a matter of concern (see Section 3.2.1). Therefore, the increased risk averseness displayed by PUC regarding the uptake of rooftop solar PV systems was found to be contingent on two reasons: technical limits posed by the current state of the grid, and efforts to avoid large revenue erosion. Further, it is important to note that the current inability of SEC to exercise technical oversight on PUC elevates this challenge.

Although several points of action may be contemplated to overcome this challenge, it is premature to conclude without a detailed analysis of PUC's structure and business model as to which of these may be the right ones to pursue. However, some of them may include: unbundling PUC's dual function as an electricity generator and distributor which is a common practice in Europe (Meyer, 2012), separating its three services such that they are individually self-sufficient and reducing the monopoly of PUC in the energy generation sector by admitting independent power producers (there are currently none in Mahé).

4.1.2 Economic challenges

The economic challenges may be explored from two perspectives: from that of PUC and the GoS, and from that of the potential adopter (from the commercial or domestic sector).

Firstly from PUC's and GoS' perspective, the current compensation mechanism for electricity produced from PV modules, i.e the net billing system (Section 3.1.3.2), and the way the tariff is set up (Section 3.1.5), imply that existing adopters don't pay for the additional measures implemented to ensure the stability of electricity supply despite the injection of their intermittent energy into the grid. Some of these measures may include the up-gradation or new installations of larger transformers, the replacement of transmission lines, or installations of utility-scale batteries. Each of these measures is capitally intensive, an expense which is borne by PUC and in turn the GoS. Therefore, PUC perceives that further increased adoption of such systems may lead to a double cost: revenue losses due to a decrease in the amount of electricity sold, and increased expenses to manage the grid for higher penetration of intermittent energy (Section 3.2.1).

Furthermore, a general agreement has been shared by the governmental stakeholders that people who have not installed PV modules should not have to pay for these additional measures. Therefore, a point of action that may help recover some of the investment costs could be to implement an additional fixed "network charge" to adopters of PV. This could be a one-time fee during the installation (at the expense of increasing the upfront cost for potential adopters) or be a monthly fixed charge like the "demand charges" levied today (Section 3.1.5).

Secondly, from the potential adopter's perspective, the economic challenge varies widely depending on which sector and consumption category they fall into. Due to the cross-subsidization from the non-domestic (including commercial and governmental) to the domestic sector, the commercial sector is currently subject to an expensive tariff system. Therefore, investment in a rooftop solar PV system is mostly seen as economically viable, which becomes more attractive with higher consumption (see Section 3.2.2). The payback periods were reported to be around 4 to 5 years, which constitutes a high annual return compared to other kinds of investments. Apart from the high tariffs, the net billing system facilitates such low payback periods. Therefore, commercial customers reported that the 100 kW system limit is restrictive, without which they would install much larger systems. The commercial sector also has better access to finance. Similarly, high consumption households within the domestic sector also experienced low payback periods (Section 3.3.3) and they rather found the capacity cap and arbitrariness in its award to be demotivating (Section 3.2.3).

In contrast, the low-consumption households perceived their payback periods to be too long (Section 3.3.3), but even before making this calculation, they are often stumped by the upfront cost of PV modules (Section 3.2.3). Furthermore, they also found access to low-cost finance to be difficult. The few low-consumption households who bought a PV module were often driven by environmental awareness over any economic benefit that the investment offers. While the rebate scheme was a dealmaker for low and mid-consumption households, it was seen as something of a "bonus" for high-consumption households and the commercial sector. Therefore, the system as it exists today, i.e, the cross-subsidized tariff system, the net billing compensation system, and the rebate scheme (see Section 3.1.3.2) works to produce higher benefits for the commercial and high consumption households who are already proposed with an attractive investment opportunity. On the other hand, amongst the low consumption households, who actually need financial support, the historical uptake has been low (see Figure 14) and is projected to be low also in the future in all scenarios of the ABM (Figure 20).

Several points of action may be pursued to overcome this challenge. However, each of them would have an impact on the payback periods and hence deployment rates within the respective subsectors. Therefore, an optimum policy mix of these measures may be constructed for each subsector to instigate desired deployment rates which could also be compatible with PUC's and the GoS' investment plans. Some of these measures may include: replacing the current net billing compensation system with controllable feed-in tariffs specifically implemented for each subsector (which is a common policy instrument in Europe and has been historically successful in Germany, as discussed in Haelg et al. (2022)) removing the cross-subsidisation from the non-domestic to the domestic sector (as recommended in Macro Consulting (2019)) which would increase the attractiveness of the investment for low-consumption households (while decreasing for high-consumption households and the commercial sector) and implementing a more targeted financial support mechanism focusing on adopters who actually need it.

4.1.3 Non-Economic Challenges

The domestic sector in Mahé experienced payback periods (currently 7.4, 5.2 and 3.8 years for low, mid and high consumption households respectively, Section 3.3.3) lower than those in Europe (between 8 to 10 years in 2018 for a 2.9kW system in 2018 according to Whitlock (2019)). Despite this, accelerated deployment rates have not been witnessed. This indicates that several other barriers took precedence during the decision-making phase, over possible economic benefits for potential adopters. While many of them have been identified in the risk perception matrix derived for the homeowners (Section 3.2.3), two, in particular, constitute challenges that are non-economic in nature.

Firstly, the information barrier was identified by homeowners as a major deterrent to the adoption of a rooftop solar PV system (see Table 13 and Section 3.2.3). Both the lack of availability of information from credible sources and difficult access to this information has resulted in poor awareness about the installation process and financial incentives available. Respondents who had installed a system often made their investment decision after learning about the system and the process from a friend or relative who had already installed one. Especially the low-consumption households reported this as a major challenge. Also, the ABM projects that the reduction of this information barrier would affect the deployment rates considerably (Figure 23). A possible point of action to alleviate this difficulty could be to conduct aggressive and sustained awareness creation and marketing campaigns by governmental authorities and the PV industry respectively, such that people are actively encouraged to invest in rooftop solar PV systems.

Secondly, the technical barriers (see Section 3.1.3.2) that have been discussed before, have resulted in capacity caps being implemented by PUC. The PV industry in Mahé reported that when an applicant (either in the commercial or domestic sectors) was awarded a downsized system capacity compared to what they had applied for, they often dropped the project entirely (Hoareau, 2022; Maurel, 2022; Orr, 2022). Currently, once PUC receives an application, it studies the site for its electricity consumption and potential to cause problems to the grid for the system capacity applied for, following which it makes an award (Section 3.1.3.2). Homeowners (Section 3.2.3) and the PV industry reported that if they had already an idea of the size of system they may be allowed to install, it could've allowed them to plan the investment better. Therefore, creating a dynamic system (for example, in the form of an indicative map) that estimates the capacity of installations each house may be awarded based on the state of the grid could be a possible point of action.

4.2 Limitations and scope for further research

This thesis contributes to an improved understanding of the PV sector in Mahé and identifies the stakeholder-specific barriers to be addressed and opportunities to be built upon to increase the role it can play in the country's energy transition. However, several limitations must be considered while interpreting the results presented previously.

The risk perception matrix elicits individual perceptions from respondents belonging to the governmental, commercial, and domestic sectors. While the distribution of respondents was even between the different consumption groups within the domestic sector, this was not the case for the respondents from the commercial sector who often tended to be from the high consumption category. Furthermore, in comparison to the 31 respondents from the domestic sector, the commercial sector was represented by only 12 (Section 2.2.4). To capture a wider perception from both these sectors, future research efforts may consider including online surveys that may attract a larger number of respondents.

Several assumptions were made to simplify the domestic sector of Mahé in the ABM (Section 2.3.3.4). Some of them may not represent developments for the entire simulation period of 25 years from 2022 to 2046. For example, the number of households is assumed to be a fixed number for the simulation period, based on the number of domestic connections PUC reported in 2021. It is also assumed that the total number is distributed between only three types of reference households (low, mid, and high), constituting three agent types. For the model to represent reality more closely, future research or modelling efforts may consider building a dynamic model that increases the number of households each year based on historical trends. Furthermore, the consumption data for the agents may be sourced from PUC and also evolve from year to year based on historical trends. This would enable the calculation of the payback period for each agent at each time step, rather than an entire agent type like computed here.

It was also assumed that 75% of the households are incapable of installing PV systems which may be due to geographical, structural, or other factors. In a more dynamic model, the eligibility of a household can be determined from, among other things, its location using Geographic Information System (GIS) data.

Additionally, the households were distributed in an artificial landscape, attempting to mimic the density of homes in the urban areas of Mahé. Future efforts may utilise GIS data to construct a landscape with the actual distribution of households. This would account for the neighbourhood effect (Section 2.3.3.4) more accurately.

Furthermore, only three factors are assumed to affect the decision-making probability of the households: the effect of a difference in payback period, reduction in the information barrier, and the neighbourhood effect. These were picked after analysing the risk perception matrix for the homeowners (Section 3.2.3). Future modelling efforts may consider a wider selection of factors which can be calibrated for the situation in Mahé.

5 Conclusion

This thesis is an effort to help policymakers and individuals interested in the country's energy transition understand the role that solar PV technology can play in this endeavour. It finds that rooftop solar PV systems could contribute significantly, but the extent of realizing this potential will be decided by how adequately the institutional, economic, and non-economic challenges are addressed. Historical trends show that there is enthusiasm amongst both the high-consumption domestic and commercial sectors to adopt these systems. Appropriate policy designs can help build on this enthusiasm and sustain a unique opportunity for the country's government, its residents, and businesses to collaboratively drive toward a more energy secure and sustainable society.

Particularly, to ensure that a wider section of the residential sector can benefit from the adoption of solar rooftop PV systems, concrete efforts must be taken to reduce the information and economic barriers that they are currently exposed to. Especially, aggressive, and sustained information dissemination and awareness creation campaigns could prove to be a low-cost high-dividend strategy. Moreover, tapping into the low-consumption domestic market in Mahé through the provision of improved access to low-cost finance and attractive payment schemes could create many green jobs within the renewable energy industry in Seychelles.

Furthermore, this work also aspires to provide a platform over which future research efforts that seek to hasten the transformation of the energy sector in Mahé can be built. Importantly, it bridges a gap in research wherein the barriers to and drivers against the adoption of PV systems on SIDS like Seychelles is now obtained. It manages this for the domestic and commercial sectors simultaneously while also building on inputs from the governmental authorities and industry. Future research can also repeat the exercise to decipher whether the risk perception of the stakeholders has changed over time. This could be valuable for endeavours seeking to diffuse other kinds of clean technology that may be beneficial for the country in the future.

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Appendix

Appendix A – Interviews Conducted

Appendix A.1 – List of Expert Interviews

Table 20: Participants of expert interviews.

Sl. No.	Name	Sector	Position	Institution / Firm	Date	Time	Duration	Place
1	Flavien Joubert	Government	Minister for Agriculture, Climate Change and Environment	Ministry of Agriculture, Climate Change and Environment	14-03-2022	08:30	1 hour 30 minutes	Minister's Office, Ministry of Agriculture, Climate Change and Environment, Victoria
2	Tony Imaduwa		Chief Executive Officer	Seychelles Energy Commission	11-02-2022	09:20	2 hours 30 minutes	SEC Office, Victoria
3	Bernice Charles and Cynthia Alexander		Officers	Seychelles Energy Commission	02-02-2022	10:30	1 hour 36 minutes	SEC Office, Victoria
4	Dr. Laurent Sam		Energy Engineer	Public Utilities Corporation	08-02-2022	13:30	1 hour 30 minutes	PUC Head Quarters, Electricity House
5	Yves Maurel	PV Industry	Managing Director	Sun Tech Seychelles	07-02-2022	11:00	1 hour 15 minutes	Victoria
6	Shana Charlette		Managing Director	Sey Power Solutions	07-02-2022	16:30	1 hour 24 minutes	Victoria
7	Brian Orr		Managing Director	MEJ Electrical and represents Vetiver Tech Pty Ltd	08-02-2022	10:30	1 hour 15 minutes	Providence Industrial Estate
8	Jim Lesperance		Managing Director	DEC Electricals	09-02-2022	10:50	2 hours	Victoria
9	Richard Hoareau		Managing Director	Energy Solutions Seychelles	10-02-2022	10:00	1 hour 5 minutes	Providence

Appendix A.2 – List of Interviews in the commercial sector

Table 21: Interview participants from the commercial sector.

Sl. No.	Name	Institution/Firm/Affiliation	Type	Date	Time	Duration	Place
1	Nilesh Kerai	Director - Vijay Construction (Pty) Ltd.	Grid Connected	08-03-2022	11:00 AM	1 hour	Providence, Mahe
2	Sudhan Rajasundaram	Managing Director - Stallion Enterprise	Grid Connected	08-03-2022	09:00	1 hour	Victoria, Mahe
3	Russel Moustache	Building & Project Manager - Central Bank of Seychelles	Grid Connected	11-03-2022	10:30	1 hour	Victoria, Mahe
4	Ajay Joseph	Chief Engineer - Kempinski Seychelles Resort	Grid Connected	15-03-2022	2:00 PM	1 hour	Baie Lazare, Mahe
5	Prasoon Lal Madhurakany	Chief Engineer - Constance Ephelia Resort	Auto-Producer	15-03-2022	09:00	1 hour	Port Launay, Mahe
6	Mayrose Marie	Manager - Pangia Beach	Grid Connected	18-03-2022	10:00	1 hour	Providence, Mahe
7	Alwyne Changlai Seng	Owner - Changlai Seng Store	Grid Connected	21-03-2022	17:00	1 hour	Castor Road, Victoria
8	Nabil Chatat	Senior Projects Manager - United Concrete Products Seychelles	Grid Connected	23-03-2022	15:00	1 hour	Anse des Genets, Mahe
9	Bertrand Morel	Utility Manager - Four Seasons	Auto-Producer	23-03-2022	10:00	1 hour	Petite Anse, Mahe
10	Gerry Adam	Chairman - Mahe Shipping	Grid Connected	24-03-2022	09:30	1 hour	Victoria, Mahe
11	Gary Aglae	Operations Manager - Central Common Cold Store	Auto-Producer	28-03-2022	09:00	1 hour	Ile du Port, Mahe
12	Eric Talma	Project Coordinator - Seychelles Trading Company	Grid Connected	30-03-2022	12:00	1 hour	Victoria, Mahe

Appendix A.3 – List of homeowners' interviews

Table 22: Homeowners who participated in the interviews.

Sl. No.	Name	Date	Time	Duration	Place
1	Sheela Arissol	19-02-2022	15:30	1 hour	Victoria
2	Ian Bernard	19-02-2022	09:45	1 hour	Victoria
3	Donald Monnaie	20-02-2022	14:30	1 hour	Beau Vallon
4	Eric Frank	22-02-2022	17:30	45 minutes	Anse La Mouche
5	Marie-Therese Purvis	22-02-2022	18:00	1 hour	Anse La Mouche
6	Allesandre Fontaine	23-02-2022	17:15	45 minutes	Beau Vallon
7	Hazel Lafortune	24-02-2022	17:15	50 minutes	Anse Boileu
8	Laurette Mariette Paola Dine	25-02-2022	13:30	45 minutes	Anse Aux Pins
9	Yutline Ethel Low Yoke	26-02-2022	12:30	1 hour	Anse Etoile
10	Mangalanayagi Rajasundaram	28-02-2022	10:20	1 hour	Beau Belle
11	Riyad Moustache	01-03-2022	12:00	1 hour	Grand Anse (Mahe)
12	David Palmyre	01-03-2022	14:20	1 hour	Point Au Sel
13	Lizanne Margaret Moncherry	02-03-2022	13:45	1 hour	Bel Ombre
14	Andrew Jean	03-03-2022	09:15	45 minutes	Sans Soucis
15	Mamy Razanajatovo	04-03-2022	09:00	1 hour	Grand Anse (Mahe)
16	Francis Changleng	04-03-2022	10:30	1 hour	Ma Constance
17	Caroline Abel	07-03-2022	15:00	1 hour	Anse Boileau
18	Joel De Commarmond	07-03-2022	10:00	35 minutes	Victoria
19	Rohit Khanna	08-03-2022	09:00	40 Minutes	Ma Constance
20	Stephanie Loustau-Lalanne	09-03-2022	11:15	1 hour	La Misere
21	Stuart Misseloine	10-03-2022	17:00	1 hour	La Misere
22	Maxwel Focktave	14-03-2022	17:00	45 minutes	Bel Ombre
23	Rodney Quatre	15-03-2022	12:00	45 minutes	Ma Constance
24	Samantha Fock Tave	15-03-2022	18:00	45 minutes	Bel Ombre

25	Rosemary Celine Hoti	19-03-2022	17:00	35 minutes	Belle Vue (La Misere)
26	Rathinavelu Balamurugan Mudaliar	20-03-2022	14:00	35 minutes	Victoria
27	Claude Nicolier	21-03-2022	14:45	1 hour	Anse Aux Pins
28	John Marie	22-03-2022	9:30	1 hour	Anse La Mouche
29	Roy P. Labrosse	24-03-2022	13:30	1 hour	Anse Royale
30	Gunther Mooser	25-03-2022	14:20	50 minutes	Sancta Maria Estate (Anse La Mouche)
31	Veilma Joubert	28-03-2022	14:30	45 minutes	Foret Noire

Appendix B – All interview questionnaires

Appendix B.1 – Questionnaire for governmental stakeholder interview - MACCE

Questionnaire – Minister for Agriculture, Climate Change and Energy

1. Seychelles has made ambitious commitments to reduce its carbon emissions (by 294 ktCO2e in 2030 compared to BAU) with 124 ktCO2e reductions coming from the energy sector. Do you foresee further increasing these ambitions, for example, towards achieving 30% penetration of renewable technologies in Seychelles' energy mix by 2030 instead of the current 15%? What is your outlook for the future concerning Seychelles' energy mix? What kinds of renewable energy technologies are being considered?

2. Today, there exists a cross-subsidization between the commercial/governmental and residential consumers concerning the electricity tariffs. Would this continue, or would there be a change in policy by bringing about tariff rates that reflect the cost of electricity production by PUC?

3. How do you perceive that the institutional arrangement between the Government (Ministry), Regulator (SEC), and Operator (PUC) will evolve in the future? The Energy Act, 2012, has charged the SEC with overarching functions concerning the energy sector, including "regulating the generation, transmission, distribution, supply and use of electrical energy". However, currently, there is a gap in SEC's capacity to satisfy its mandate. Do you agree with this? What is the relationship between SEC and the Ministry?

4. Among other renewable technology options, how much do you think PV should be pursued in Seychelles' context?

5. What problems do you experience with PVs today?

6. Sooner than later, the island will need to strengthen its grid and energy storage capacity to allow for larger integration of intermittent sources. Do you agree with this, what are your thoughts?

7. For installing rooftop PV systems on government buildings, will the government consider establishing large-scale systems?

8. One of the challenges is the upfront cost. Are there any discussions/plans on facilitating a financial mechanism that would alleviate this concern? (low-cost loan, continuing the rebate, etc)

Appendix B.2 – Questionnaire for governmental stakeholder interview - SEC

Questionnaire for Semi-structured Expert's Interview – SEC

The interview is divided into 2 parts.

1) **Background data**
   a. Name:
   b. Title/role in the company:

2) **Barriers to and enablers of PV adoption**

   a. What do you think is the general perception of rooftop solar PV technology in Seychelles? How aware do you think the people are?

   b. What barriers do you think people experience before deciding to adopt PV? What creates this resistance(s)? How? Why? How do you think this can be avoided?

   c. Is there a difference between the barriers experienced by residential, commercial, and governmental customers?

   d. In the end, what do you think are the factors that motivate people to buy it despite these barriers?

   e. Do you perceive any benefits of installing PV systems to PUC or society? Do these benefits motivate one to adopt the technology?

   f. Do you perceive any negative outcomes of installing PV systems to PUC or society? Do such outcomes prevent one from adopting the technology?

   g. What problems do you experience with PVs today?

   h. How do you think the technical problems associated with grid stability, safety, and capacity be addressed? What are the barriers you experience with implementing technical solutions to these issues?

   i. Sooner than later, the island will need to strengthen its grid and energy storage capacity to allow for larger integration of intermittent sources. Do you agree with this, what are your thoughts?

   j. What is your outlook for the future concerning Seychelles' energy mix? In the Electricity Master Plan (EDP International, 2019), the recommended scenario is Hypothesis 1, Scenario 3 with the 4 MW Floating PV Farm commissioned by the end of 2020, a 5 MW WTE plant by 2022, a 5MW biodiesel plant by 2025, and a 7MW rooftop solar capacity by 2030 (growing 5% from 2019 as the base). Do you think the WtE and Biodiesel plants are likely to be implemented given their high costs and other restrictions? The proposed 7MW rooftop solar capacity is close to already being achieved probably by 2023, rather than 2030. However, the other renewable energy sources that should have been commissioned by now, i.e, the 4 MW floating farm and 5MW WTE, are lacking.

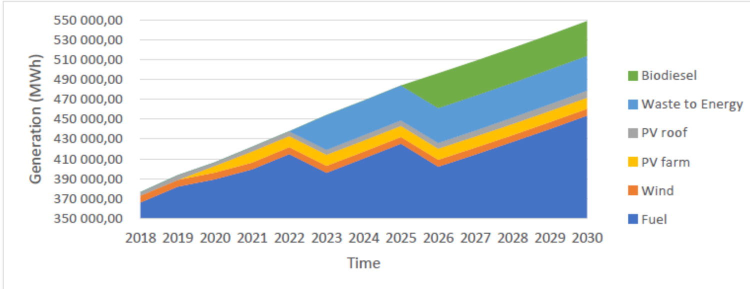


Figure 4-7 - Hypothesis 1 - Scenario 3 generation mix

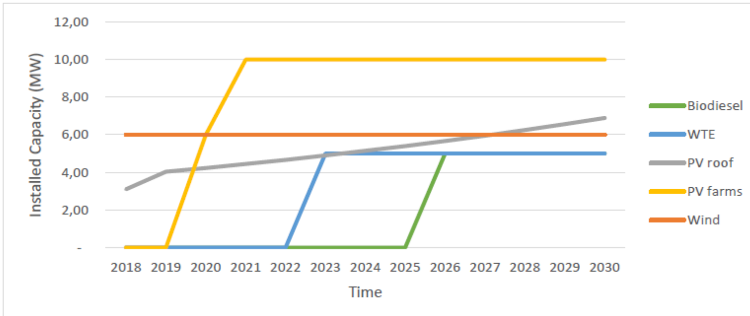


Figure 4-8 - Hypothesis 1 - Scenario 3 Renewables Installed capacity

k. Do you foresee any other system than the current net billing mechanism? How do you think a feed-in-tariff system would work? How do you think these will work? At what rate would you propose that prosumers can sell the energy they produce to you? What are your considerations regarding this?

l. Do you foresee any changes in regulation as to how future PV systems will be connected to the grid?

m. Do you believe that the SEC should also be equipped with a technical task force to maintain supervision over the PUC and installers/suppliers?

n. Would you consider a certification process instead of the current endorsement mechanism for installers/suppliers?

o. How do you think the application and adoption process be streamlined for customers?

p. What are your thoughts on the rebate scheme for adopters? Do you think it will continue in the future? Do you think it should continue for commercial customers?

q. Can you comment on your relationship with PUC, highlighting any synergies or resistances? What is particularly easy or difficult?

r. Do you foresee a future where individual battery systems are permitted to be installed? How do you think this will change the system? Would you then prefer a net-metering system?

s. What do you think can be done to remove the barriers to a wider spread of PV?

t. Finally, what kind of synergies can be built to enable this?

Appendix B.3 – Questionnaire for governmental stakeholder interview - PUC

Questionnaire for Semi-structured Expert's Interview – PUC

The interview is divided into 3 parts.

1) **Background data**

   a. Name:

   b. Title/role in the company:

2) **Barriers to and enablers of PV adoption**

   a. What do you think is the general perception of rooftop solar PV technology in Seychelles? How aware do you think the people are?

   b. What barriers do you think people experience before deciding to adopt PV? What creates this resistance(s)? How? Why? How do you think this can be avoided?

   c. Is there a difference between the barriers experienced by residential, commercial, and governmental customers?

   d. In the end, what do you think are the factors that motivate people to buy it despite these barriers?

   e. Do you perceive any benefits of installing PV systems to PUC or society? Do these benefits motivate one to adopt the technology?

   f. Do you perceive any negative outcomes of installing PV systems to PUC or society? Do such outcomes prevent one from adopting the technology?

   g. What problems do you experience with PVs today?

   h. How do you think the technical problems associated with grid stability, safety, and capacity be addressed? What are the barriers you experience with implementing technical solutions to these issues?

   i. Sooner than later, the island will need to strengthen its grid and energy storage capacity to allow for larger integration of intermittent sources. Do you agree with this, what are your thoughts?

   j. What is your outlook for the future concerning Seychelles' energy mix? In the Electricity Master Plan (EDP International, 2019), the recommended scenario is Hypothesis 1, Scenario 3 with the 4 MW Floating PV Farm commissioned by the end of 2020, a 5 MW WTE plant by 2022, a 5MW biodiesel plant by 2025, and a 7MW rooftop solar capacity by 2030 (growing 5% from 2019 as the base). Do you think the WTE and Biodiesel plants are likely to be implemented given their high costs and other restrictions? The proposed 7MW rooftop solar capacity is close to already being achieved in 2022, rather than 2030. Albeit, the other renewable energy sources that should have been commissioned by now, 4 MW floating farm and 5MW WTE, are lacking.

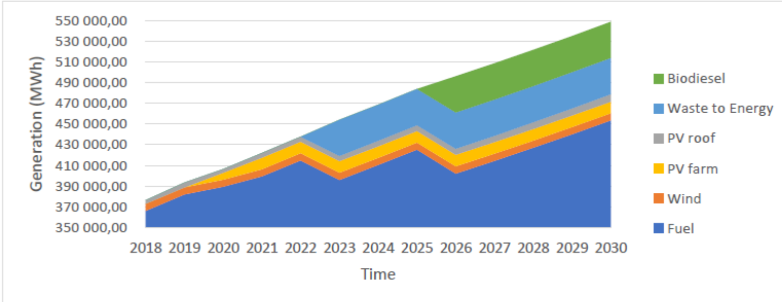


Figure 4-7 - Hypothesis 1 - Scenario 3 generation mix

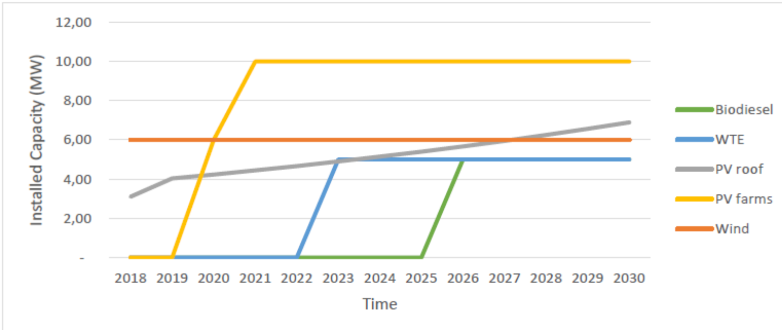


Figure 4-8 - Hypothesis 1 - Scenario 3 Renewables Installed capacity

k. Do you foresee any other system than the current net billing mechanism? How do you think a feed-in-tariff system would work? At what rate would you propose that prosumers can sell the energy they produce to you?

Appendix B.4 – Questionnaire for PV industry on Mahé

Questionnaire for Semi-structured Interview – Installers/Suppliers

The interview is divided into 4 parts.

1) Background data

a. Company Name:

b. Nature of Business:

i. PV Supplier Only

ii. PV Installer Only

iii. PV Supplier and Installer

iv. Other

c. Name:

d. Title/role in the company:

e. When was the company established and when did you make your first installation?

f. What was your motivation to establish the company?

2) Details of the products and costs

a. What kind of products and services do you offer?

i. Suppliers of PV systems and components
ii. Installation services
iii. Operation and Maintenance services

b. What are the retail costs for each of the products and services?

c. Do you offer a package deal for your customers which combines some or all of your products and services? For a complete system to be commissioned, what is your calculated SCR/kW? Is this profitable for you? What factors does this depend on?

d. How and from where do you import these products? Is there anything particularly easy or difficult about it?

e. Do you receive any support from the government? What are your thoughts on the tax exemption offered by the government?

f. How do you offer the installation services? Initially, how were your personnel trained? Did you receive any support from the government? What are your thoughts on having a regular national-level training and certification program on the installation, operation, and maintenance of solar PV systems?

3) Installation history and procedure

a. What is the installation procedure for a residential home-owner when he approaches you?

b. What is the installation procedure for a commercial property owner when he approaches you?

c. Have you done any projects on governmental buildings? What is the procedure?

d. How many projects have you undertaken since the company was started? Can you provide details of these projects? How many are in each consumer category?

4) Barriers to and enablers of PV adoption

a. What do you think is the general perception of rooftop solar PV technology in Seychelles? How aware do you think the people are?

b. What is your opinion on the PV suppliers and installation industry in Seychelles in general and can you provide an outlook for the future?

c. What barriers do you think your customers experience before deciding to adopt PV? What created this resistance(s)? How? Why? How do you think this can be avoided?

d. Is there a difference between the barriers experienced by residential, commercial, and governmental customers?

e. In the end, what are the factors that motivate your customers to buy it despite these barriers?

f. What barriers do you experience to expanding your business? Has the market for the goods and services you offer increased or decreased over the past few years and what is your outlook for the future?

g. Do you perceive any benefits of installing PV systems to you or society? Do these benefits motivate one to adopt the technology?

h. Do you perceive any negative outcomes of installing PV systems for you or society? Do such outcomes prevent one from adopting the technology?

i. What problems do you experience with PVs today?

j. What are the biggest obstacles and driving forces as you see it to get a large spread of PVs on buildings?

k. What do you think can be done to persuade others to adopt rooftop PV on a large scale?

Appendix B.5 – Questionnaire for commercial property owners who haven't installed PV yet

Questionnaire for Semi-structured Interview – Commercial Space-Owners who have not installed rooftop PV

The interview is divided into 4 parts.

1) Background data – Interviewee and property

a. Company Name:

b. Interviewee Name:

c. Age:

d. Level of education:
1. Primary School/Did not Answer
2. Secondary School
3. Vocational training/Other
4. Post-Secondary Degree
5. University Degree

e. Title/role in the company:

f. What is the nature of activity on the property and how many people are working here daily?

g. Type of commercial property (Office, Trade/Shops, Warehouse, School, Hospital, Gym, Others)

i. Energy consumption of the property (from the energy bill, if possible) [kWh/month]:

j. How long have you operated from here and how old is the roof? Does it need renovation?

k. Location of the property:

l. The inclination of the roof in degrees as perceived by the interviewer?
1. Flat - 0
2. Gentle Slope – (10-30)
3. Steep Slope - (>45)

m. Amount of regular shade on the roof:
1. No Shading
2. Minimal (One side, less than 50%)
3. Completely Shaded (75 to 100%)

n. Orientation of roof:
1. N
2. S
3. E
4. W

5. Combination

2) **Knowledge about renewable energy technologies and rooftop PV in particular, the idea for installation, and motivations**

a. How aware are you of renewable energy technologies and PV in specific?
   1. Not at all aware
   2. Slightly Aware
   3. Somewhat Aware
   4. Moderately Aware
   5. Extremely Aware

   What is your general opinion on them?

b. How important do you think PV technology is to Seychelles?
   1. Not Important
   2. Slightly Important
   3. Moderately Important
   4. Important
   5. Very Important

   Why?

c. Did you ever consider investing in rooftop PV? Where did you hear about it? (possible sources: Media, Friends & Peers, Neighbours, Government, PUC, PV Suppliers/Installers, Other Companies, Others)

d. Did you search and find information on PV products? What was easy or difficult about this?

e. Are you aware of current policies/schemes/financing mechanisms with regards to solar PV

f. Is the information provided, both on products and/or on the process, sufficient to make an informed decision? If not, what further information would you like to be provided? (Eg: Environmental Impact, Finance, Administration, Technology - products and materials, Design, Regulations, Grants/taxes, Installation, Maintenance, Building-integrated solar cells, Safety/insurance, Off-grid issues, Sales of electricity, others)

g. Whom did you have to contact to get more information or to make progress to install a PV system?
   1. Installers/Suppliers
   2. PUC
   3. Seychelles Energy Commission
   4. Ministry responsible for Energy (MACCE)
   5. Local authorities (Seychelles Planning Authority, etc)
   6. Electrical contractors and wiremen

7. Building contractors/Architects
8. Others

3) Barriers to and enablers of PV adoption

a. **During decision-making:** Are there any factors you were considering against investing in PV? How do you think this can be avoided?

b. **During adoption:** If you are in the process of adopting a PV system, are there any barriers you experience? How do you think this can be avoided?

c. What are the driving forces that motivate you to buy it despite these barriers?

d. Do you perceive any benefits of installing such a system for you or society? Do these benefits motivate you to adopt the technology?

e. Do you perceive any negative outcomes of installing such a system for you or society? Do such outcomes prevent you from adopting the technology?

f. How much do you agree with this statement: "I think there should be a larger deployment of solar PV systems in Seychelles."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

g. How much do you agree with this statement: "If my neighbouring property had a rooftop PV system installed, I am more motivated to do the same."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

h. How much do you agree with this statement: "If my family member/friend had a rooftop PV system installed on their home, I am more motivated to do the same on my commercial property."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

i. How much do you agree with this statement: "The rooftop PV system will improve the aesthetics of my property."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree

4. Agree
5. Strongly agree

Would this factor affect your decision?

j. What do you know about the whole rooftop PV installation process in general? What has been especially hard or easy? What do you think can be streamlined?

k. How much do you agree with this statement: "The rooftop PV system will improve the value of my property."
   1. Strongly disagree
   2. Disagree
   3. Neither agree nor disagree
   4. Agree
   5. Strongly agree

   Would this factor affect your decision?

l. How much do you agree with this statement: "If my competitor in business had a rooftop PV system installed on his/her property, I am more motivated to do the same."
   1. Strongly disagree
   2. Disagree
   3. Neither agree nor disagree
   4. Agree
   5. Strongly agree

m. If you decide to adopt a PV system, how did you plan to finance this investment?
   1. Self-financed
   2. Fully supported by loan
   3. Partly supported by loan
   4. Other Schemes (Specify)

n. What is the pay-back period that is acceptable to you? [Years]

o. Have you already calculated a pay-back period for your investment? If so, how did you do it? Did the installer/supplier company help you with this?

p. If there was a feed-in-tariff mechanism rather than the current net-billing system to credit you for the energy you generate, what would be your thoughts?

q. What problems do you experience with PVs or perceive them to have today?

r. Is the environment an important profile issue for your company? How do you notice it?

s. From your customers, is there some expectation for you to be environmentally sustainable? Are PVs an important issue in your environmental work? Is there interest and/or demand from your customers to have PVs installed on the property?

t. What do you think the energy company's role is in general? What kind of service do you get and what did you expect? What has been especially hard or easy?

u. What do you think can be done to promote the adoption of rooftop PV? Would you recommend it to others? To whom would you make such a recommendation?

v. have you already decided to invest in a rooftop PV system?
    1. Yes
    2. No
    3. Don't know yet

4) Details of the installed PV system

a. Do you plan to supply electricity back into the grid?
    1. Yes
    2. No
    3. Not yet thought about this

b. Do you also plan to have a paired battery system?
    1. Yes
    2. No
    3. Not yet thought about this

c. Would you like to go off-grid in the future (completely disconnected from PUC's distribution grid)? Why?
    1. Yes
    2. No
    3. Not yet thought about this

Thank you for your valuable time! 😊

Appendix B.6 - Questionnaire for commercial property owners who have already installed PV

Questionnaire for Semi-structured Interview – Commercial Property-Owners who have installed rooftop PV

The interview is divided into 4 parts.

1) Background data – Interviewee and property

a. Company Name:

b. Interviewee Name:

c. Age:

d. Level of education:
   1. Primary School/Did not Answer
   2. Secondary School
   3. Vocational training/Other
   4. Post-Secondary Degree
   5. University Degree

e. Title/role in the company:

f. What is the nature of activity on the property and how many people are working here daily?

g. Type of commercial property (Office, Trade/Shops, Warehouse, School, Hospital, Gym, Others)

o. Size of Installed PV system [kw]:

p. Energy consumption and production of the property (from the energy bill, if possible) [kWh/month]:

q. How long have you operated from here and how old is the roof? Does it need renovation?

r. Location of the property:

s. The inclination of the roof in degrees as perceived by the interviewer?
   1. Flat - 0
   2. Gentle Slope – (10-30)
   3. Steep Slope - (>45)

t. Amount of regular shade on the roof:
   4. No Shading
   5. Minimal (One side, less than 50%)
   6. Completely Shaded (75 to 100%)

u. Orientation of roof:
   1. N
   2. S

3. E
4. W
5. Combination

2) Knowledge about renewable energy technologies and rooftop PV in particular, the idea for installing and motivations, awareness of governmental programs

a. How aware are you of renewable energy technologies and PV in specific?
   1. Not at all aware
   2. Slightly Aware
   3. Somewhat Aware
   4. Moderately Aware
   5. Extremely Aware

   What is your general opinion on them?

b. How important do you think PV technology is to Seychelles?
   1. Not Important
   2. Slightly Important
   3. Moderately Important
   4. Important
   5. Very Important

   Why?

c. How did you come up with the idea to invest in rooftop PV and when? (possible sources: Media, Friends & Peers, Neighbours, Government, PUC, PV Suppliers/Installers, Other Companies, Others)

d. How did you search and find information on PV products? What was easy or difficult about this?

e. Are you aware of current policies/schemes/financing mechanisms with regards to solar PV? Have you made use of this? Have you received subsidies? How did the process work?

f. Is the information provided, both on products and/or on the process, sufficient to make an informed decision? If not, what further information would you like to be provided? (Eg: Environmental Impact, Finance, Administration, Technology - products and materials, Design, Regulations, Grants/taxes, Installation, Maintenance, Building-integrated solar cells, Safety/insurance, Off-grid issues, Sales of electricity, others)

g. Whom did you have to contact while installing your PV system?
   1. Installers/Suppliers
   2. PUC
   3. Seychelles Energy Commission
   4. Ministry responsible for Energy (MACCE)
   5. Local authorities (Seychelles Planning Authority, etc)
   6. Electrical contractors and wiremen
   7. Building contractors/Architects
   8. Others

3) Barriers to and enablers of PV adoption

a. **During decision-making:** Were there any factors you were considering against investing in PV? What were they and what did you do to tackle them? How do you think this can be avoided?

b. **During adoption:** In the process of adopting the PV system, were there any barriers you experienced? What were they and what did you do to tackle them? How do you think this can be avoided?

c. In the end, what are the factors that motivated you to buy it despite these barriers?

d. How much did you have to worry about maintaining the systems once it was installed?

e. Do you perceive any benefits of installing such a system for you or society? Do these benefits motivate you to adopt the technology?

f. Do you perceive any negative outcomes of installing such a system for you or society? Do such outcomes prevent you from adopting the technology?

g. How much do you agree with this statement: "I think there should be a larger deployment of solar PV systems in Seychelles."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

h. How much do you agree with this statement: "If my neighbouring property had a rooftop PV system installed, I am more motivated to do the same."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

i. How much do you agree with this statement: "If my family member/friend had a rooftop PV system installed on their home, I am more motivated to do the same on my commercial property."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

j. How much do you agree with this statement: "The rooftop PV system will improve the aesthetics of my property."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree

5. Strongly agree

Would this factor affect your decision?

k. What do you think about the whole rooftop PV installation process in general? What has been especially hard or easy?

l. How much do you agree with this statement: “The rooftop PV system will improve the value of my property.”
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

    Would this factor affect your decision?

m. How much do you agree with this statement: “If my competitor in business had a rooftop PV system installed on his/her property, I am more motivated to do the same.”
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

n. How did you finance this investment?
    5. Self-financed
    6. Fully supported by loan
    7. Partly supported by loan
    8. Other Schemes (Specify)

o. What is the pay-back period that is acceptable to you? [Years]

p. Have you calculated a pay-back period for your investment? If so, how did you do it? Did the installer/supplier company help you with this?

q. If there was a feed-in-tariff mechanism rather than the current net-billing system to credit you for the energy you generate, what would be your thoughts?

r. What do you think can be done to promote the adoption of rooftop PV? Would you recommend it to others? To whom would you make such a recommendation?

s. What problems do you experience with PVs today?

t. Is the environment an important profile issue for your company? How do you notice it?

u. From your customers, is there some expectation for you to be environmentally sustainable? Are PVs an important issue in your environmental work? Is there interest and/or demand from your customers to have PVs installed on the property?

v. What do you think the energy company's role is in general? What kind of service do you get and what did you expect? What has been hard or easy?

4) Details of the installed PV system

a. Where did you buy your PV system? Why did you choose them?
   1. Through local suppliers
   2. From the International market independently

b. What is the capacity of the installed system (kW)?

c. When was it installed? Can I take a picture?

d. Who installed the system?

e. Sometimes, you may produce energy beyond your consumption. How do you get compensated from PUC for this (Fixed rate/Credit/Other)?

f. How satisfied are you with the performance of the installed system?
   1. Not at all satisfied
   2. Slightly satisfied
   3. Moderately satisfied
   4. Very satisfied
   5. Extremely satisfied

   In your experience, how has the system performed so far? Do you have some way to keep track of how it performs? Does it produce as much energy as you expected?

g. Do you also have a paired battery system?
   1. Yes
   2. No
   3. No, but in the future, I plan to have one
   4. No, and also no in the future
   5. No, and not yet thought about this

h. Would you like to go off-grid in the future?
   1. Yes
   2. No
   3. Not yet thought about this

Thank you for your valuable time! 😊

Appendix B.7 - Questionnaire for auto-producers

Questionnaire for Semi-structured Interview – Auto-producers

The interview is divided into 4 parts.

1) Background data – Interviewee and property

a. Company Name:

b. Interviewee Name:

c. Age:

d. Level of education:
   1. Primary School/Did not Answer
   2. Secondary School
   3. Vocational training/Other
   4. Post-Secondary Degree
   5. University Degree

e. Title/role in the company:

f. What is the nature of activity on the property and how many people are working here daily?

g. Energy consumption of the property (from the energy bill, if possible) [kWh/month]:

h. How is the energy being generated? Specifications of diesel generators. How old are they and how much did it cost you to install them?

i. Type of fuel used and amount of fuel used yearly. How much does it cost you every year?

j. How long have you operated from here and how old is the roof? Does it need renovation?

k. Location of the property:

2) Knowledge about renewable energy technologies and rooftop PV in particular, the idea for installation, and motivations

a. How aware are you of renewable energy technologies and PV in specific?
   1. Not at all aware
   2. Slightly Aware
   3. Somewhat Aware
   4. Moderately Aware
   5. Extremely Aware

   What is your general opinion on them?

b. How important do you think PV technology is to Seychelles?
   1. Not Important
   2. Slightly Important

3. Moderately Important
4. Important
5. Very Important

Why?

c. Did you ever consider investing in rooftop PV? Where did you hear about it? (possible sources: Media, Friends & Peers, Neighbours, Government, PUC, PV Suppliers/Installers, Other Companies, Others)

d. Did you search and find information on PV products? What was easy or difficult about this?

e. Are you aware of current policies/schemes/financing mechanisms with regards to solar PV

f. Is the information provided, both on products and/or on the process, sufficient to make an informed decision? If not, what further information would you like to be provided? (Eg: Environmental Impact, Finance, Administration, Technology - products and materials, Design, Regulations, Grants/taxes, Installation, Maintenance, Building-integrated solar cells, Safety/insurance, Off-grid issues, Sales of electricity, others)

g. Whom did you have to contact to get more information or to make progress to install a PV system?
1. Installers/Suppliers
2. PUC
3. Seychelles Energy Commission
4. Ministry responsible for Energy (MACCE)
5. Local authorities (Seychelles Planning Authority, etc)
6. Electrical contractors and wiremen
7. Building contractors/Architects
8. Others

3) Barriers to and enablers of PV adoption

a. Why have you chosen to generate your own energy? What issues are you facing concerning the energy supply for your property?

b. Would you like to be connected to PUC's distribution grid? What have been the issues you faced in this regard?

c. Have you considered going green with your energy? Is it after receiving a connection from PUC, or would you remain off-grid?

d. What kind of facilitation do you need from PUC, SEC, and the government to make this shift?

e. **During decision-making:** Are there any factors you are considering against investing in PV? How do you think this can be avoided?

f. **During adoption:** If you are in the process of adopting a PV system, are there any barriers you experience? How do you think this can be avoided?

g. Are there any driving forces that motivate you to invest in PVs despite these barriers? What are they?

h. Do you perceive any benefits of installing such a system for you or society? Do these benefits motivate you to adopt the technology?

i. Do you perceive any negative outcomes of installing such a system for you or society? Do such outcomes prevent you from adopting the technology?

j. How much do you agree with this statement: “I think there should be a larger deployment of solar PV systems in Seychelles.”
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

k. How much do you agree with this statement: “If my neighbouring property had a rooftop PV system installed, I am more motivated to do the same.”
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

l. How much do you agree with this statement: “The rooftop PV system will improve the aesthetics of my property.”
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

Would this factor affect your decision?

m. How much do you agree with this statement: “The rooftop PV system will improve the marketability of my property, products, or services.”
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

Would this factor affect your decision?

n. How much do you agree with this statement: “The rooftop PV system will improve the value of my property.”
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree

5. Strongly agree

Would this factor affect your decision?

o. How much do you agree with this statement: “If my competitor in business had a rooftop PV system installed on his/her property, I am more motivated to do the same.”
   1. Strongly disagree
   2. Disagree
   3. Neither agree nor disagree
   4. Agree
   5. Strongly agree

p. If you decide to adopt a PV system, how do you plan to finance this investment?
   9. Self-financed
   10. Fully supported by loan
   11. Partly supported by loan
   12. Other Schemes (Specify)

q. What is the pay-back period that is acceptable to you? [Years]

r. Have you already calculated a pay-back period for your investment? If so, how did you do it? Did the installer/supplier company help you with this?

s. What problems do you experience with PVs or perceive them to have today?

t. Is the environment an important profile issue for your company? How do you notice it?

u. From your customers, is there some expectation for you to be environmentally sustainable? Are PVs an important issue in your environmental work? Is there interest and/or demand from your customers to have PVs installed on the property?

v. What do you think the energy company’s role is in general? What kind of service do you get and what did you expect? What has been especially hard or easy?

w. What do you think can be done to promote the adoption of rooftop PV? Would you recommend it to others? To whom would you make such a recommendation?

x. have you already decided to invest in a rooftop PV system?
   1. Yes
   2. No
   3. Don’t know yet

4) Details of the installed PV system

a. Do you plan to supply electricity back into the grid?
   1. Yes
   2. No, I will remain off-grid.
   3. Not yet thought about this

b. Do you also plan to have a paired battery system?
   4. Yes
   5. No
   6. Not yet thought about this

Thank you for your valuable time! 😊

Appendix B.8 - Questionnaire for homeowners' who haven't installed PV yet

Questionnaire for Semi-structured Interview – Residential Home-Owners who have NOT installed rooftop PV

The interview is divided into 4 parts.

1) Background data – Interviewee and house

a. Name:

b. Age:

c. Highest level of education in the household:
   1. Primary School/Did not Answer
   2. Secondary School
   3. Vocational training/Other
   4. Post-Secondary Degree
   5. University Degree

d. Household Income SCR/Month:
   1. <10,000 SCR
   2. 10,001 to 30,000 SCR
   3. >30,001 SCR

e. Energy consumption of the household (from the latest energy bill, if possible) [kWh/month]:

f. How many people are living in the household?

g. The inclination of the roof in degrees as perceived by the interviewer?
   1. Flat - 0
   2. Gentle Slope – (10-30)
   3. Steep Slope - (>45)

h. How old is the roof?

i. Amount of regular shade on the roof:

   1. No Shading
   2. Minimal (One side, less than 50%)
   3. Completely Shaded (75 to 100%)

j. Orientation of roof:
   1. N
   2. S
   3. E
   4. W
   5. Combination

k. Location of the house [Coordinates]:

2) Knowledge about renewable energy technologies and rooftop PV in particular, the idea for installing and motivations, awareness of governmental programs

a. How aware are you of renewable energy technologies and PV in specific?
   1. Not at all aware
   2. Slightly Aware
   3. Somewhat Aware
   4. Moderately Aware
   5. Extremely Aware

   What is your general opinion on them?

b. How important do you think PV technology is to Seychelles?
   1. Not Important
   2. Slightly Important
   3. Moderately Important
   4. Important
   5. Very Important

   Why?

c. How did you come up with the idea to invest in rooftop PV and when? (possible sources: Media, Friends & Peers, Neighbours, Government, PUC, PV Suppliers/Installers, Others)

d. How did you search and find information on PV products? What was easy or difficult about this?

e. Are you aware of current policies/schemes/financing mechanisms with regards to solar PV? Do you plan to make use of these? Do you know how the process works?

f. Is the information provided, both on products and/or on the process, sufficient to make an informed decision? If not, what further information would you like to be provided? (Eg: Environmental Impact, Finance, Administration, Technology - products and materials, Design, Regulations, Grants/taxes, Installation, Maintenance, Building-integrated solar cells, Safety/insurance, Off-grid issues, Sales of electricity, others)

g. Whom did you have to contact concerning installing a PV system until now?
   1. Installers/Suppliers
   2. PUC
   3. Seychelles Energy Commission
   4. Ministry responsible for Energy (MACCE)
   5. Local authorities (Seychelles Planning Authority, etc)
   6. Electrical contractors and wiremen
   7. Building contractors/Architects
   8. Others [Specify]

3) Barriers to and enablers of PV adoption

a. **During decision-making:** Are there any factors you are considering against investing in PV? What are they and how do you think they can be addressed?

b. **During adoption:** If you have already decided to adopt PV, are there any barriers you experienced in the process? What are they and how do you think they can be avoided?

c. What are the driving forces that may motivate you to buy it despite these barriers?

d. Do you perceive any benefits of installing such a system for you or society? Do these benefits motivate you to adopt the technology?

e. Do you perceive any negative outcomes of installing such a system for you or society? Do such outcomes prevent you from adopting the technology?

f. How much do you agree with this statement: "I think there should be a larger deployment of solar PV systems in Seychelles."
   1. Strongly disagree
   2. Disagree
   3. Neither agree nor disagree
   4. Agree
   5. Strongly agree

g. How much do you agree with this statement: "If my neighbour had a rooftop PV system installed, I am more motivated to do the same."
   1. Strongly disagree
   2. Disagree
   3. Neither agree nor disagree
   4. Agree
   5. Strongly agree

h. How much do you agree with this statement: "If my family member/friend had a rooftop PV system installed on their home, I am more motivated to do the same."
   1. Strongly disagree
   2. Disagree
   3. Neither agree nor disagree
   4. Agree
   5. Strongly agree

i. What do you think about the whole rooftop PV adoption procedure in general? What has been especially hard or easy?

j. How much do you agree with this statement: "The rooftop PV system will improve the aesthetics of my home."
   1. Strongly disagree
   2. Disagree
   3. Neither agree nor disagree
   4. Agree
   5. Strongly agree

   Would this factor affect your decision?

k. How much do you agree with this statement: "The rooftop PV system will improve the value of my home."
   1. Strongly disagree

2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree

Would this factor affect your decision?

l. How do you plan to finance this investment?
   13. Self-financed
   14. Fully supported by loan
   15. Partly supported by loan
   16. Other Schemes (Specify)

m. Would you like to be supported by any subsidies (NOT rebates)?
   1. Yes
   2. No

n. What is the pay-back period that is acceptable to you? [Years]

o. Have you calculated a pay-back period for your investment? If so, how did you do it? Did the installer/supplier company help you with this?

p. If there was a feed-in-tariff mechanism rather than the current net-billing system to credit you for the energy you generate, what would be your thoughts?

q. Have you already decided to invest in a rooftop PV system?
   1. Yes
   2. No
   3. Don't know yet

r. What do you think can be done to promote the adoption of rooftop PV? Would you recommend it to others? To whom would you make such a recommendation?

4) Details of the PV system they are looking to install

a. Do you plan to supply electricity back into the grid?
   1. Yes
   2. No
   3. Not yet thought about this

b. Do you also plan to have a paired battery system?
   7. Yes
   8. No
   9. Not yet thought about this

c. Would you like to go off-grid in the future (completely disconnected from PUC's distribution grid)? Why?
   4. Yes
   5. No
   6. Not yet thought about this

Thank you for your valuable time! 😊

Appendix B.9 - Questionnaire for homeowners' who have installed PV

Questionnaire for Semi-structured Interview – Residential Home-Owners who have installed rooftop PV

The interview is divided into 4 parts.

5) Background data – Interviewee and house

a. Name:

b. Age:

c. Highest level of education in the household:
   1. Primary School/Did not Answer
   2. Secondary School
   3. Vocational training/Other
   4. Post-Secondary Degree
   5. University Degree

d. Household Income SCR/Month:
   1. <10,000 SCR
   2. 10,001 to 30,000 SCR
   3. >30,001 SCR

e. Energy consumption of the household (from the latest energy bill, if possible) [kWh/month]:

f. How many people are living in the household?

g. The inclination of the roof in degrees as perceived by the interviewer?
   1. Flat - 0
   2. Gentle Slope – (10-30)
   3. Steep Slope - (>45)

h. How old is the roof?

i. Amount of regular shade on the roof:
   1. No Shading
   2. Minimal (One side, less than 50%)
   3. Completely Shaded (75 to 100%)

j. Orientation of roof:
   1. N
   2. S
   3. E
   4. W
   5. Combination

k. Location of the house [Coordinates]:

6) Knowledge about renewable energy technologies and rooftop PV in particular, ideas for installation and motivations, awareness of governmental programs

a. How aware are you of renewable energy technologies and PV in specific?
   1. Not at all aware
   2. Slightly Aware
   3. Somewhat Aware
   4. Moderately Aware
   5. Extremely Aware

   What is your general opinion on them?

b. How important do you think PV technology is to Seychelles?
   1. Not Important
   2. Slightly Important
   3. Moderately Important
   4. Important
   5. Very Important

   Why?

c. How did you come up with the idea to invest in rooftop PV and when? (possible sources: Media, Friends & Peers, Neighbours, Government, PUC, PV Suppliers/Installers, Others)

d. How did you search and find information on PV products? What was easy or difficult about this?

e. Are you aware of current policies/schemes/financing mechanisms with regards to solar PV? Have you made use of this? Have you received subsidies? How did the process work?

f. Is the information provided, both on products and/or on the process, sufficient to make an informed decision? If not, what further information would you like to be provided? (Eg: Environmental Impact, Finance, Administration, Technology - products and materials, Design, Regulations, Grants/taxes, Installation, Maintenance, Building-integrated solar cells, Safety/insurance, Off-grid issues, Sales of electricity, others)

g. Whom did you have to contact while installing your PV system?
   1. Installers/Suppliers
   2. PUC
   3. Seychelles Energy Commission
   4. Ministry responsible for Energy (MACCE)
   5. Local authorities (Seychelles Planning Authority, etc)
   6. Electrical contractors and wiremen
   7. Building contractors/Architects
   8. Others

7) Barriers to and enablers of PV adoption

a. **During decision-making:** Were there any factors you were considering against investing in PV? What were they and what did you do to tackle them? How do you think this can be avoided?

b. **During adoption:** In the process of adopting the PV system, were there any barriers you experienced? What were they and what did you do to tackle them? How do you think this can be avoided?

c. In the end, what are the factors that motivated you to buy it despite these barriers?

d. How much did you have to worry about maintaining the systems once it was installed?

e. Do you perceive any benefits of installing such a system for you or society? Do these benefits motivate you to adopt the technology?

f. Do you perceive any negative outcomes of installing such a system for you or society? Do such outcomes prevent you from adopting the technology?

g. How much do you agree with this statement: "I think there should be a larger deployment of solar PV systems in Seychelles."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

h. How much do you agree with this statement: "If my neighbour had a rooftop PV system installed, I am more motivated to do the same."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

i. How much do you agree with this statement: "If my family member/friend had a rooftop PV system installed on their home, I am more motivated to do the same."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

j. What do you think about the whole rooftop PV installation process in general? What has been especially hard or easy?

k. How much do you agree with this statement: "The rooftop PV system will improve the aesthetics of my home."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

    Would this factor affect your decision?

l. How much do you agree with this statement: "The rooftop PV system will improve the value of my home."
    1. Strongly disagree
    2. Disagree
    3. Neither agree nor disagree
    4. Agree
    5. Strongly agree

    Would this factor affect your decision?

m. How did you finance this investment?
    17. Self-financed
    18. Fully supported by loan
    19. Partly supported by loan
    20. Other Schemes (Specify)

n. What is the pay-back period that is acceptable to you? [Years]

o. Have you calculated a pay-back period for your investment? If so, how did you do it? Did the installer/supplier company help you with this?

p. If there was a feed-in-tariff mechanism rather than the current net-billing system to credit you for the energy you generate, what would be your thoughts?

q. What do you think can be done to promote the adoption of rooftop PV? Would you recommend it to others? To whom would you make such a recommendation?

8) Details of the installed PV system

a. Where did you buy your PV system? Why did you choose them?
    1. Through local suppliers
    2. From the International market independently

b. What is the capacity of the installed system (kW)?

c. When was it installed? Can I take a picture?

d. Who installed the system?

e. Do you supply electricity back into the grid?
    1. Yes
    2. No
    3. I don't know

f. If yes, how do you get compensated for this? Would you like to negotiate the price at which you sell the electricity?

g. Sometimes, you may produce energy beyond your consumption. How do you get compensated from PUC for this (Fixed rate/Credit/Other)?

h. How satisfied are you with the performance of the installed system?

1. Not at all satisfied
2. Slightly satisfied
3. Moderately satisfied
4. Very satisfied
5. Extremely satisfied

In your experience, how has the system performed so far? Do you have some way to keep track of how it performs (a mobile application or so)? Does it produce as much energy as you expected?

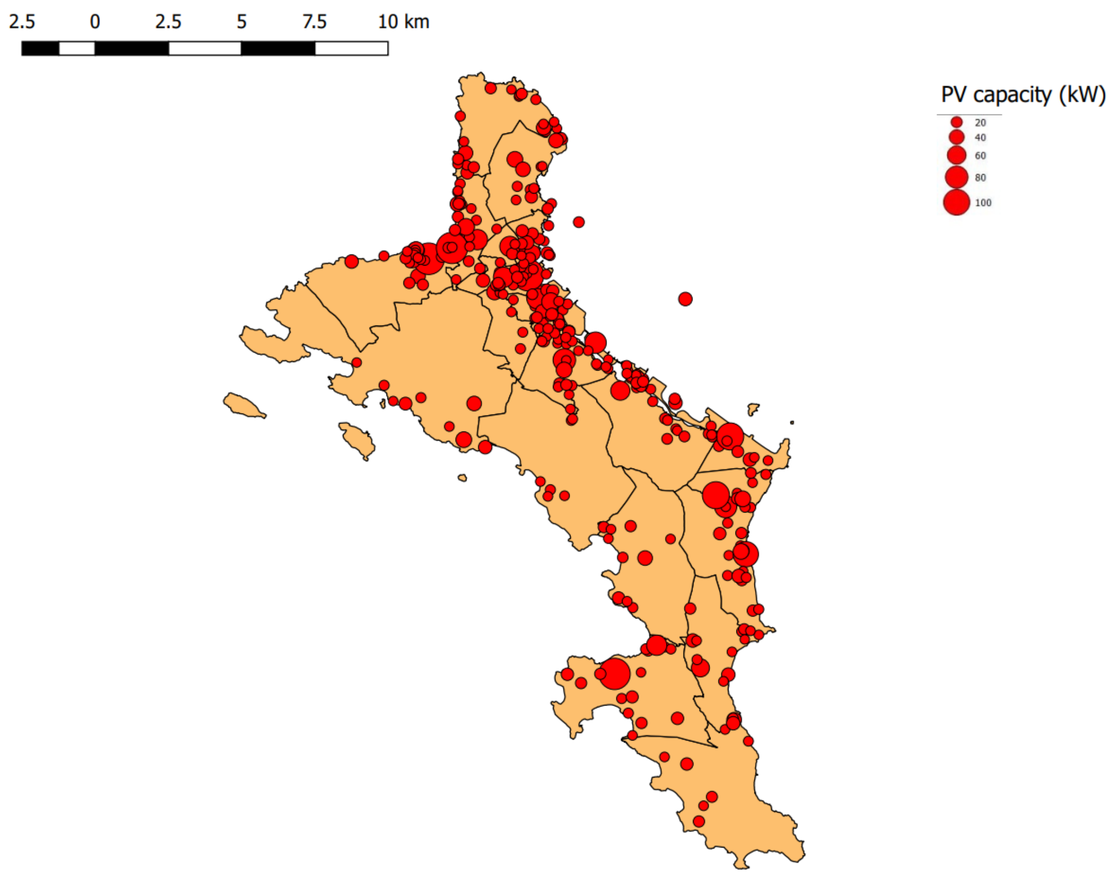
i. Do you also have a paired battery system?
    1. Yes
    2. No
    3. No, but in the future, I plan to have one
    4. No, and also no in the future
    5. No, and not yet thought about this

j. Would you like to go off-grid in the future (completely disconnected from PUC's distribution grid)?
    1. Yes
    2. No
    3. Not yet thought about this

Thank you for your valuable time! 😊

Appendix C – PV installations in Seychelles

Appendix C.1 – Distribution of PV installations in Seychelles



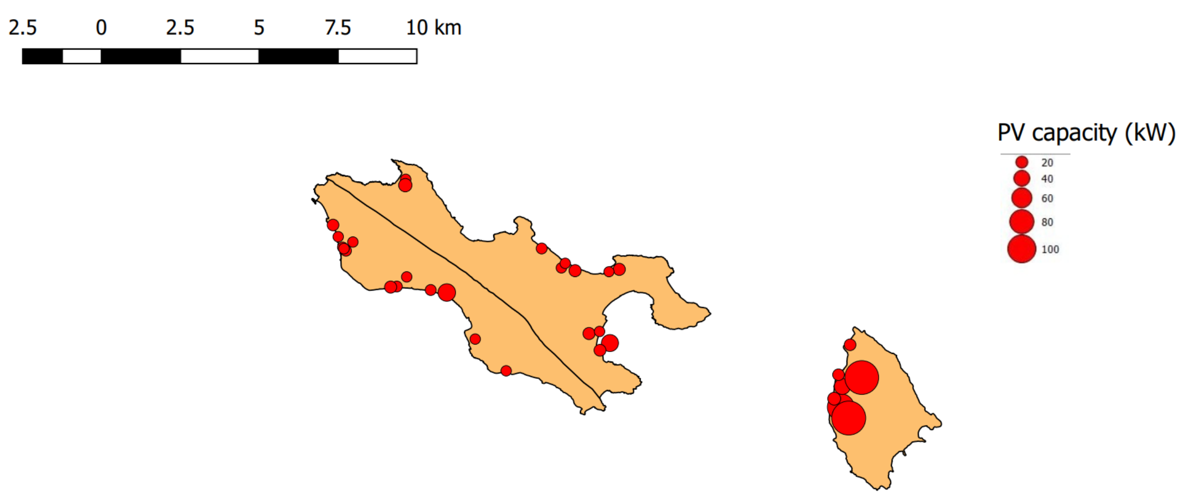


Figure 24: Geographical distribution of PV installation in Seychelles (Sourced from PUC).

Appendix C.2 – Historical trends of PV installations in Seychelles

The first rooftop solar PV installation (hereafter, simply 'installation') in Seychelles was commissioned on 2nd October 2013 and the data frame is complete until 22nd March 2022. During this time, 14 different installers have operated in the industry. However, currently, only 6 have been endorsed by SEC. As of the 22nd of March 2022, 660 installations have been commissioned in two sectors: domestic and commercial; and on the three islands: Mahé, Praslin, and La Digue.

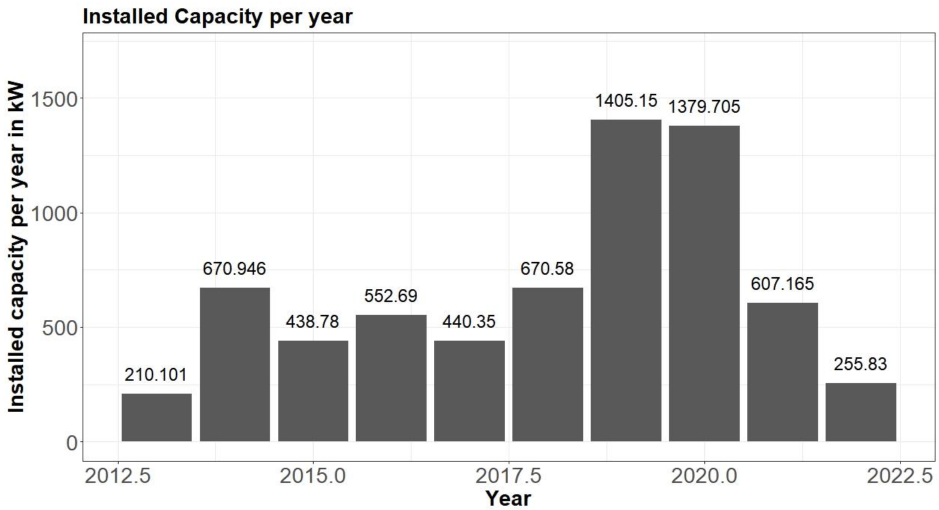


Figure 25: Capacity of rooftop installations each year in Seychelles.

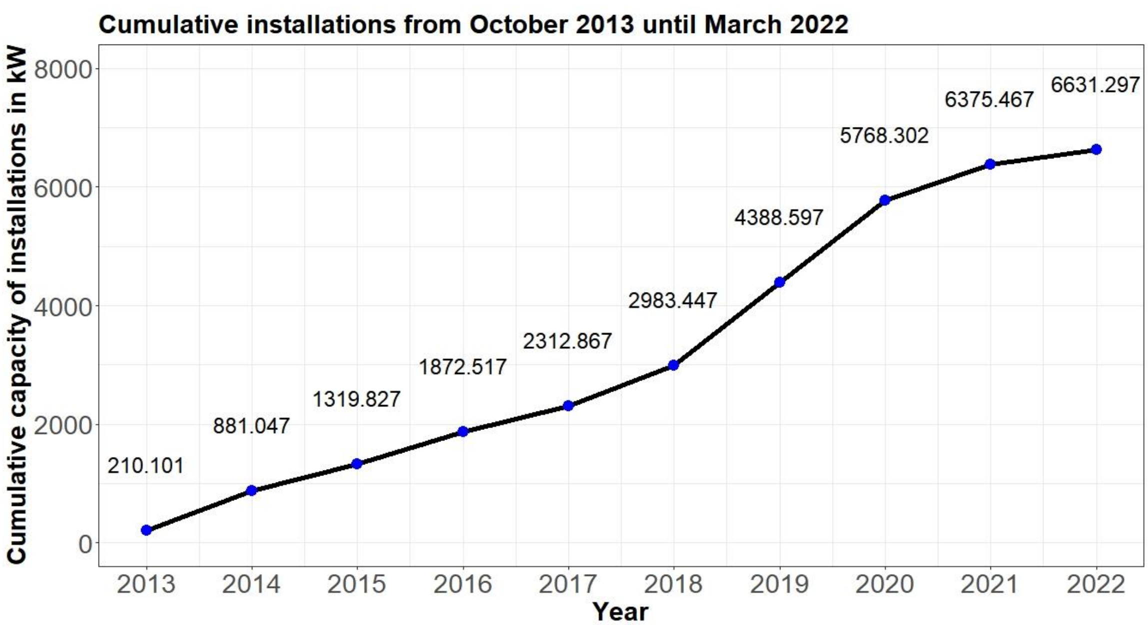


Figure 26: Cumulative capacity of rooftop installations each year in Seychelles from October 2013 until March 2022.

Until March 2022, the cumulative capacity of installations in all of Seychelles was 6631.3 kW (see Figure 26), which were distributed between 2013 and 2022 as shown in Figure 25. However, it is essential to determine the drivers of this growth and the distribution of installations across the islands.

Firstly, the distribution concerning the total installed capacity between the commercial and domestic sectors was 66.5% (4408.8 kW) and 33.5% (2222.5 kW) respectively as of March 2022 (see Figure 27 for yearly distribution). The commercial sector only accounted for 195 installations (29.5% of the total 660) compared to the 465 (70.5%) from the domestic sector (see Figure 28). Hence, the average capacity of an installation within the commercial sector was 22.6 kW, against the 4.8 kW in the domestic sector.

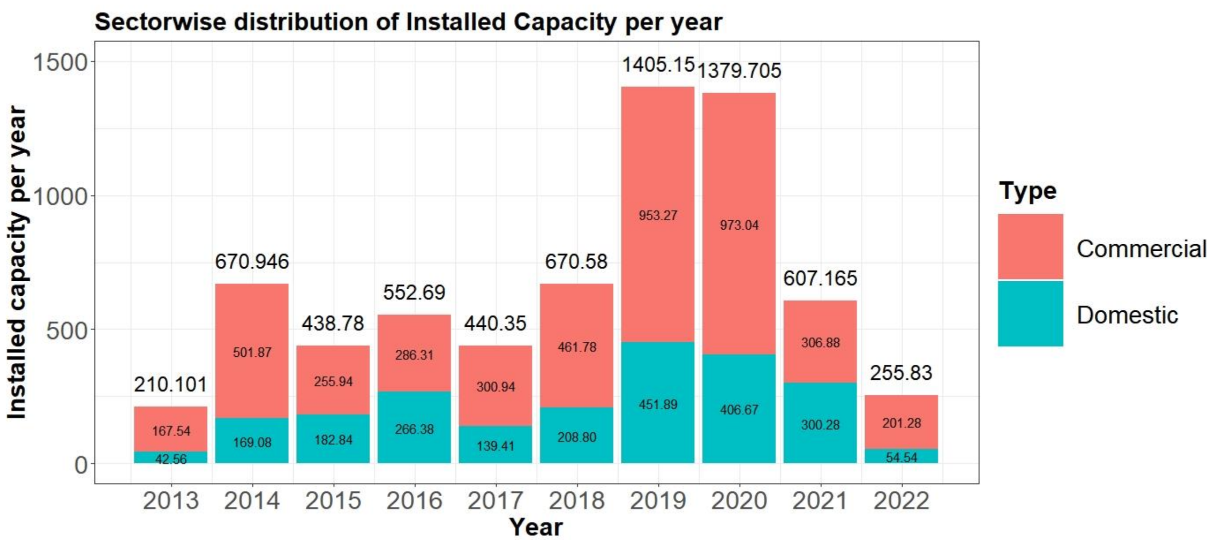


Figure 27: Sector-wise distribution of installed yearly capacities in Seychelles.

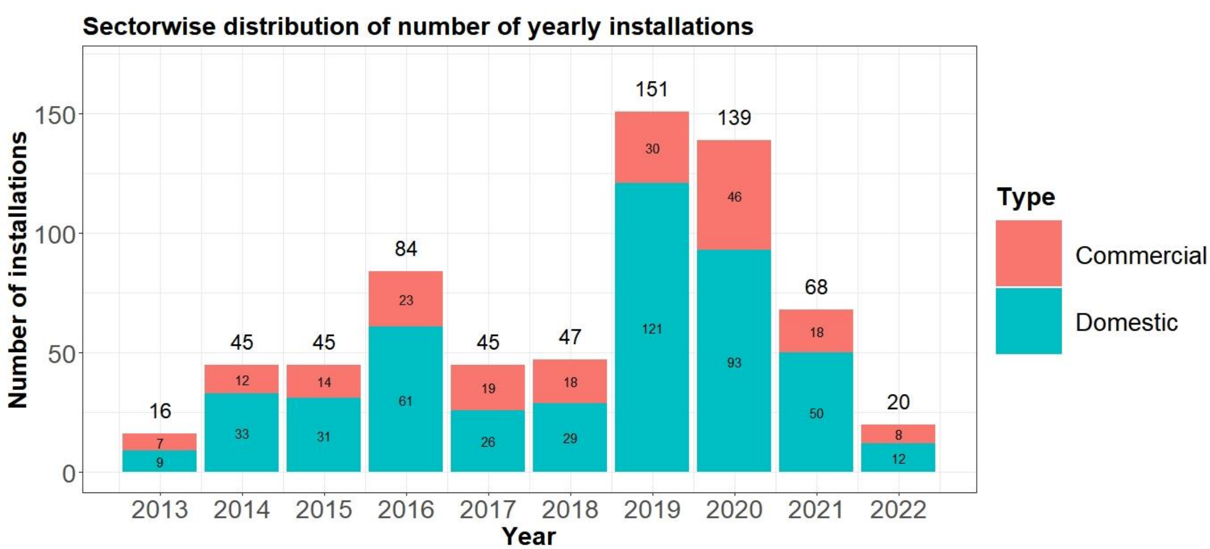


Figure 28: Sector-wise distribution of yearly installation counts in Seychelles.

Next, the distribution of installations amongst the three islands: Mahé, Praslin and La Digue, is depicted according to the yearly installed capacity (Figure 29), and yearly installation counts (Figure 30).

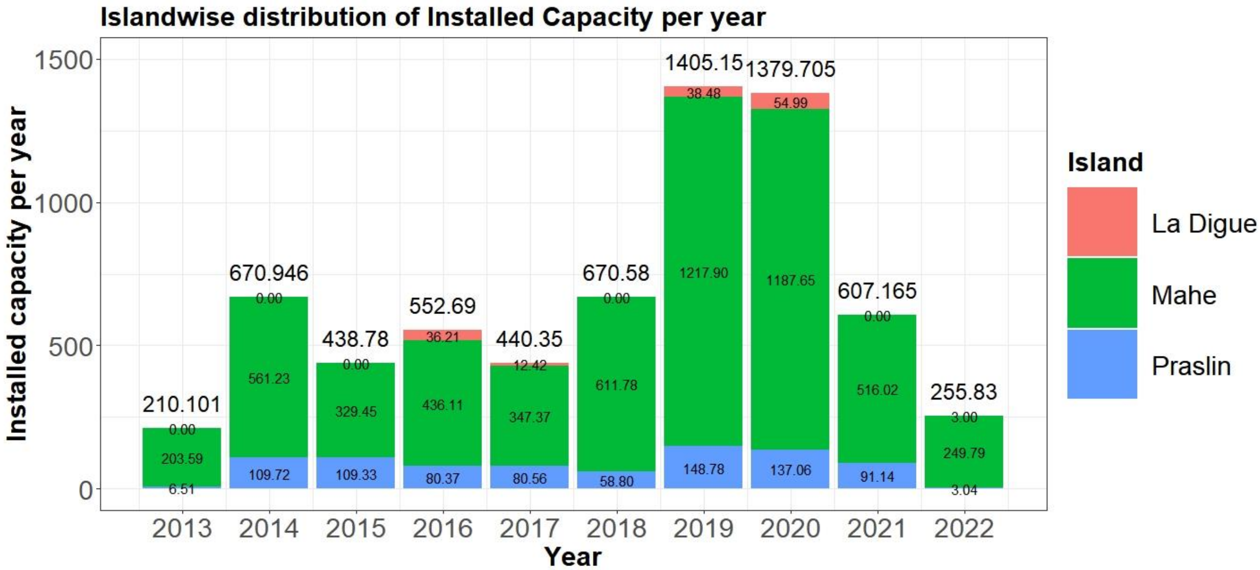


Figure 29: Island-wise distribution of installed yearly capacities in Seychelles.

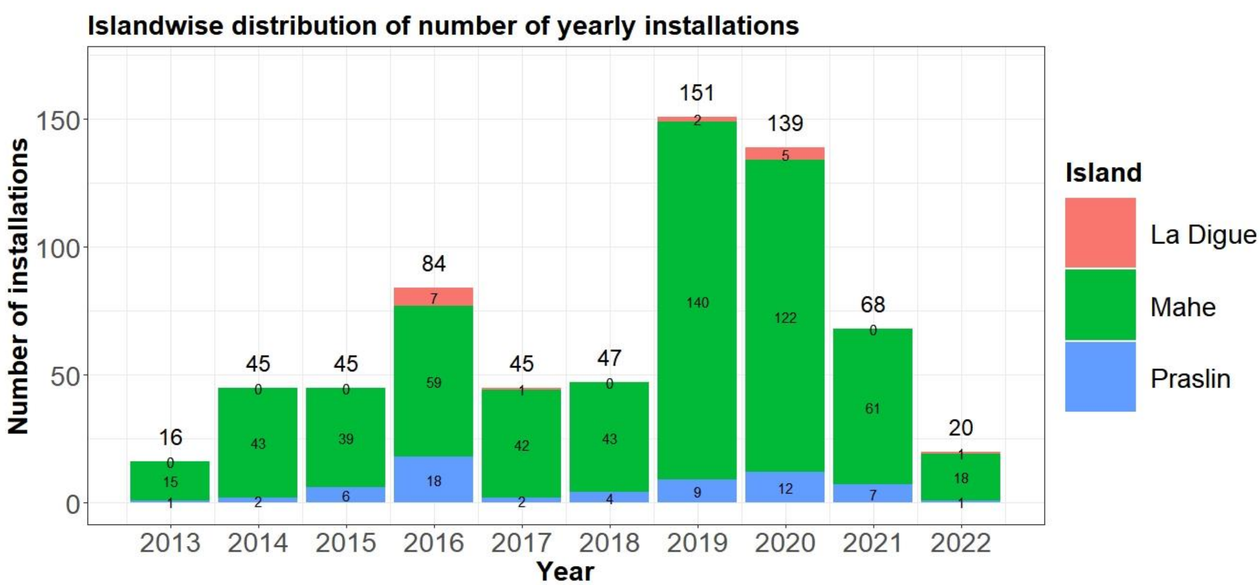


Figure 30: Island-wise distribution of yearly installation counts in Seychelles.

With 582 installations, Mahé dominated the cumulative installed capacity (see Figure 30) at 85.4% (5660.886 kW), which is not surprising given that it is the most populated and largest island (NBS, 2020a, 2021a, 2021c). Only the remaining 77 installations were situated on Praslin or La Digue, which further underlines the importance of Mahé in Seychelles' energy transition discussions. Most of the installations are situated along the coast, which has higher solar irradiation than at higher altitudes (see Appendix C.1 for the geographical distribution of installations on all 3 islands, data sourced from PUC).

The distribution of installations based on whether they were "bought" or installed as a "grant" is depicted in Figures 31 and 32. As part of the GoS project, installations were made on 24 homes (domestic sector, see Figure 32) during 2016: 15 on Mahé, 5 on Praslin and 4 on La Digue, amounting to a cumulative capacity of 74.88 kW (see Figure 31).

Secondly, as part of the Democratization of PV initiative (PUC, 2021; Seychelles Energy Commission, 2020), 136 free installations were commissioned between 2019 and 2020. This included both the domestic (124 installations of a total 338.9 kW capacity on households who found it difficult to pay electricity bills) and commercial (12 installations of a total 612.9 kW capacity mostly on governmental buildings) sectors. Except for 2 installations each on Praslin and La Digue, all the remaining 132 installations were commissioned on Mahé.

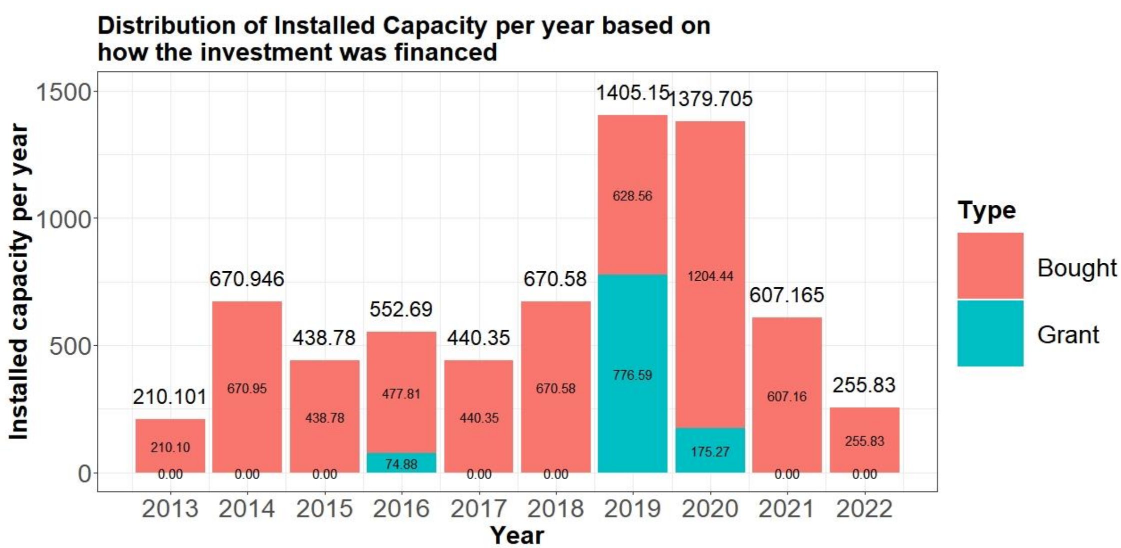


Figure 31: Distribution of installed yearly capacities in Seychelles based on how the investment was financed.

Until March 2022, the 500 "bought" installations accounted for 84.5% (5604.5 kW) of all installations across both sectors in Seychelles, and 160 "grant" installations accounted for the remaining 15.5%.

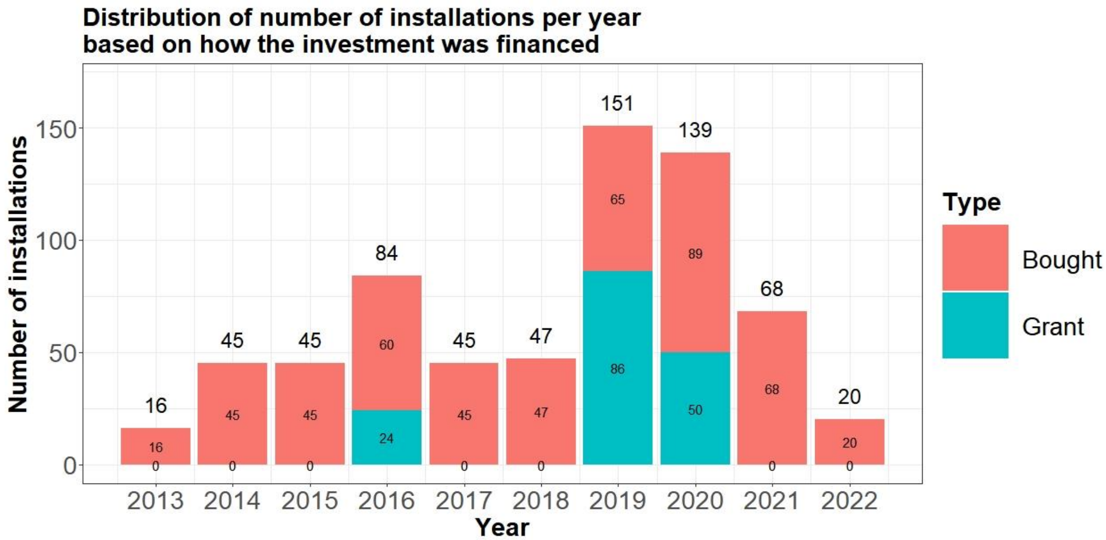


Figure 32: Distribution of yearly installation counts in Seychelles based on how the investment was financed.

Appendix D - Tariff rates

Table 23: Demand charges during Nov 2011, Sept 2018, and May 2022.

For all (Nov 2011, Sept 2018, May 2022)	2.4 kVA or less	Above 2.4 kVA but less than 9.6 kVA	9.6 kVA or more
Power Demand Charge in SCR/kVA	0	4.9	9.85

Table 24: Tariff rates applicable in November 2011.

Consumption bracket	November 2011
0 to 200 kWh	1.30
201 to 300 kWh	1.53
301 to 400 kWh	3.11
401 to 500 kWh	3.33
More than 500 kWh	3.96

Table 25: Tariff rates applicable in September 2018 and May 2022.

Consumption bracket	September 2018 (SCR/kWh)	May 2022 (SCR/kWh)
0 to 200 kWh	1.32	1.57
201 to 300 kWh	1.61	1.86
301 to 400 kWh	3.25	3.5
401 to 600 kWh	3.65	3.9
More than 600 kWh	4.30	4.55

Appendix E – Agent-Based Model

Appendix E.1 - Distribution of households

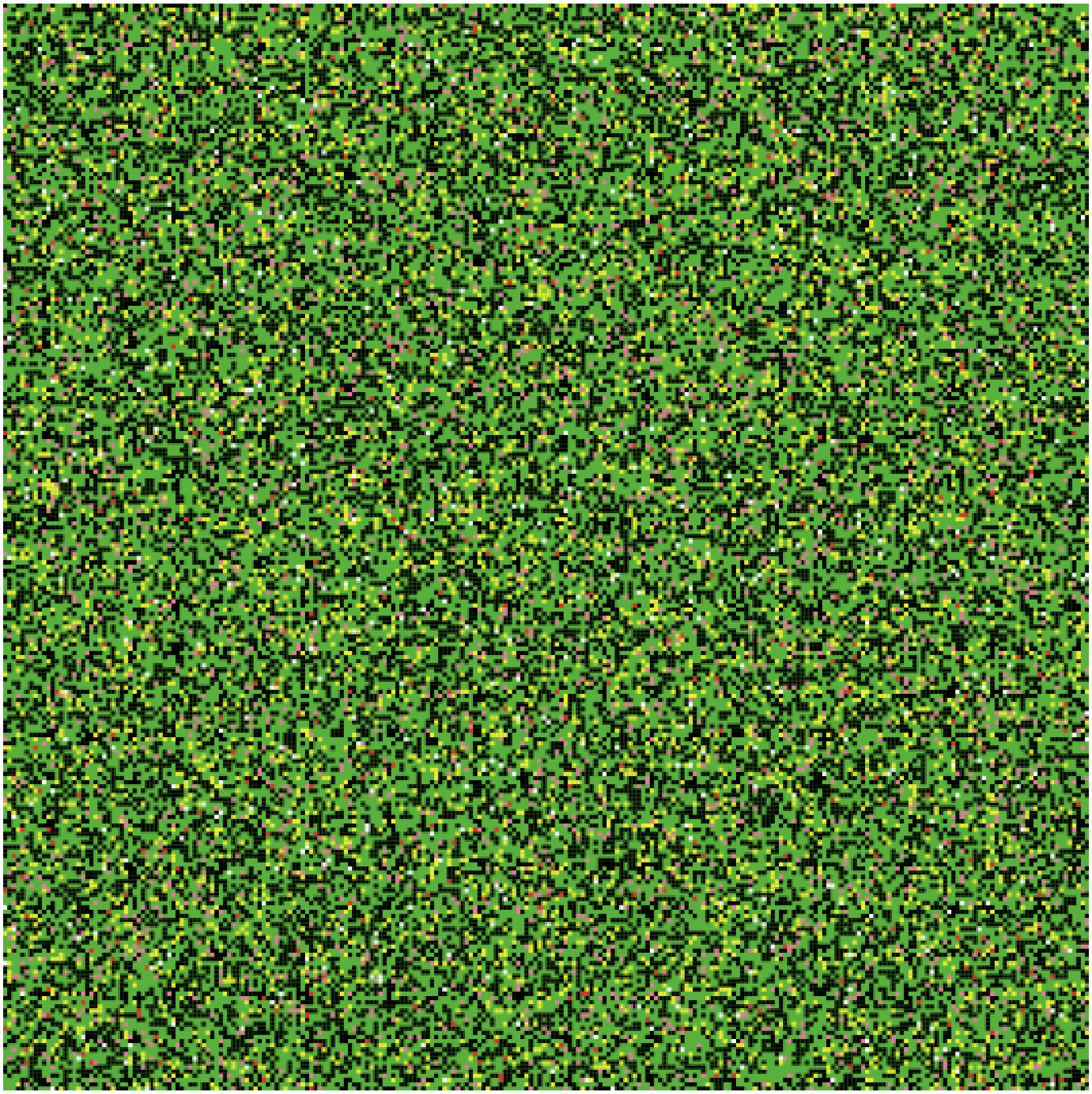


Figure 33: Distribution of 31,682 households in 63,504 patches. Green coloured spaces represent vacant patches.

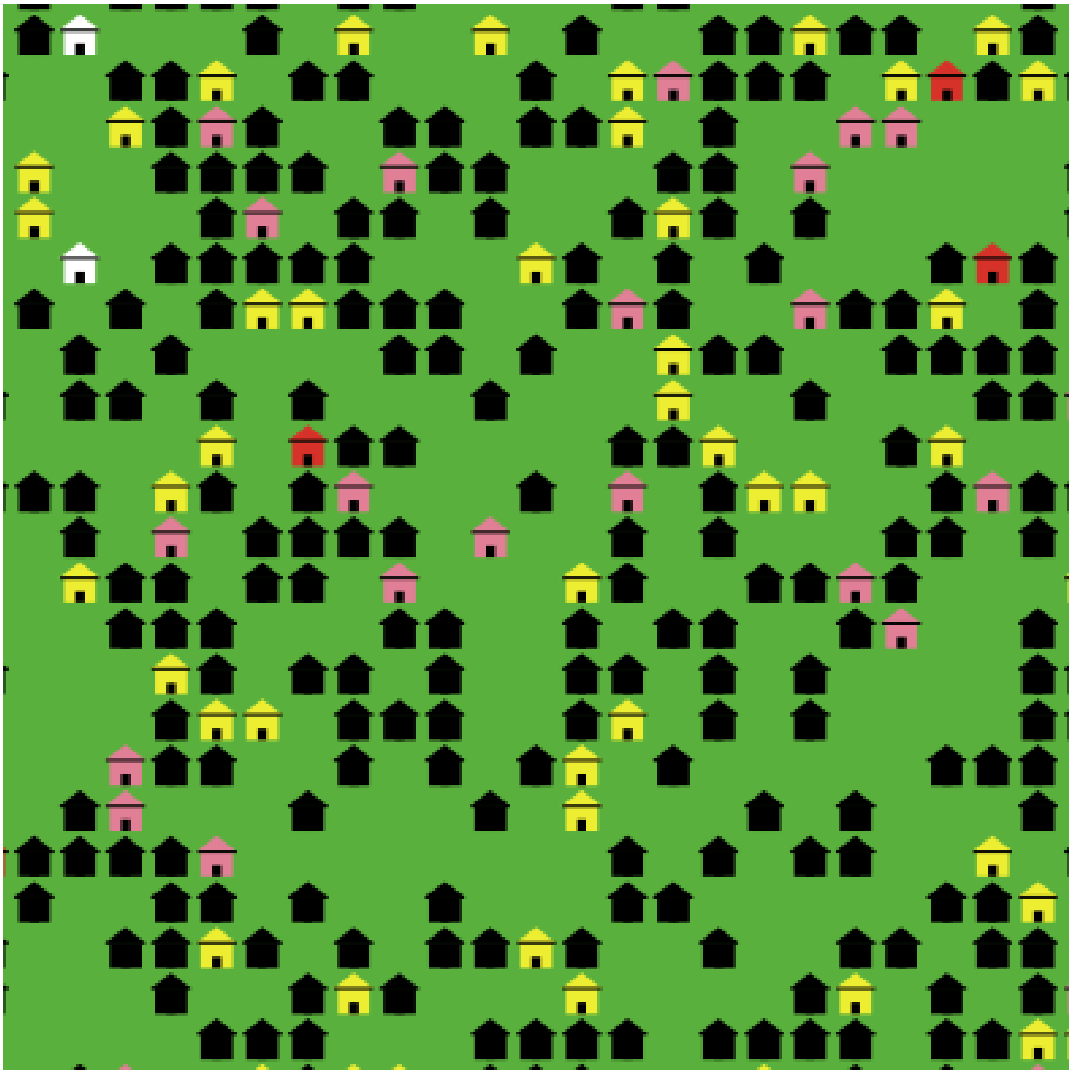


Figure 34: Closer view of household distribution at initialization. Households in black are incapable of adopting a PV system. Households in red have already made the adoption by 2021. Households in yellow are low-consumption reference households, pink is mid-consumption reference households and white are high-consumption reference households.

Appendix E.2 – Settlement area in Seychelles

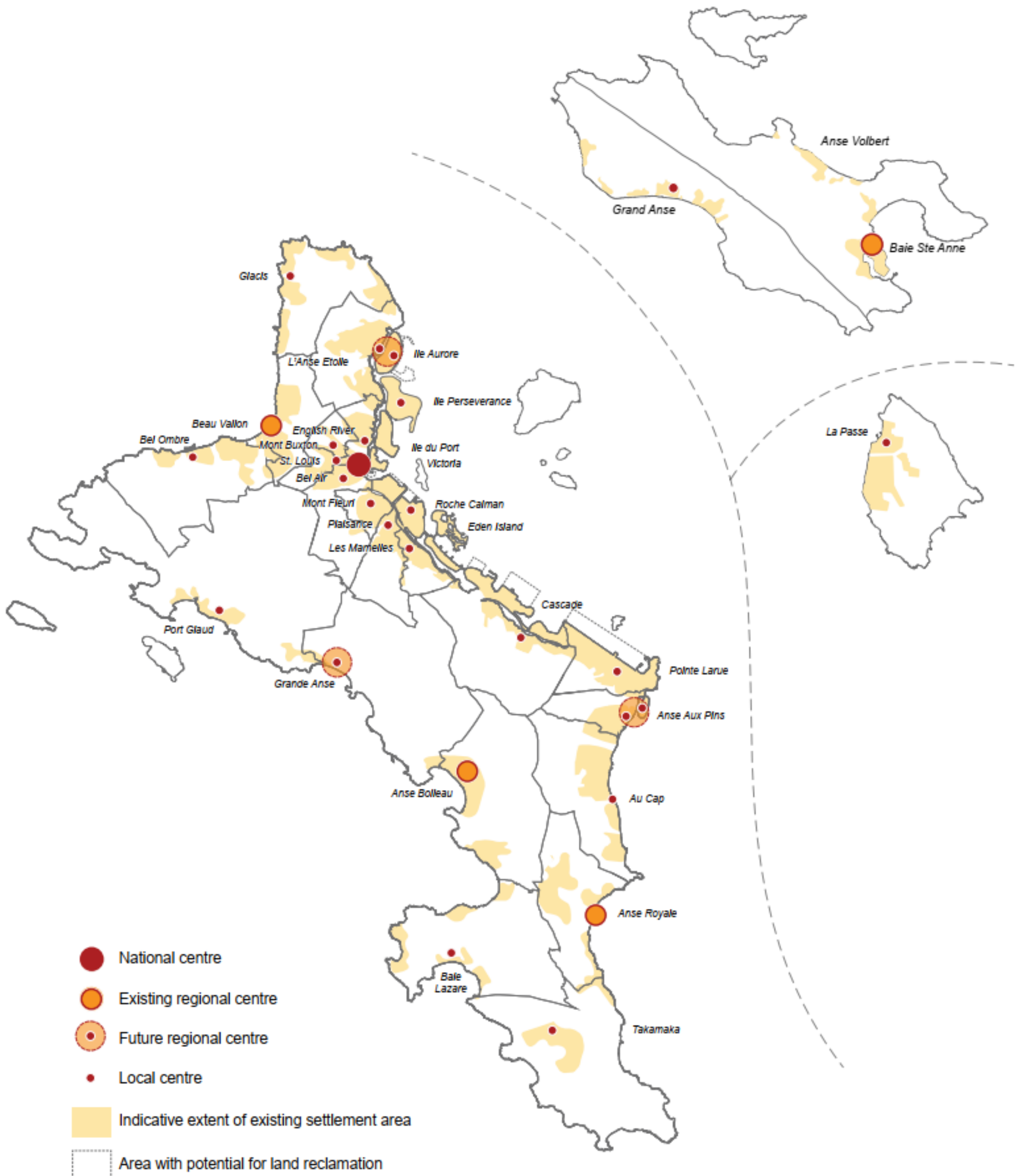


Figure 35: Indicative extent of settlement area in Seychelles as of 2014 (Sourced from Government of Seychelles (2015)).

Appendix E.3 – Historical adoption of PV modules

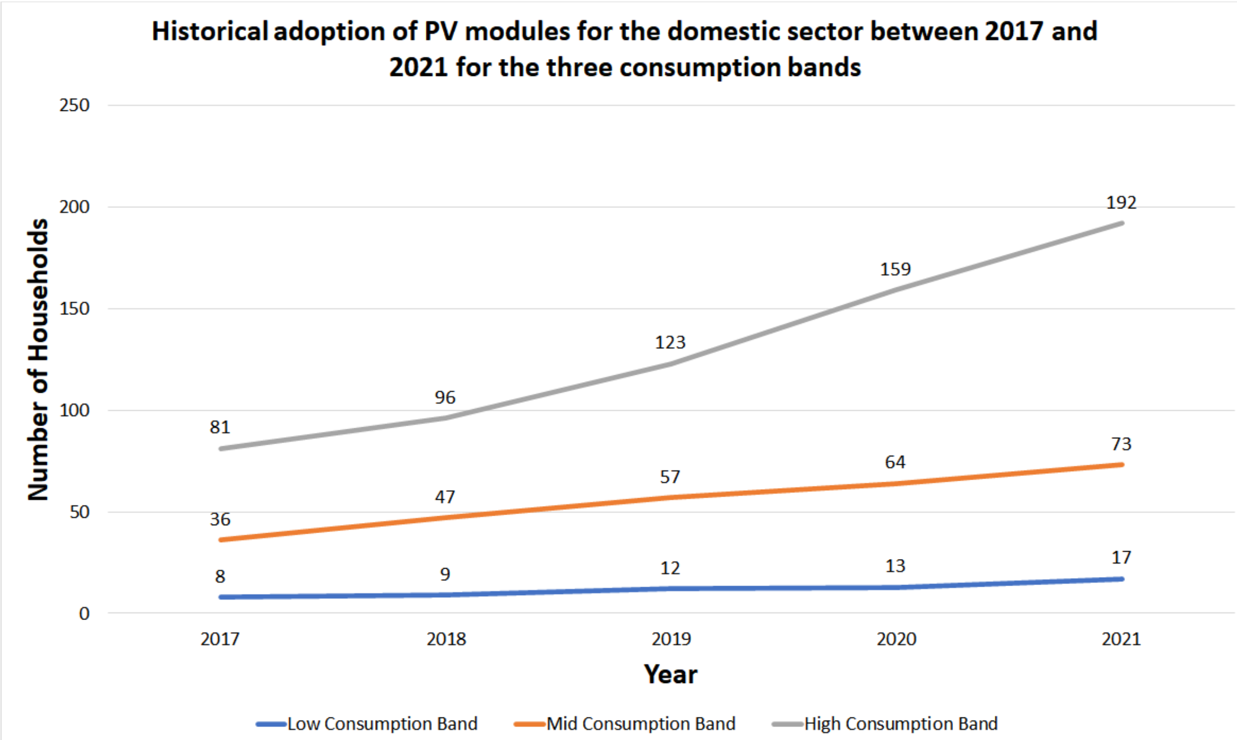


Figure 36: Historical adoption of PV modules for the domestic sector between the beginning of 2017 and the end of 2021.

Appendix E.4 – Projected cumulative and yearly adoption for each agent type from 2021 to 2046 for the Business as Usual scenario

Table 26: Projected adoption for each agent type from 2021 to 2046 for the BAU scenario.

	Agent Type – Low Consumption Reference households		Agent Type – Mid Consumption Reference households		Agent Type – High Consumption Reference households	
Year	**Cumulative - Low Consumption band**	**Yearly - Low Consumption band**	**Cumulative - Mid Consumption band**	**Yearly - Mid Consumption band**	**Cumulative - High Consumption band**	**Yearly - High Consumption band**
2021	154		73		192	
2022	156	2	82	9	214	22
2023	158	2	91	9	236	22
2024	159	1	100	9	258	22
2025	161	2	110	10	280	22
2026	163	2	119	9	302	22
2027	165	2	128	9	324	22
2028	167	2	137	9	346	22
2029	169	2	146	9	368	22
2030	170	1	155	9	390	22
2031	172	2	164	9	412	22
2032	174	2	174	10	434	22
2033	176	2	183	9	456	22
2034	178	2	192	9	478	22
2035	180	2	201	9	500	22
2036	182	2	210	9	522	22
2037	183	1	219	9	544	22
2038	185	2	228	9	566	22
2039	187	2	237	9	588	22
2040	189	2	247	10	610	22
2041	191	2	256	9	632	22
2042	193	2	265	9	654	22
2043	194	1	274	9	676	22
2044	196	2	283	9	698	22
2045	198	2	292	9	705	7
2046	200	2	301	9	705	0

Appendix E.5 – Calculated Payback periods for the respective agent types

Table 27: Calculated payback periods for all agent types for all scenarios.

	Low-consumption reference household			Mid-consumption reference household			High-consumption reference household		
Year	**Average tariff applicable (SCR/kWh)**	**Conservative Scenario (No rebate)**	**BAU and Optimistic Scenarios - SCR 15736**	**Average tariff applicable (SCR/kWh)**	**Conservative Scenario (No rebate)**	**BAU and Optimistic Scenarios - SCR 17696**	**Average tariff applicable (SCR/kWh)**	**Conservative Scenario (No rebate)**	**BAU and Optimistic Scenarios - SCR 25200**
2022	1.828	9.916482	7.437361	2.534134	6.93511	5.201333	3.519072	4.886106	3.833066
2023	1.8562	9.749107	7.311831	2.570025	6.830728	5.123046	3.559825	4.827096	3.786774
2024	1.8844	9.587289	7.190467	2.605917	6.729442	5.047081	3.600577	4.769495	3.741587
2025	1.9126	9.430755	7.073066	2.641808	6.631115	4.973336	3.64133	4.713252	3.697465
2026	1.9408	9.27925	6.959438	2.677699	6.535621	4.901715	3.682082	4.658321	3.654372
2027	1.969	9.132536	6.849402	2.71359	6.442837	4.832128	3.722835	4.604655	3.612272
2028	1.9972	8.99039	6.742792	2.749481	6.352652	4.764489	3.763588	4.552211	3.571131
2029	2.0254	8.8526	6.63945	2.785372	6.264956	4.698717	3.80434	4.500949	3.530917
2030	2.0536	8.71897	6.539228	2.821264	6.179649	4.634736	3.845093	4.450828	3.491598
2031	2.0818	8.589315	6.441986	2.857155	6.096633	4.572475	3.885845	4.401811	3.453145
2032	2.11	8.463459	6.347594	2.893046	6.015818	4.511864	3.926598	4.353862	3.41553
2033	2.1382	8.341238	6.255929	2.928937	5.937118	4.452839	3.967351	4.306947	3.378725
2034	2.1664	8.222497	6.166873	2.964828	5.860451	4.395338	4.008103	4.261031	3.342706
2035	2.1946	8.107089	6.080317	3.000719	5.785738	4.339303	4.048856	4.216085	3.307446
2036	2.2228	7.994876	5.996157	3.036611	5.712906	4.284679	4.089608	4.172076	3.272922
2037	2.251	7.885727	5.914295	3.072502	5.641885	4.231414	4.130361	4.128977	3.239112
2038	2.2792	7.779518	5.834638	3.108393	5.572608	4.179456	4.171113	4.08676	3.205992
2039	2.3074	7.676132	5.757099	3.144284	5.505012	4.128759	4.211866	4.045397	3.173544
2040	2.3356	7.575458	5.681593	3.180175	5.439036	4.079277	4.252619	4.004862	3.141745
2041	2.3638	7.47739	5.608042	3.216066	5.374623	4.030967	4.293371	3.965132	3.110578
2042	2.392	7.381829	5.536372	3.251958	5.311717	3.983788	4.334124	3.926183	3.080023
2043	2.4202	7.288679	5.46651	3.287849	5.250267	3.9377	4.374876	3.887991	3.050062
2044	2.4484	7.197852	5.398389	3.32374	5.190223	3.892667	4.415629	3.850535	3.020679
2045	2.4766	7.10926	5.331945	3.359631	5.131536	3.848652	4.456381	3.813794	2.991856
2046	2.5048	7.022822	5.267117	3.395522	5.074162	3.805621	4.497134	3.777748	2.963578

Appendix E.6 – ABM Results: Cumulative adoption amongst the three agent types

Table 28: ABM Results – Cumulative adoption amongst the low, mid, and high reference households.

	Low Consumption Reference households			Mid Consumption Reference households			High Consumption Reference households		
Year	**BAU**	**Conservative**	**Optimistic**	**BAU**	**Conservative**	**Optimistic**	**BAU**	**Conservative**	**Optimistic**
2021	154	154	154	73	73	73	192	192	192
2022	156	155	158	82	77	91	214	205	238
2023	158	156	163	91	82	110	236	218	285
2024	159	156	165	100	86	129	258	231	331
2025	161	157	169	110	91	151	280	245	376
2026	163	158	174	119	96	170	302	257	424
2027	165	160	178	128	101	188	324	269	472
2028	167	161	182	137	106	208	346	281	520
2029	169	162	186	146	110	226	368	292	565
2030	170	162	188	155	115	245	390	305	609
2031	172	163	192	164	119	263	412	317	654
2032	174	164	196	174	125	283	434	330	695
2033	176	165	200	183	129	302	456	342	705
2034	178	166	204	192	133	321	478	355	705
2035	180	168	208	201	139	341	500	367	705
2036	182	168	212	210	143	361	522	380	705
2037	183	169	213	219	147	380	544	393	705
2038	185	170	218	228	153	400	566	405	705
2039	187	171	222	237	158	418	588	417	705
2040	189	172	226	247	163	440	610	430	705
2041	191	172	230	256	168	460	632	443	705
2042	193	174	234	265	173	479	654	455	705
2043	194	174	236	274	178	499	676	468	705
2044	196	175	241	283	183	518	698	480	705
2045	198	176	244	292	188	538	705	493	705
2046	200	177	248	301	193	557	705	505	705

Appendix E.7 – ABM Results: Cumulative capacity of installations from 2021 to 2046

Table 29: ABM Results – Cumulative installed capacity for the three scenarios along with historical installations.

Year	Historical	BAU	Conservative	Optimistic
2013	42.56			
2014	211.64			
2015	391.48			
2016	583.04			
2017	692.29			
2018	871.53			
2019	1296.845			
2020	1694.33			
2021	1979.295	1979.295	1979.295	1979.295
2022		2128.195	2062.605	2287.535
2023		2277.095	2149.075	2606.965
2024		2423.185	2229.575	2912.745
2025		2575.245	2321.265	3228.405
2026		2724.145	2402.515	3553.055
2027		2873.045	2486.575	3871.735
2028		3021.945	2567.825	4196.735
2029		3170.845	2640.695	4499.755
2030		3316.935	2724.355	4795.095
2031		3465.835	2802.445	5098.115
2032		3617.895	2892.075	5386.575
2033		3766.795	2970.165	5510.055
2034		3915.695	3053.475	5581.335
2035		4064.595	3140.695	5655.775
2036		4213.495	3221.195	5730.215
2037		4359.585	3304.505	5793.065
2038		4508.485	3388.915	5870.315
2039		4657.385	3470.165	5938.435
2040		4809.445	3556.635	6019.195
2041		4958.345	3640.295	6093.635
2042		5107.245	3724.355	6164.915
2043		5253.335	3808.015	6233.735
2044		5402.235	3889.265	6307.825
2045		5472.835	3975.735	6379.455
2046		5506.895	4056.985	6450.735