Analysis of Solar Energy on Caribbean Small Island Developing States (SIDS)

A case study of Curaçao

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Research Introduction

In 2014, the Intergovernmental Panel on Climate Change (IPCC) reported being more than 95% confident that global warming is caused by anthropogenic drivers, such as greenhouse gas emissions (IPCC, 2014). The consumption of fossil fuel causes an increase in CO2-emissions, which is not in line with the Paris Agreement and causes environmental issues. In order to combat this, the energy sector needs to be decarbonized. This can be done by introducing more renewable energy into the energy mix. One of the most prominent renewable energy technologies to do so is rooftop Solar photovoltaic (PV). Next to environmental advantages, numerous studies show that rooftop solar PV is also beneficial financially for both utilities as well as for broader society (Drawdown, 2017). Additionally, PV is creating jobs and energizing local economies (Woody, 2014).

When assessing the implementation of a different technological solution to a social issue, human behavior change plays a huge role in its success (Kemp et al., 1998). Studies show that the adoption of rooftop Solar PV impacts behavior of users drastically (Rai & Andrews, 2012). As households adopt rooftop solar (increasingly accompanied with distributed energy storage), they transform generation and its ownership, shifting away from utility monopolies and making power production their own. As electric vehicles also spread, gassing up can be done at home, supplanting oil companies. With producer and user as one, energy gets democratized.

The **problem owner** in this rooftop Solar PV case is the Small Island Developing State (SIDS) Curaçao and its government. SIDS have common characteristics which arguably make them the most vulnerable to the impacts of climate change (The Carbon War Room, 2013; Arens, 2013). The **problem** is the lackluster performance of SIDS (incl. Curaçao) in terms of renewable electricity generation, despite the immense renewable energy potential, they still rely on petroleum-based fuels for the energy (Weiser, 2004). The **desired situation** is to maintain stable electricity for the population in the long term without being dependent on fossil fuels.

To clearly understand why this research is relevant, first the need for the energy transition of SIDS and specifically Curaçao is explained. Furthermore, the role that rooftop Solar PV can

play in this will be elaborated upon. This is followed by the research question that stems from this, followed by the societal relevance, after which the outline of this thesis is briefly presented.

1.1 Research background

1.1.1 Climate Change & Energy Transition

There is scientific consensus that the Earth's climate is changing due to global warming caused primarily by the human use of oil, coal, and natural gas. The burning of these fossil fuels releases carbon dioxide into the atmosphere, which traps more heat from the sun. Global warming is accelerating as planetary temperatures reach record highs (IPCC, 2014). The rise in global temperatures resulting from greenhouse gas emissions causes variations in our climate conducting environmental, economic and social losses.

The damage of Climate Change and the need for reform of current affairs has become a priority in the 21st century. The Paris Climate Change Agreement that took effect on 5th October, 2016 (UNFCCC, 2015) signifies the importance of a more environmentally friendly, largely decarbonized society. To bring about such a society, the energy sector needs to be fundamentally transformed. This can be done by increasing the fraction of renewable energy supply in a country. There are mainly three reasons to concentrate on the energy sector:

1. The energy sector has direct correlation with combatting poverty and increasing health (World Bank, 2005).
2. The energy sector accounts for 41% of CO2 emissions worldwide (World Bank, 2005).
3. Technological progress - Renewable energy is the future (White House, 2015).

1.1.2 Solar Energy

Silicon PV technology was discovered accidentally in the 1950s by the United States' Bell labs. In 1954, with the inauguration of the Bell 'solar battery' the (New York Times, 1954) announced it might mark "the beginning of a new era, leading eventually to the realization of one of mankind's most cherished dreams - the harnessing of the almost limitless energy of the sun for the uses of civilization" (New York Times, 1954).

The most abundant renewable energy source that we have is solar energy. The waves and particles of the sun's light continuously hit the Earth's surface with an energy more than ten thousand times the world's total demand. Any scenario for reversing global warming includes a massive ramp-up of solar power by mid-century (Drawdown, 2017).

The most prominent technology to harness renewable electricity from the sun's energy is Silicon Photovoltaic (PV) technology. PV panels usually make up a solar rooftop array or a solar farm. Inside a panel's hermetically sealed environment, photons energize electrons and create electrical current - from light to voltage, just like the name implies.

As mentioned in the introduction, rooftop Solar PV has numerous financial benefits. By implementing it in the energy mix, utilities can circumvent large investments in new fossil plants, which would ultimately also be included in the price for consumers. Additionally, broader society is exempted from environmental and health impacts (Drawdown, 2017). The adoption of PV systems also has an impact on the awareness of the adopters' use of electricity, on changes in their use of electricity and their environmental outlook (Rai & Andrews, 2012).

The International Renewable Energy Agency already credits 220 million to 330 million tons of annual carbon dioxide savings to solar PV, and they are less than 2% of the global electricity mix at present. Oxford researchers calculate that solar PV could meet 20 percent of the global energy needs by 2027. Due to complementary government interventions and market progress, there are many promising signs. The 'new era' cited by the New York times in 1954 can become a reality if it is supported by the right technology and the right government incentives.

1.1.3 Small Island Developing States

Within the Earth's 50,000 islands, which comprise approximately 750 million people, there is a specific group of islands considered under the umbrella term of Small Island Developing States (SIDS), officially recognized by the UN in 1994. SIDS are a distinct group of developing countries facing special social, economic, and environmental vulnerabilities (UN-OHRLLS, 2011). They are divided into 3 geographical regions the Caribbean (1), the Pacific (2), and Africa, Indian Ocean, Mediterranean and South China Sea (AIMS) (3).

As mentioned before, SIDS are arguably the most vulnerable to the negative effects of Climate Change (The Carbon War Room, 2013). Recent research suggests that the melting of polar ice and mountain glaciers has led to 5 islands in the Pacific to disappear and another 6 islands facing serious recession of shorelines (Simon et al., 2007).

Due to their geographical location SIDS face isolation, remoteness, poor connectivity, generally underdeveloped technological sectors (Arens, 2013). The main paradox here is that, although these islands have enormous potential for renewable energy, the implementation has been limited and they still rely on energy based from petroleum fuels (Weiser, 2004). Furthermore, research is mainly available for Mediterranean islands and only limited research is available for Caribbean islands. In addition, in wicked problems such as the Energy Transition, there is no agreement on the objective of the policy and the standards and values at stake, nor on the knowledge needed to solve the problem (Rittel & Webber, 1973). Hence it is important to do an in-depth research of a Carribbean small Island Developing State.

1.1.4 Curaçao

Similarly to other SIDS, **Curaçao** is an island nation driven mainly by the oil and tourist industries (Curaçao Ministry of Economic Development, 2012). The country has an underdeveloped high-tech sector, natural resource scarcity, it is highly dependent on (fuel) imports and it is experiencing brain drain (United Nations Development Program, 2011). Additionally, the island is one of the most polluting countries in the world due to its use of diesel in utilities and the big ISLA refinery (Curaçao Ministry of Economic Development, 2012).

After the recent increase in attention for climate change, many SIDS, including Curaçao, have set ambitious targets for the transition (National Energy Policy, 2017). Additionally, despite Curaçao's immense solar potential, due to its geographical location close to the Earth's equator, solar panels currently cover about 2% of the island's electricity demand, the rest (27% of demand) comes from wind energy. Currently there is a capacity of 12.5 MW PV on the island, which is planned to increase to 25-30 MW in 2020, which would only cover 4.5% of the yearly electricity demand (kWh) (National Energy Policy, 2017).

1.2 Research Question

There are a lot of factors that can play a huge part during regime changes of the magnitude that is required for the transition to a Renewable Energy infrastructure and specifically Solar PV. The policy measures alone are not sufficient for the transition. There are social and technological challenges that also play a role. Hence, the main research question of this paper is formulated as follows:

"How can the government of Curaçao overcome the main obstacles of rooftop Solar PV for the technology to be successfully implemented?"

This will in turn lead to policy and socio-technical recommendations for Curaçao.

1.3 Societal Relevance

This case is interesting because rooftop Solar PV could be a sustainable solution for several wicked issues of our generation. Problems such as the effect of CO2 on the environment and the depletion of fossil fuel resources could partly be solved. Apart from those problems it is, from an academic point of view, interesting to analyze if the current plans regarding rooftop Solar PV in Curaçao have set the right precedence for large scale implementation.

Furthermore, this will specifically be useful to the government and the society of Curaçao. The SIDS will be able to draw conclusions, like in Table 1.1.

Table 1.1: Societal Relevance

Societal Relevance
1. The role the population of Curaçao can play to improve their energy situation
2. The role the government needs to play to make sure the population takes interest
3. The role the government needs to play to increase stakeholder interest in the transition
4. The government will have recommended pathways that it can use for referral
5. Other stakeholders will realize the potential and the environment for deployment of Solar PV

To answer the research question, first the literature review will go in depth into the concepts of the systems innovations approach and transitions within the multi-layered perspective. Then, the methodology section will explain in detail the steps that will be taken to collect and analyze the data that will be used to answer the research question.

Chapter 2

Theoretical Background

In the literature research it is found that there is a need for intervention approaches in order to introduce and develop (niche) technology. When it comes to a radical transition, such as the energy transition, Rotmans (2006) speaks of the necessity of a 'transition process'. In his view, a transition is "a structural social change that is the result of interacting and mutually reinforcing developments in the fields of economy, culture, technology, institutions and nature & environment" (2006, p. 14). He declares that the energy transition is a typical example of a transition process (p. 139). Hence, the implementation of Renewable energy sources needs to be analyzed with a systems innovation approach.

From the literature review on transitions it can be deducted that they arise from a series of developments that link together at different levels of scale (multi-levels). Rotmans (2006), Dirven et al. (2002) and Loorbach (2007) argue that transitions are always the result of developments and events on a large scale (mega-trends such as globalization, liberalization and individualization) and on a small scale (niche developments such as deviant ideas and initiatives from individuals). This means that the implementation of rooftop Solar PV, which is defined as a Niche development, needs to be analyzed from a Multi-Level Perspective called Socio-Technical Systems (Rip & Kemp, 1998; Geels, 2002).

To be able to analyze the functioning of a Niche and thus to work towards the previously stated research question (section 1.2), more knowledge is needed about the internal processes that take place in a niche. In order to do this, the innovations approach Strategic Niche Management abbreviated as SNM (Geels & Kemp, 2000 p. 12-15) is used to analyze the current situation on Curaçao and the barriers that are in place for further scale-up of rooftop Solar PV. In this theoretical background, first, transitions literature will be reviewed, including the multi-layered perspective, clarifying important concepts such as Niches, Regimes and Landscapes. Then the theory on how to analyze implementation of new (renewable) technology, with the use of system the innovation approach SNM is explained, through which the obstacles mentioned in the previously stated research question can be gathered.

2.1 Transitions Theory

Chapter one briefly outlines the background and the need for a transition towards sustainable energy and the importance of a drastic scale-up in Solar PV in the energy mix of Curaçao. To answer the main question and the objective of the research, a theoretical deepening will have to take place. The theory about transitions, the role of niches, the way in which strategic niche management can be used to analyze the transition and uncover current barriers and the need of having a Multi-Level Perspective form the theoretical framework for this research. By working this out, it ultimately becomes clear what barriers Curaçao needs to overcome for solar PV to transition from a niche technology to a more dominant one.

With the increasing discussions about our energy supply, it is becoming increasingly clear that sustainable development requires integral, long-term innovations (system innovations) that pave the way for fundamental changes (transitions) in our society. It becomes even more clear that a transition is necessary because the electricity (utility) system on Curaçao is currently in a *lock-in situation*. The aim of this research is to analyze the current transition pathway of Curaçao and uncover the barriers that hold back the large-scale roll-out of Solar PV. This roll-out will have to be part of a larger socio-technical transition in which different technologies, regulations and cultural changes have to take part. A number of theoretical approaches and concepts have been looked at to support research, including the network approach, process management, evolutionary economy and transition theory.

2.1.1 Transitions

A transition is seen as "a non-lineair process of social change in which a societal system is structurally transformed" by Grin et al. (2010), de Haan and Rotmans (2011), Geels and Schot (2007) and Loorbach (2007, in Avelino, 2011, p. 3). A sustainable transition is generally about a "radical transformation towards a sustainable society as a response to a number of persistent problems confronting contemporary modern societies" (Grin et al., 2010:1, in Avelino, 2011, p. 3). According to Bridges (2017, p. 11), a transition differs from a change in that a change is aimed at a new situation, where a transition consists of letting go of an old situation and an old identity. Transitions are gradual changes that usually require a long time, at least one generation (25-50 years). They take a long time, because existing boundaries, barriers, institutions and relationships must be broken. In the short term, a transition is going smoothly within the various domains and institutions.

An example of such a transition and system innovation is the transition from coal to natural gas as the main energy carrier in the Netherlands in the 1950s and 1960s, with system innovations in the areas of distribution, housing, business and institutions (Verbong, 2000). In the same way a transition from fossil fuel electricity supply to renewable energy supply is needed, with innovations in distribution, housing, business and institutions.

Transitions can only occur when innovations in different social domains come together and reinforce each other. Furthermore, to make a transition possible, it is a condition that innovations take place at system level. Therefore, Rotmans (2006) speaks of a 'transition process'. In his view, a transition is "a structural social change that is the result of interacting and mutually

reinforcing developments in the fields of economy, culture, technology, institutions and nature & environment" (p. 14). Given that the switch to renewable energy is radical and time-consuming, he calls it a typical example of a transition process (p. 139). Innovations in various fields are needed in a transition process. In addition to technological improvements, institutional changes, legal changes, behavioral changes etc. are also needed. These changes are very complex and take place at system level: the umbrella level at which individuals, companies and organizations have organized (p. 15).

2.1.2 Wicked Problems

According to Rotmans, the theory of transitions is particularly suitable for so-called 'wicked problems', because these problems exceed scale levels and domains and require structural change. Dirven, Rotmans and Verkaik (2002) describe 'wicked problems' as poorly structured problems surrounded by a great deal of uncertainty and characterized by a high degree of complexity (p. 23). These kinds of persistent problems are also characterized by a dissensus on the nature and solution of the problem among a large and complex set of actors within a multitude of sectors. Such wicked problems are based on so-called 'weaving errors' that gradually crept into certain social systems (Rotmans, 2006, p. 6; Loorbach, 2007, p. 16). Here flaws are barriers in a system that cause the system to not function optimally and can play at different levels, as Rotmans summarizes:

- Institutional flaws (dominance of institutions that hold back innovation);
- Technological flaws (dominance of a certain technology that other technologies exclusion);
- Economic flaws (insufficient market development or investment capital);
- Social flaws (ingrained behavior and habits that hamper behavioral change);
- Ecological flaws (dominance of species or ecosystems that threaten biodiversity).

Rotmans cites the lock-in situation of the energy system as an example of a policy field / social problem with a persistent character, a 'wicked problem'. Many different actors are needed in a transition process to make it a success. Rotmans also distinguishes different phases in which a transition can take place. These are the pre-development phase, the take-off phase, the acceleration phase and the stabilization phase.

Rotmans describes the energy transition as a persistent problem, since there is uncertainty about both the nature of the problem and the data to solve it. To solve such a problem it is necessary to investigate the problem at system level. This requires transition control, which is characterized by learning and experimenting. This learning and experimentation is described by Rotmans (2006, p. 38) as an evolutionary process of learning by doing and doing by learning. Because there is no consensus about a solution or the nature of the problem, it is an illusion to think that a simple intervention can solve the problem. Therefore, several end solutions for the problem must be kept open and experimentation with solution directions. Solutions not only

have to be found at the technical level, but solutions are also required at the social level. There must be support for experiments for which it is not immediately clear what they are intended for and what exactly they will mean.

2.1.3 Socio-Technical Transitions

Socio-Technical Transitions are defined as "major, long-term technological changes in the way societal functions are fulfilled. They do not only involve changes in technology, but also changes in user practices, regulation, industrial networks, infrastructure, and symbolic meaning or culture." (Geels, 2002)

Addressing a wicked environmental issue, like Climate Change, require a shift to new practices (i.e. in energy, transport, built environment). These shifts are reffered to as 'Socio-Technical Transitions' since they not only concern technological changes, but also social considerations like consumer behavior, policy changes, cultural implications, infrastructure shifts and innovation in business models. For mainstream social sciences, socio technical transitions to sustainability are challenging because they are multi-actor, long-term, goal-oriented, disruptive, contested, and nonlinear processes. The functioning of technical systems, such as the electricity grid, demands organizational cooperation, in addition to good infrastructure and regulation.

Socio-Technical Transitions are complex because of coordination between the multitude of stakeholders with conflicts of interests that are affected by multiple innovations when changes are occur. To analyze the transition towards more renewable energy technology, including an upscaling of Solar PV, we need to understand the importance of Niches and the interaction between different levels of the socio-technical system, which can be described by the *Multi-Level Perspective*.

2.1.4 Multi-Level Perspective

System innovations, like Rooftop Solar PV, which are not only a technological departure from status quo, but also impact the social environment, should be approached within a multi-layered systems perspective, called the Multi-Level Perspective (MLP). This Multi-Level Perspective will be described in detail in this section, for which an analysis was done of existing literature on transitions theory, mainly by Geels and Kemp (2000), Geels (2002), and Rotmans (2006). Generally, the Multi-Level Perspective is used as a framework to analyze (socio-technical) transitions, which, as explained in the previous section, are described as large-scale changes in the way social functions are fulfilled. As mentioned in section 2.1.1, an example of such a societal function is the supply of electricity, which is currently mainly provided by burning fossil fuels. Hence, a transition would need to take place for this societal function to shift to a non-fossil fuel-based supply.

The MLP takes concepts from evolutionary economics, sociology of innovation, and institutional theory in order to get a deeper understanding of transition processes. In order to comprehend the intricacies of sustainability transitions, various stages, stakeholders and barriers are analyzed. The MLP analyzes Socio-Technical Systems as a whole, this mitigates a focus

that is too narrow (individual level) while also mitigating a focus that is too broad (e.g. green economy). This framework provides an integral perspective on transitions, that can be used to analyze niche innovations (such as Solar PV) to industry-wide regime shifts (Geels, 2002).

The concept of the Multi-Level Perspective describes transitions in terms of interferences between three different levels of scale (levels): the macro, meso and micro levels, based on (Geels & Kemp, 2000). The different levels of scale are functional in nature and not so much spatial (Figure 2.1).

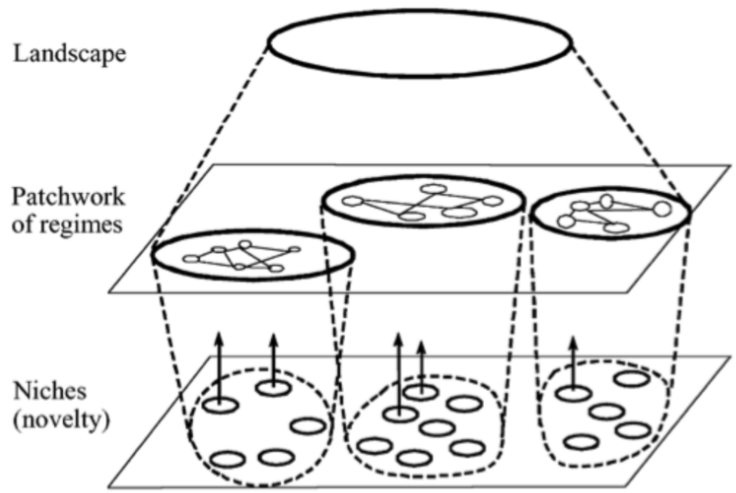

Figure 2.1: (Static) Multi-Level Perspective (Geels, 2002)

Macro-level: Landscape

Landscape changes play a role at the macro level, for example in the areas of politics, culture, worldviews, paradigms and macroeconomic aspects. At this scale level, trends and developments form an undercurrent and are relatively slow. Developments at the macro level are external to the regimes and niches, but do influence them (Fischer, 2004, p. 15; Rotmans, 2006, p. 18). Even though such landscape changes are usually slow, they can also occur suddenly as a result of, for example, the outbreak of war, terrorist attacks or major accidents, such as floods. Although for many types of studies this landscape can be assumed to be constant, it must be included in the study of long-term transitions, since developments in the landscape can lead to increased pressure for transition.

Meso-level: Regime

At the meso level there are regimes; systems of dominant practices, rules and interests that are shared by large groups of actors. Regimes are the established systems here that are intended to perform a certain social function. There is a lot of resistance to innovation at this level, because existing organizations, institutions and networks maintain existing rules, methods and interests (Rotmans, 2006, p. 18).

A further broadening is needed to more explicitly incorporate the selection environment (market, government, etc.). This leads to the introduction of the term *socio-technical regimes*.

The focus is on an intertwined system, rather than separate variables. Most technology development in the meso-level is incremental and concentrated around optimization and further enhancement due to the anchoring and general rigidity of the Socio-Technical system. Thus, Socio-technical regimes provide an explanation for the embeddedness of certain technical systems, such as fossil-based energy supply. Due to the aforementioned characteristics, it becomes difficult to achieve radical alternatives (renewable energy) and regime shifts.

Micro-level: Niche

At the micro level, niches develop, often formed by individuals or groups of actors who are open to innovation. At this level there is room for learning processes about innovations, new practices or behavior and the first steps towards a transition are often taken (Fischer, 2004 p. 16). The concept of niches plays a crucial role in transition theory (Rotmans et al., 2000; Rotmans, 2003, 2005; Geels, 2002, 2004, 2005); niches are spaces where deviating practices take place, such as niches for alternative technology (Rooftop Solar PV), but also in the form of new initiatives and new forms of culture and governance (Rotmans, 2006 p. 18). These deviating practices are made possible by the heterogeneity of the selection environment (prices, preferences, standards, protection of sponsors). Within this micro level is also where radical new technological development such as Solar PV reside and are protected.

There are two types of niches for new technology, namely **Market Niches** and **Technological Niches**. The main distinction between these two types is the type of 'protection' within which the niche technology operate, e.g. technological niches are 'protected' from the market, since there is almost no market contact. However, technological niches enable society to learn about the characteristics and possibilities of alternative technology, as well as to improve the technology (Kemp et al., 1998; Weber et al., 1999; Hoogma, 2000). On the basis of expectation that the new technology will have market potential, actors are prepared to invest time and money for development. If the niche exists within an existing regime, as is currently the case with Rooftop Solar PV on Curaçao, literature refers to *market niches*. Nodes for sustainable system innovation usually deviate from the existing regime, for example off-grid electricity generation. The specific nature of the market niche offers a protection to the new technology. In combating specific issues in the regime, willingness to accept shortcomings (efficiency loss, higher costs) increases since specific performance is required. In the case of renewable energy, CO2 neutrality is a specific requirement, which excuses some shortcomings in efficiency or cost.

Interaction of the different levels for Socio-Technical Transitions

Core to MLP is the interdependence between the 3 different levels, all of which contribute to the success of new technology (Kemp et al., 2001, p. 277). According to Rotmans (2006), Dirven, et al. (2002) and Loorbach (2007) transitions are always the result of developments and events on a large scale (megatrends) and on a small scale (niche developments).

As can be seen in Figure 2.2, the success of Socio-Technical Transitions is dependent on developments of all 3 levels, illustrated by the vertical dottet arrows. Transitions will only be realized if developments at the three different levels link together and reinforce each other in one and the same direction (modulation). Thus, Landscape and Regime level developments have to cooperate to open a 'gateway' through which the new technology can break free of the niche-level. These 'gateways' can result from developments in the socio-technical regime or shifts in the landscape that place pressure on the regime (Geels, 2002).

Some landscape-level developments enforce **stabilizing pressures** on the current regimes, while others create **Destabilizing pressures**. For instance, the climate change phenomenon can be catagorized as a destabalizing landscape pressure, since it puts more pressure on the current fossil-fuel based electricity regime to change. On the other hand, more electricity intensive appliences are being bought, which increased the need for electricity. The existing oil & gas infrastructure also stabilizes the fossil fuel utilities (Geels & Kemp, 2000).

Figure 2.2 also shows the importance of parallel development of different Niche technologies (multiple arrows simultaneously moving into the regime from the bottom of the image). Additionally depicted in the image is the importance of aspects on deeper dimensions rather than only technology, i.e. regulation, infrastructure, symbolic significance, industrial networks (represented in the image by the growing number in close proximity of each other). Additionally, if the regime shifts, this can also put pressure on the landscape to change (bottom-up).

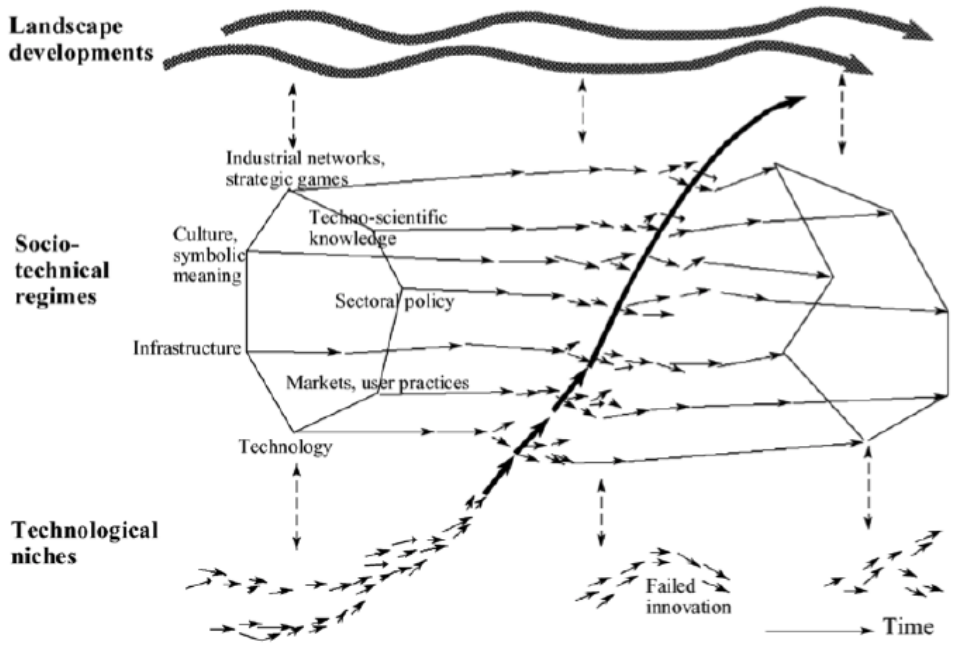

Figure 2.2: Interaction of the different levels for Socio-Technical Transitions (Geels & Kemp, 2000)

2.1.5 Pitfalls in transitions

Just like in every process, there are opportunities and barriers in a transition process that can influence the process and the end result. Transitions are integral renewal processes and one of the conditions for a transition is that the dominant perspective changes (Rotmans, 2006, p. 44). People's way of acting and thinking must change. This is not easy; there are a number of pitfalls that inhibit or stop the transition process. Rotmans (2006) distinguishes the following: 'backlashes', 'lock-in situations', and 'short-term and ad-hoc thinking'. These pitfalls are explained in more detail below.

Short-term and ad-hoc thinking is detrimental to a transition, due to its nature. A transition is about problems that are very complex, poorly structured and that are accompanied by a great deal of uncertainty (Rotmans, 2006, p. 46). They often try to solve this in the traditional way by looking for solutions and subjecting them to a cost-benefit analysis. However, this is not possible with a transition process, due to the high intrinsic uncertainty. Giving the right solution is therefore hardly possible. These problems must therefore be approached differently. Rotmans indicates that as many options as possible must be kept open, whereby promising options can be selected for further analysis.

A *lock-in situation* occurs with a too high degree of path dependence. Path dependence means that previous choices, no matter how small, have an important impact on future historical trajectories (Edwards, in Edelenbos & Monnikhof, 2001, p. 120). An option to stimulate innovation can therefore become embedded in such a way that innovation is blocked (Rotmans, 2006, p. 45). In fact, this problem is currently also affecting energy production: investments made in the current energy infrastructure make this technology embedded in such a way that innovation is blocked. In this case we speak of the 'carbon lock-in' (Brown, Chandler, Lapsa, & Sovacool, 2007). To prevent this, it is important to state clearly which products are only used as transitional agents. This reduces the risk that these agents become so obvious that they can no longer be filtered out of the system.

Backlash effects occur when a renewal is introduced too abruptly or without thought. This may cause defects in implementation. Due to these implementation problems, public opinion about the renewal can deteriorate. This leads to a lack of support, which makes a continuation of the transition more difficult. It is therefore important that these backlashes are prevented as much as possible. One of the options that Rotmans refers to is **Strategic Niche Management (SNM)** from Hoogma, Kemp, Schot, and Truffer (2002). With Strategic Niche Management, a new solution to a problem is not only offered, but an attempt is made to bring together the expertise of different disciplines to arrive at a solution that is actually adopted by society. Technical and cultural improvements instead of offering different 'gadgets' to see if the general public is interested or not. The aim is to create a niche and to develop it in a bottom-up manner, with the ultimate goal of changing the regime (Hoogma et al., In Wright, 2004).

2.2 Strategic Niche Management

"New technological options generally emerge as 'hopeful monstrosities'. They are 'hopeful', since they have in principle shown themselves to fulfill some (social) function, but as the performance characteristics are still low, they are considered 'monstrous'. They must initially be shielded from the regular market in order to develop further." (Mokyr, 1990) Developers of new technology therefore create 'protected spaces' (Schot et al., 1994; Kemp et al., 1998). In the quasi-evolutionary theory of technology development these were called 'niches' (Schot, 1991; Weber & Hoogma, 1998).

In the following section, the innovation approach *Strategic Niche Management (SNM)*, that can be used for a micro-level analysis of niche developments such as Solar PV, will be discussed. Such an innovation approach is necessary in order to uncover the barriers that are in place on Curaçao, which will provide an answer to the previously stated research question.

Strategic niche management is a recently developed analytical tool (Dutch 'invention') to facilitate the development of niches (e.g. from technological niches to market niches) by experimenting with technological, market and institutional co-evolution. (Schot & Geels, 2008). The aim of SNM is to stimulate learning processes and processes of social embedding for socio-technical solutions. A core element of SNM are practical experiments with real users in (partially) protected niches. SNM can be used by both companies and the government to support initiatives to provide protection against selection pressure. Protection is in principle temporary and a balance must be found between protection and selection pressure.

Niche development processes are the result of a number of niche internal processes and external developments. In the literature about niche development trajectories, three processes are distinguished that take place within a niche: learning processes, building up actor networks and articulating visions and expectations (Schot, Slob, & Hoogma, 1996; Weber et al., 1999). The relationship between these niche internal processes, the experiments and resources (in terms of money, power and knowledge) is shown in Figure 2.3.

Based on visions and expectations, actors (providers, knowledge institutions, users and sponsors) can decide to transfer their money, knowledge or power to a new experiment. Because the experiment involves learning in various fields, the actors involved can adjust their vision of the problem and their expectations about possible solutions. The relationships between the actors involved can also change, new actors are attracted on the basis of new expectations, old actors disappear, and new partnerships are created. These changes in the composition of the actor network and the visions and expectations can lead to the experiment being modified or a new experiment being set up, for which new knowledge, power or financial resources must be deployed.

External developments exert a major influence on the niche internal processes that take place in the immediate environment of the experiment (see Figure 2.2). Research by Raven (2005) shows that changes in visions and expectations can mainly be explained by external circumstances.

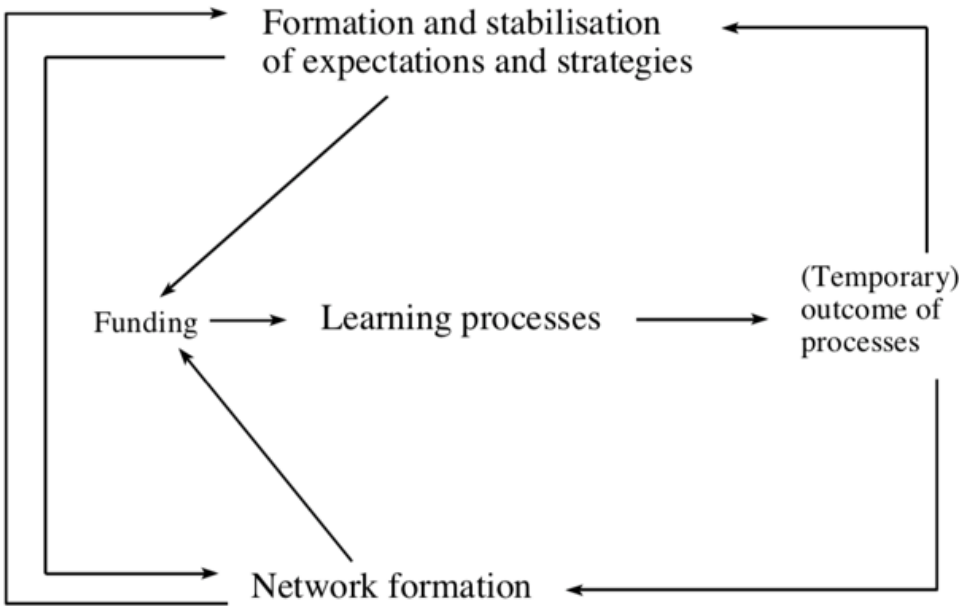

Figure 2.3: Interactions between Niche-Processes (Geels & Kemp, 2000. p. 13)

2.2.1 Internal Niche Processes

SNM analyzes within a niche three characteristic niche processes. The first being the voicing and shaping of expectations, the second being the formation of social networks and the third being the learning processes. All three of these have underlying criteria to measure their level of effectiveness in innovation pathways.

Voicing and shaping of expectations

The pathway of new technologies can be quite uncertain, therefor the expectations of stakeholders play an important role in attracting new actors and thus enhancing the success of the implementation of an innovation. Expectations of a certain technology can determine whether or not a particular actor participates in projects related to that technology. Because of this, the way that expectations regarding (new) technologies are voiced can be critical in the attraction of actors. This is particularly the case for niche technologies that are still developing and are unproven.

Expectations can also direct and provide the relevant actors with cognitive guidelines. This will in turn have an impact on the direction in which technology will be developed. Due to this, it is important to have a growing number of actors with aligned expectations. Also important in forming aligned expectations is to gather results from experimentation and implementing this in future development. According to van der Laak (2007), expectations are regarded to be effective if they are (a) supported by multiple actors (**Robust**); (b) specific and clear (**Focus**); and (c) backed by adequate evidence through e.g. experimental learning (**High Quality**) (van der Laak, 2007).

Building of social networks

At the start of implementation, the social network around a particular technology is very important, but usually does not involve many actors yet. Yet, social networks are essential for the implementation procedure and success of new technology. Through experimentation either as a technological niche or a market niche, more actors can get involved and the network grows. This is important, because different actor types will bring in a broad range of perspectives. Thus, the broadness of a social network is one of the criteria for a good quality network building process. The social network's quality is also assessed on the amount of interaction between these actors. This frequent contact will increase alignment between actors and thus increase the potential of the innovation system (van de Poel, 2000). Well-functioning networks are anticipated to generate coordination and convergence between varying expectations (Mourik, 2006). In summary, Social networks can be considered to be "**Highly-Functioning**" when a broad range of actor types participate and alignment between actors increases (van der Laak, 2007).

Learning processes

For new technologies it is critical that good learning processes are in place. This means that learning should be broad; Not solely focusing on technological and financial optimization, but also on aligning technical with social considerations and impacts. A good learning process should also apply "elasticity" by examining the fundamental social values attributed to the technology, while applying that as a feedback loop for future technological design. If the learning process is properly executed, opportunities or barriers for the implementation of a particular new technology can be uncovered (Mourik, 2006).

Within the Learning process, two types of learning can be distinguished: **First-order learning** and **Second-order learning**. First-order learning encompasses learning and optimizing processes based on accumulation of information on various elements e.g. on the technical infrastructure, developments within the industry, impact on the environment and user practices (Hoogma, 2002). Second-order learning is when the learning process challenges the underlying assumptions about the technology e.g. social values and norms with regards to the technology. Important in second-order learning is the flexibility to reevaluate expectations and rebuild the social network (Mourik. 2006). The learning Process can only be regarded as being "**sufficient**" if it includes both first-order and second-order learning (Schot, 2008).

SNM feedback loop

The "Strategic Niche Management (SNM) feedback loop" as outlined in Raven (2006) is another complement to the SNM assessment. Experiments produce results, which in turn lead to learning. The sort of learning generated depends on the features of the network, this may be single or double loop learning. Learning also affects expectations' 'robustness', 'focus' and 'quality'. Learning leads to expectations changes that may align or misalign actors' expectations. These expectations can attract new actors as well, but they can also lead actors to leave the network. Through financing, actors in the network can also affect learning. Changes in expectations and in the network result in new experiment design and the loop goes on as shown in Figure 2.4.

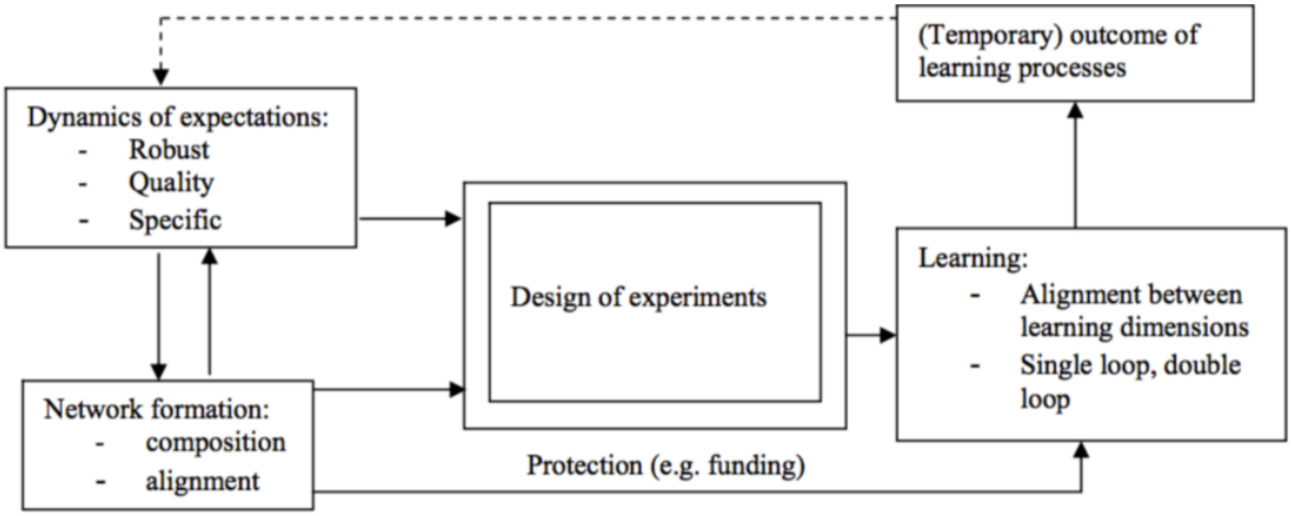

Figure 2.4: Feedback loop of SNM (Raven, 2005)

2.2.2 Why SNM?

The SNM perspective has both an instrumental and analytical side. It offers a handle for both technology providers - which they need when thinking about the introduction of a new technology; How to set up an experiment to take advantage of learning processes and how these learning processes can be used within an adaptive planning and decision-making strategy - as well as technology analysts who want to learn (innovation) processes to understand and evaluate technology domains.

SNM as a tool for Socio-Technical Transitions can be used determine to what extent experiments lead to learning processes (of a different nature) and to social embedding (investments, adjustments in the environment, follow-up projects); what the relationship is between the design of an experiment and what has been learned by different actors. This leads to understanding how to organize and use experiments as a basis for technology development and application. The focus of this micro-analysis will therefore be on the occurrence of learning processes on the part of the provider and users, and processes of networking and coordination.

The framework of SNM will contribute to understanding the difficulties that the implementation of rooftop Solar PV has faced when it was introduced. SNM is mostly used as a policy tool for the purpose of evaluating the existing policy and providing suggestions for the future policy making (Raven, 2005). Therefore, it is a desirable framework to provide insights into the nature of the obstacles that innovations - like Solar PV - face and help to develop methods to overcome these obstacles (Canils & Romijn, 2008). This fits well with the Research Question, which is aimed at mapping the barriers and providing a solution for a single country to overcome these barriers.

Chapter 3

Methodology

The methodology used to carry out the suggested research is outlined in this chapter. The first section the research objective is discussed in detail. This is followed by an explanation and expansion of the research questions (RQs). The last section explains the research design and methods used to collect and analyze the data.

3.1 Research Objective

As touched upon in the introduction, the overarching objective of this thesis is add to the body of research about SIDS in the face of the energy transition. SIDS face common barriers due to their geographical location and other factors, making them very vulnerable to climate change, but also hold back their progress. This same geographical location makes it so that they have great renewable energy potential, especially wind and solar energy.

Although transitions on islands have received attention from the academic research community, which has covered issues such as the RET policy (Weiser, 2004); energy supply (Zsigraiov et al., 2009); Techno-economic feasibility of RETs (Bueno & Carta, 2006). None of them have performed a comprehensive research specifically on managing the implementation of one specific niche technology to identify structural, and societal changes that need to be made for widespread adoption to take place. Jaramillo - Nieves and Del Ro (2010) state this very clearly:

1	The impact of society is scarcely studied; The public is frequently left out of the research.
2	There is a lack of a comprehensive assessment of the (social) impact of renewable energy technologies (RETs) on island sustainable development.

Since wicked issues do not have one approach that can be implemented on a broad scale, this research will be done by specifically looking at the way that the SIDS Curaçao has dealt with

the implementation of the renewable energy technology rooftop Solar PV, what its barriers are and how these can be overcome. Solar PV has a long history of exceeding expectations and making unforeseen advances (Drawdown, 2017). Yet, Solar PV is still a niche technology across the world and on the Island.

Research has shown that the extent to which user expectation is satisfied is one of the key factors of success of PV (Rai & Andrews, 2012). As social impact of Solar PV becomes increasingly present in the Socio-Technical landscape, studying the transition from a Niche technology becomes increasingly relevant as the technology is gaining worldwide popularity.

This thesis aims to discover the current trajectory of Curaçao's transition. As mentioned in the theoretical framework, transitions are major changes in the way social functions are fulfilled through socio-technical systems. Since the implementation of rooftop Solar PV has not been optimal, it will be useful to study how the technical transition has been handled to determine which aspects of the transition are lacking. This is important since technological transitions not only involve technological changes, but also changes in user practices, regulation, industrial networks, infrastructure and symbolic significance or culture.

Furthermore, this thesis aims to contribute to the exisiting body of emperical RET transitions research in SIDS, while contributing to a certain extent on RET transitions in general. In order to effectively address these points in this research, a Research Question (RQ) has been formulated, expanded to a set of Supporting Questions (SQs). In the following section, the RQ in addition to the SQs will be introduced and elaborated upon.

3.2 Research Questions

As explained in the previous section (3.1), the goal of this thesis is to explore the energy transition in Curaçao. For the energy transition to be successful, renewable energy has to be introduced successfully. For the energy transition to be successful, the country has to overcome the technical and social barriers that inhibit the successful introduction of rooftop Solar PV. The proposed thesis is interested on mapping these barriers and how the government of the country can overcome them. Therefore, the RQ of this thesis will be formulated as:

RQ	*"How can the government of Curaçao overcome the main obstacles of rooftop Solar PV for the technology to be successfully implemented?"*

A number of SQs support this research question. These SQs are intended to provide a clearer understanding of the underlying components that need to be understood in order to answer the RQ.

Firstly, as Curaçao has already taken actions to transition to a carbon neutral energy supply and has made plans for the future in order to continue to do so, the first SQ is aimed at mapping their current progress. The first supporting question is therefore formulated in the following way:

SQ 1	*"What has been the progress in decarbonization of the electricity?"*

The second supporting question is related to current electricity infrastructure on Curaçao, since this is the regime in which the solar PV niche resides. The second supporting question is therefore formulated as follows:

SQ 2	*"What does the current electricity infrastructure of Curaçao look like?"*

Thirdly, since Curaçao's local context for the implementation of rooftop solar PV has not yet been the subject of academic research, the third SQ aims to identify the social aspects to be considered. Social aspects, such as acceptance, has an impact on the success of the implementation of technologies. Thus, the third research question is as follows:

SQ 3	*"What are relevant aspects of the local (social) context to consider when designing rooftop Solar PV infrastructure on Curaçao?"*

In order to perform the SNM analysis, it is important to map the most relevant stakeholders with regards to the technology. Therefore, the fourth SQ is:

SQ 4	*"Who are the relevant actors that participate in the electricity sector (with respect to expectations and network building)?"*

Finally, the electricity supplier, government and media can have an influence on how rooftop Solar PV is perceived by potential adopters. Therefor it is important to study the wat that the technology can be stimulated by different parties. Hence the last SQ:

3.3 Research Design and Methods

In the research objective, it was explained that the purpose of the proposed thesis is to explore what the barriers have been for the SIDS Curaçao, related to the implementation of rooftop Solar PV and how it can overcome these barriers to take full advantage of the potential. To research this, mainly a micro-level of analysis will be used. As part of the micro-level analysis, a qualitative case study approach will be taken.

3.3.1 Case study

As aforementioned, a micro-research on a specific Caribbean SIDS case will add to broader the literature on SIDS. To investigate the development of Solar PV in SIDS, a single case study will be performed on Curaçao.

SQ 5	*"How can the implementation of rooftop Solar PV be stimulated in the (renewable) electricity infrastructure of Curaçao?"*

First, the most prominent results from the extensive existing literature will be collected to identify all significant socio-technical energy-related SNM experiments with rooftop solar PV in Curaçao.

Therefore, it is appropriate to adopt a qualitative approach, as Bauer and Gaskell (2015, p. 7) state that qualitative research is intended for "exploring the range of opinions, the different representations of the issue". Where in this case, various stakeholders will be interviewed to obtain their interpretation of the climate change issue and the role of rooftop Solar PV in this. Field data will be used as a primary source and a confirmation of the literature.

Case studies are often found to be one of the applicable research methods in answering exploratory 'how' questions (Yin, 2009). Since it is intended to "cover contextual conditions and not just the phenomenon of study" (Yin, 1993, p. xi), a case study is fitting. In this thesis, the phenomenon of study is socio-technical transitions. The context in which this phenomenon is applied is that of the pursuit of Solar PV in Curaçao.

However, qualitative research is limited by the fact that it is often the victim of the question: "How do I know that you know (what you are claiming)?" (Gioia et al., 2012), which can lead to scientific skepticism. Additionally, in performing case studies, the generalizability of the study is often put into question (Jensen & Rodgers, 2001).

3.3.2 Case Selection

Sampling in case studies is mostly strategic and purposive, taking into account the unique context of a case (Miles, Huberman, & Saldana, 2014). As this thesis is focused on the case in Curaçao, while also being directed at Caribbean SIDS, a strategic and purposive sampling method is applicable. The benefits of this purposive sampling should be noted, since it allows the selection of a case containing a feature or process of interest, according to (Silverman, 2010). This case is applicable as it is part of the Caribbean SIDS, yet has its own unique characteristics, just like every Caribbean SIDS has.

3.3.3 Data collection

For this thesis, data will be collected from multiple sources. Field research will be performed in the form of conducting interviews with actors participating in the electricity regime. This micro-level of analysis will focus on all relevant stakeholders in Curaçao.

A mix of scientific literature, web resources and media articles will be used to aggregate the gathered data. In this regard, the literature review and will be paramount in understanding the theoretical frameworks and the technology. Web resources - such as corporate websites, public records or demonstration projects - will be used. Finally, media and government articles will be

referred to in order to reveal important milestones - such as new project developments, technological breakthroughs - and insights on network actors - for instance public statements hinted to actors' expectations, their objectives, creation or dissolution of partnerships or collaborations.

3.3.4 Interviews

As mentioned in section 2, a combination of SNM and MLP will be applied in this study. By combing these two theories, the development of rooftop Solar PV will be derived. The barriers that Solar PV currently encounters will be identified, not only on the three internal niche processes, but also on the regime and landscape levels.

Bauer and Gaskell (2014) state that the selection of interview respondents should be done with the relevant 'social milieus' in mind. Through in-depth interviews with all-important stakeholders (social milieus) involved with rooftop Solar PV-related activities, the key concepts used in SNM will be gathered. Stakeholders include local people who are knowledgeable about the electricity regime, primarily officials from Solar PV technology suppliers, the national government, academics, entrepreneurs, local companies, home owners and other important stakeholders. From the stakeholders I will make a selection of the most prominent actors within the context of solar PV to have in-depth interviews with. Actors that are closely involved with the development, implementation and end-use applications for PV.

Each of the stakeholders will be analyzed within the framework of the three key SNM niche-formation processes: actor network activities, people's learning processes, and the dynamics of their expectations. Also, interviews that are conducted by different instances will serve as a check between the consistency of the found literature and field observations. As is explained in chapter 2, van Laak et al's conditions for high-quality expectation, building social networks and a good learning process, will also be analyzed. Finally, there will be a discussion about the findings from the literature and interviews, structured according to the different actors within the different stakeholder groups.

Firstly, personal connections with individuals will be used to contact relevant 'social milieus'. Additionally, through publicly available contact information potential interviewees will be contacted by email. These interviewees can subsequently act as 'informants' (Yin, 2003, p. 90) to provide additional contact information to approach new interview candidates.

The interviews will maintain a semi-structured form. Semi-structured interviews ensures "detail, depth, and an insider's perspective" (Leech, 2006, p. 665). Additionally, semi-structured interviews are "the heart" of qualitative research, according to Gioia, et al. (2012, p. 19), through which, both retrospective and real-time accounts, can be gathered (Gioia et al., 2012).

Before to the interviews, a topic guide will be created. The use of a topic guide is beneficial because it provides an "easy and comfortable framework for discussion" that helps to structure the interview so that it progresses well (Bauer & Gaskell, 2014, p. 6). The interviews will begin with "broad and orienting questions", after which, more "detailed and specific questions" related to the 3 pillars of the SNM framework (Rubin & Rubin, 2012).

3.3.5 Research Ethics

Within qualitative research, it is pivotal to apply diplomacy and discretion (Gioia et al., 2012). Before each interview begins, the respondent will be asked for consent to record the interviews and their decision will be respected. Furthermore, all interviewees will be asked after the interview if they would like to receive a transcription of the interview. Additionally, each respondent will be asked if it's okay for their name to be used while quoting their statements in the thesis.

Chapter 4

Socio-Technical Overview of PV Innovation System

Based on the theoretical framework presented in chapter 2, this chapter presents the macro level of analysis for the in-depth case study of Curaçao. For this chapter, the frameworks discussed will be applied, upon which the micro-level of analysis (SNM) will be based. As is discussed in the research methodology, there is a lack of data for Caribbean SIDS. Therefore, the depth and the breadth of the primary and secondary data collected for the purposes of this case provide a unique insight into the hurdles, challenges and opportunities of this SIDS.

Rooftop Solar PV is a niche renewable energy solution for harvesting the sun's energy. The technology is particularly suitable for tropical island states, such as the SIDS Curaçao, located in the 'Dutch Caribbean'. It is specifically the PV technology in Curaçao that is of focus in the data collection. However, in accordance with the proposed framework, the case study also covers broad socio-economic situation of the island and describes the socio-technical landscape and regimes. It draws upon the experience from past technology (science) related projects on the island and uses the insights of government officials and other professionals with experience from a variety of fields as well as other islands (see section xx for more details on the data sources).

Sections 4.1 - 4.3 present the analysis of Curaçao relevant to the establishment of PV activities on the island. The analysis is based on the theoretical framework and therefore features analyzes of three 'levels' - the *socio-technical landscape*, *the socio-technical regime* and *the socio-technical Niche* - which is in detail scrutinized at a micro level of analysis using the SNM framework in Chapter 5. This is followed by Chapter 6 that gives the recommendations, the limitations and the roadmap for widespread adoption of Solar PV on Curaçao.

4.1 Socio-Technical Landscape of Curaçao

This section is aimed at laying out an overview of characteristics of the island that ultimately have an influence on the development of renewable energy supply, specifically on solar PV. This overview is divided into four main areas that have had precedence in the analysis of the qualitative research and that have come forth through the literature review. These five areas are: general overview, political-, societal-, educational-, and economic aspects. After a general overview of these four areas are put forth, the main landscape shifts are categorized as being either destabilizing or stabilizing Landscape pressures on the existing energy regime. As stated in the literature review, destabilizing pressures create openings for Solar PV and stabilizing pressures created stability for the incumbent regime.

4.1.1 General Overview of the Landscape

Curaçao is an island in the southern Caribbean Sea, 65 km off the coast of Venezuela. The island has an area of 444 (m^2 and a population of around 160.000 inhabitants (CBS, 2019). Curaçao has for the most part a tropical semi-arid steppe climate (BSh) (Koppen climate classification, 2018). The temperatures are relatively constant, the annual average temperature is 31.2 degrees Celsius during the day and 25.6 degrees Celsius at night. The island has approximately 6 daily average solar hours, which is among the highest in the world. As a comparison, the Netherlands has about 2.5 daily average solar hours. Additionally, it lies on the border of the hurricane belt, thus tropical storms or hurricanes rarely reach Curaçao.

Curaçao profits from its favourable position between Americas, has a well-developed harbor (It is said that this is the largest natural harbor in the world) and international airport. The island also has multiple 'Free Zones' and a multi-lingual and multicultural society. For a long time, Dutch was the only official language, but since 2007 Papiamento, Dutch and English have become jointly official languages. In addition to these languages, Spanish is also spoken. Curaçao's education system is mainly based on that of the Netherlands. The currency of Curaçao is Antillean Guilder (ANG) (US$1 = ANG1.79). Curaçao received an overall rating of "Partially compliant" with the international standard of exchange of information on request (EOIR) for the transparency of its entities and its EOI practice" over the period 1 January 2014 until 30 June 2016 by the Organization for Economic Cooperation and Development (OECD) (OECD, 2017).

Until 2010 it was an island territory and the largest island of the Netherlands Antilles. On October 10th 2010 ('10/10/10'), the Netherlands Antilles was dissolved and Curaçao became a constituent country within the Kingdom of the Netherlands (Government of the Netherlands, 2013). As an independent country within the Kingdom, Curaçao became responsible for its own government and legislation, while the Netherlands still supervises the finances (under a debt relief (of 1.7 bln euros) agreement) and remains responsible for defense and foreign affairs. Given the Dutch responsibility for the protection of the islands of the democratic constitutional state and the universal rights of the islands, this cooperation has resulted in 5 'Consensus Kingdom Acts' to which Curaçao has to comply (for example, there is a limit to how much money can be loaned, based of the GDP) (Overheid, 2010; Dutch Caribbean Legal Portal, 2010).

4.1.2 Political and Legislation Developments

Despite Curaçao's separate status since '10/10/10', the bond with the Netherlands is still strong. This is evident from the direct inauguration report of His Majesty King Willem-Alexander of the Netherlands (NOS, 2013). In contrast to the Netherlands, the island is not part of the territory of the European Union and therefore Curaçao does not have to comply with European law or to introduce the euro as legal tender. Due to the distinctive relationship with the Netherlands, the country gets a so-called "Overseas Countries and Territories" (OCT) status within the EU, making Curaçao eligible for European funds and EU-wide cooperation agreements such as the Erasmus+ program. Furthermore, the residents of Curaçao possess European citizenship as well as Dutch nationality (Europees Parlement, 2010). Due to this relationship, the Dutch judicial system garners a level of transparency and trust for foreign companies. Companies can appeal to the Dutch Supreme Court in the Hague, which warrants a level of security that is often lacking in SIDS. This, to some extent, can eliminate the doubt that foreign companies have to establish in the region and therefore attracts them to Curaçao, as opposed to elsewhere in the region.

When focusing on barriers, in the textual data, the second order 'lengthy bureaucratic procedure' has been quoted numerous times, especially in the context of receiving any types of permits, which can take anywhere from weeks up to months. Interviewees often refer to the 'red tape' (Interviewee #2, Energy Consultant; Interviewee #3, Energy Consultant) and that the island is infamously correlated to this slow process of decision making (Interviewee #3, Energy Consultant; Interviewee #11, Curaçao Resident). This is a hurdle for doing any type of business on the island, which is also true for the installation process of solar panels that can take up to three months (more on this in section 4.2):

"I once had a foreigner visit me here and we talked about projects and so on and I told him that a project was almost finalized, but certain decisions still had to be made that such a project could be started, but that it was taking very long. He said to me 'It went into the Curaçao mode'. It is well known here that we have a large red tape to do business with the government. That man who comes here and wants to start a business, you have to go to so many agencies to get what you need. There are those 'one window, one portal -policies made' - that you have a window, you go to it and then you can arrange everything - they say. But apparently things are not going so smoothly." (Interviewee #3, Energy Consultant)

Throughout the literature on Small Islands Developing States (SIDS) it becomes clear that have similar attributes when it comes to their size, geographic isolation and cultural tradition, that can hamper long-term development and anti-corruption efforts. Thus, despite some SIDS having relatively well developed legal and policy frameworks, corruption can be a major challenge for SIDS and can manifest itself through various forms of bureaucratic, administrative and political corruption This appears to be no different on Curaçao. The general issues with corruption have been brought up numerous times during interviews (Interviewee #6, Professor at UoC; Interviewee #1, Program Manager at Aqualectra). Though there is a lack of official evidence or reporting on this matter, making it hard to support any of the claims, there seems to be this narrative among the general public. One indicator to its truth could be the recent arrest of the first prime minister after '10/10/10' Gerrit Schotte. On the 27th of November

2018, convictions against Schotte for illegally obtained money became final. Schotte is currently in jail, serving out his (three year) sentence. Furthermore, a research conducted by the anti-corruption group 'Transparancy International' (2013), concluded that there is a general lack of Trust in Curaçao's key institutions.

Interviewees have noted that there is a general lack of policy enforcement and guarantee towards citizens. Interviewees express the fact that not only on Curaçao, but on neighboring islands also, there is a lack of continuity in policy. When the government changes, all of their political implementations can go out the window with them:

"There must be some policy and there must be some publicity. That if you say something (as a government) that people also know: 'I am investing in this and this will be stable for the next five or ten years.' You can just plan for it, otherwise you can't plan for it - you tell me something and after 2 years you suddenly unilaterally break the deal." (Interviewee #2, Energy Consultant

"The government is unreliable, in the sense of, if we agree on something you should not come and change unilaterally in the middle and suddenly - because then you are unreliable. Because we have an agreement, based on that agreement I do something, and then suddenly you break it and you decide, I can't say anything else about it - people get angry." (Interviewee #2, Energy Consultant)

Also prevalent in the interviews was the notion that there are not enough skilled workers on the island, which has two effects. On the one hand, the skilled workers get too much work assigned to them, which leads to the work not properly getting done (Interviewee #1, Program Manager at Aqualectra; Interviewee #6, Professor at UoC). On the other hand, inadequate people get certain positions, which leads to lackluster execution:

"The point is, after all, the person who was a maintenance manager at the time was someone who climbed from LTS to manager position, so he doesn't know much about chemistry. Then he gets a paper on his desk and he doesn't know what to do with it. He wasn't stupid, he was a very intelligent man, but he just didn't have a chemical background." (Interviewee #5, Energy Entrepreneur)

This has several causes, including 'Brain drain', but one factor that also has massive impact is the so called '80-20' law put in place in 2016 (Amigoe, 2016). This law aims to ensure that no more than twenty percent of employees in a company are immigrants (VanEps Kunneman VanDoorne, 2017). To combat the lack of expertise, the Ministry of Social Development, Labor and Welfare allows for exceptions for employment of foreign experts. However, the '80-20' rule is regarded by many as a regulation that causes economic imbalance as some insufficiently skilled locals could be chosen for employment over foreign employees (Amigoe, 2012). With the corruption and the general smallness of the island also comes a level favoritism (Knipselkrant, 2014), in which undeserving or inadequate people get put in certain positions due to their political past or affiliations, leading to lackluster results or obstruction of innovation. Next to

news articles, this is something that has come up in several interviews (Interviewee #6, Professor at UoC; Interviewee #3, Energy Consultant), for which the majority of interviewees have asked to remain anonymous.

As aforementioned, another barrier that is present on the island - and is characteristic for Carribbean Islands (Groot, Renske, & Villaseca, 2014) - is that of 'Brain Drain'. This is the phenomenon in which young adults that have obtained their high school diploma go study abroad, but don't return after graduating. 'Brain Drain' has been a very powerful impediment to the economic development of Curaçao for a long time. Approximately 300-400 young adults (17-20 years of age) leave Curaçao annually to study overseas (primarily in the Netherlands). While it is very important that they receive higher education, the issue comes in when only about 5% of them return to the island after graduating (United Nations Development Program, 2011; Groot, Renske, & Villaseca, 2014)). By implementing numerous policies such as encouraging a Transnational Education (TNE) program that supports international universities in offering education on the island (Groot, Renske, & Villaseca, 2014), the government is trying to reverse the trend. Another stimulus for preferential employment of local employees is the '80-20' law introduced above. These initiatives have to this point still been relatively unsuccessful. This, yet again, enhances the lack of expertise. This leads to a handful of experts getting too much work on their plate:

"We are simply overburdened here in terms of work, so we simply cannot do many things that are expected of us because we just cannot get around to doing that." (Interviewee #6, Professor at UoC)

National Development Plan

Curaçao has a National Development Plan, for the period 2015 to 2030. The plan will be implemented with the help of the United Nations Development Program (UNDP). The reason for the cooperation is the adjustment of the national goals of Curaçao on the international agenda for the year 2030, which includes the goals for global sustainable development, the so-called Sustainable Development Goals (SDGs). The purpose of this plan is to help guide sustainable long-term developments while working on the implementation of short-term priorities. Five themes have been identified in the plan that will be given priority in the coming years. These are: education, economy, environment, national identity and good governance.

Curaçao is one of the first countries in the region with a National Development Plan. It is the first country with a plan linked to the Sustainable Development Goals (SDGs) that the United Nations has recently ratified, which should make the goals measurable. In the field of the environment, a few projects are already underway, such as increasing the capacity of sustainable energy by, for example, expanding the Aqualectra wind farm. The sustainable energy policy has also been finalized so that Curaçao can claim funds from the European Union.

National Energy Policy

In 2017 Curaçao published a comprehensive document that contains an overview of the energy vision of the Government of Curaçao. As mentioned by the Co-author, interviewee #14 (Energy

Advisor), there had been a need for an energy policy for years. Previously the government had to give each company individual permissions, hence leading to a lack of collective vision.

"At one point, what you saw is that everyone had been in need of an energy policy for years. But because there was no energy policy, companies started to put things on paper themselves, then deposited them with the government and the government had to give individual permission for this. But everyone went their own way."(Interviewee #14, Energy Advisor)

The document was co-funded by the European Union, through the provision of technical assistance to the Government of Curaçao for the programming of the 11th European Development Fund (EDF). Next to Solar PV, Many other sources of renewable energy are also being stimulated (National Energy Policy for Curaçao, 2017).

"There has been considerable coordination between all stakeholders and the stakeholders are all now happy that there is an energy policy. I almost want to say that almost everyone is very happy with what lies there and that means that it is also being followed. Before it was approved by the government, you saw that companies started to behave accordingly. The direction is clear, everyone has been able to give their input. This has had a considerable influence on the energy sector." (Interviewee #14, Energy Advisor)

More details on the specific goals in the regime analysis (Section 4.2).

4.1.3 Mentality towards Climate Change

Consumer-citizens are an essential component of the societal communication of sustainability, and a commonplace argument in both large companies and governmental responses begs the role of active consumers. By consumers not caring or being aware of climate issues and hence not placing pressure on the utility, strengthened by the fact that the utility company is a monopoly, they have less incentive to (quickly) move to a climate neutral energy supply.

When focusing on barriers, in the textual data, the second order code 'nobody thinks about green' has been quoted numerous times. From an interview with Aqualectra, the Technical Director stated:

"Regarding your question about paying more for green; we have done a survey about this in the past and the green mindset is not yet alive on the island. Certainly not if they have to pay more. Our society still does not think about paying more and getting less. People are open to green and would even like to get more of it, but do not yet want to pay extra for it. That is why green is currently done by Aqualectra on its own initiative." (Hanst)

Through the first order codes and a focus group discussion surrounding this issue, different reasons have been assigned to this acknowledgement. It does not just seem to be a lack of awareness, but also a lack of care for the environment, for several reasons, including 'lack of education', 'Different ascriptions of responsibility', 'scale' and 'issue salience'.

Firstly, through interviews and a focus group session (See Appendix for an in-depth analysis of the focus group discussion) there is a consensus that there is a lack of sustainability topics in formal education. This type of education, on environmental subjects is almost completely left in the hands of Non-Governmental Organizations (NGOs).

"I have to admit that on Curaçao I hardly ever heard anything about Climate Change or about environmental conservation. Only when I started studying in the Netherlands did I become more aware of it."

Secondly, there are different ascriptions of responsibility. In the focus group session the power of the consumer-citizen was questioned with the suggestion that environmental issues should be embedded within financial and practical decision making by the government:

"The government should promote a better trash pick-up system, due to the fact that the landfill is very far off and closed a lot of the times and every kind of waste gets put onto one pile, so recycling at home is of no use."

This aligns with what I have gathered while conducting interviews on the island. It seems to be normalized that consumers take the most convenient route in disposing of their waste, due to the lackluster infrastructure on the island:

"You just have to start a campaign now. Maybe the government says, I don't have the money for it, but you just have to start a campaign. People just throw trash in the woods and then I wonder why in the woods? i think if someone has to drive all the way from one end of the island, to the other, then it will take him at least an hour, which also costs fuel. That does not take into account the time it takes to load and unload. The woods are close by and nobody cares or sees you, so why not just dump it there? Easy. Some woods have now just become a garbage dump and are often on fire."

Such an obvious external ascription of responsibility also shows that the grandness of climate change removes the feeling that individuals have the power to align their habits as citizen-consumers with actions needed to tackle climate change.

The literature on this, talks about different ascriptions of responsibility and differing opinions on whose role it is to advocate environmental practices. One main component of the role that citizen-consumers should take on is environmental responsibility (Johnson, 2008) and showing accountability towards fellow citizens. This argument laid forth by Johnson (2008) has its roots in the bigger debate of acceptance of collective rights and responsibilities in communities (Giddens, 1991; Etzioni, 1993, 1995). This has even led to environmental campaigns on the island, most notably in the form of a song in which people were promoted to make fun of others and call them a pig if they see them throw plastic waste on the ground. Yet, in-line with my findings from interviews, it seems that despite this active attempt to reform the role of inhabitants into consumer-citizens, research on issues like climate change shows that citizens still refuse to take responsibility to some issues (Whitmarsh, 2009).

"I happened to be raised in the Netherlands as a child. I did high school on Curaçao, but grew up in the Netherlands as a child. You just don't throw stuff on the ground in the Netherlands. And if you do, some old lady walking behind you would immediately tell you: 'Could you pick that up, young man'. That's how people deal with things like that. That's how people deal with nature, with the environment and so on. On Curaçao it is: We drive around in large containers; burn money on fuel. Gigantic boats, there are people who go out on the boat on a Sunday; that's just 400 or 500 guilders in fuel. We grew up less consciously on Curaçao."

"I suspect that people who come from Europe - say the Dutch - in the Netherlands deal with the environment much more than we do here. If I go outside later and I want to throw my cup on the floor, no problem, nobody will look at it or think about it. That means that you naturally look at things like this differently"

In line with research on the psychology of denial, my thesis interviews show that individuals tend to deflect responsibility for global climate change to external actors, thus shifting the blame away from themselves Lorenzoni et al. (2007, p. 452). This is in line with conducted interviews:

"I think it's not that people don't think about nature. Take as an example if you walk in the city and you have a bottle of coke in your hand and it has just run out. First of all you have to walk 10 minutes before you walk past the first trash bin and when you arrive there it is also packed and you also see a lot of waste around it. If you are 3 trash cans further, and you still couldn't throw your bottle away, you get annoyed and think, what will it hurt if I put one extra bottle next to the bin."

A **third** aspect of responsibility is also attributed to the power of citizen- consumers in which the participants suggest that there is also a survival aspect that comes into play, when consumers don't have sufficient financial means, that trumps the need for climate actions:

"If I have to fight to survive everyday and have to struggle to feed my kids, then the environment is the last thing on my mind."

This is in line with the research on this issue, that caring about the environment is directly linked with the financial situation of an individual. Yet, the results on this seems to indicate that a environment awareness arises when the GDP of a country reaches a threshold of about $5000, - (Everett et al., 2010), which Curaçao surpasses at approx. $22.000, -. The GDP can grant a skewed picture of reality, since an issue faced by Curaçao is the general income inequality within society. 33% of the population was living on or below the poverty line in 2008. This contributes to a number of societal problems, including violent crime in some neighborhoods and the fact that Curaçao is recognized as a drug passage from South America to Europe and North America (Foreign & Commonwealth Office, 2011).

The **fourth** and last aspect is that of scale. The previous aspect touched upon responsibility and as Barr et al. (2011) states, another aspect about the conversation regarding environmental issues is the subject of scale. Through interviews, a recurring theme was that inhabitants of

Curaçao use their definition of scale to challenge the impact that citizen-consumer action can make. This is in line with literature in which it is concluded that citizen-consumers have used their definition of scale to deny or challenge the basis for citizen consumer action (Stoll-Kleemann et al., 2001). This has proven especially true in the context of a Small Island Developing State, like Curaçao, in which people tend to feel that the impact that they can make is very limited compared to other bigger nations.

"We are SO small, I mean it makes no sense. It makes no sense to do it for the environment. Environment this and Carbon footprint and this, leave that up to the big boys, that does not play any role with us."

Curaçao inhabitants seems to suffer from typical island characteristics, including island mentality and other island specific barriers that are limiting to development (United Nations, 2012). As Lorenzoni and Pidgeon (2006) and Leiserowitz (2005) have noted, "global climate change represents distance in both spatial and temporal contexts". Indeed, Lorenzoni et al. (2007) highlight, the impacts of climate change are often polarized in literal terms - reflecting for example on the melting ice caps in Antarctica or natural disasters in developing nations.

Curaçao and sustainability

A study undertaken by "the Curacao Business Council for Sustainable Development" (BPM) in 2011 showcased that nearly all of the 26 businesses surveyed "intend to (further) invest in sustainability in the near future", but that businesses are usually unaware of wider sustainability consequences with regard to social and economic elements (BPM, 2011, p.17). Although some progress has been made since then, it still seems that Curacao has not yet passed the phase where green initiatives or industrial certificates such as green labels would attract businesses (i.e. their clients as well). From an interview with the biggest solar panel retailer (Dynaf Group), it became clear that it is mainly international companies (e.g. Corendon) or companies in the tourism branch, that care about green marketing, due to their international audience and the upcoming ecotourism branch (Wearing & Neil, 2009).

Curaçao is among the top most polluting countries in the world. After Qatar, Curaçao is the second when it comes to CO2 emissions per capita (Ket World Energy Statistics, 2018). The Central Bureau of Statistics Curaçao (2018) sets the ecological footprint of the island at 26.4 tonnes of greenhouse gases per capita. For comparison: for an average country in Europe that is 6.7 tonnes. This is mainly due to the combination of Curaçao's low population and having an old refinery on the island. The refinery in Curaçao is still 'flaring' - burning natural gases that are released during oil refining - which is prohibited in Europe because of the air pollution that this causes. The gases consist for the most part of methane (CH4), which causes much more damage than CO2 as it has a 25-fold effect on the greenhouse effect. Gases such as sulfur dioxide do not contribute to this, but do have an influence on the air quality and thus cause various health problems (Chen et al., 2007). The World Health Organization (WHO) prescribes an average of 20 micrograms per cubic meter of sulfur dioxide in the air (World Health organization, 2018). Daily air measurements indicate that this average is twice as high in the areas closest to the refinery (e.g. Beth Haim).

The implications of the Refinery's lengthy history and the related pollution have important impacts on the mentality of locals.

"A large part of the inhabitants of Curaçao has some kind of a connection to the refinery or get their income directly or indirectly from it. This makes it that they show resistance to the notion of shutting it down and replacing it" (Interviewee #3, Energy Consultant).

The most common argument against closure is the loss of employment. Everyone has an uncle, brother, brother-in-law or friend who works or has worked at the refinery, making the ISLA appear to be 'stuck' on Curaçao. Many islanders, including those that live in close proximity to smoke, do not ask for the refinery to stop but only for cleaner air. On the 31st of December 2019 (this year) the contract of the Venezuelan state oil company, Petrleos de Venezuela (PdVSA), which currently leases the refinery, will end. For environmental organizations this seems like the ideal moment to finally take action, but the island government puts the future of the ISLA first (see (4.1.4).

4.1.4 Economic Developments

Despite a small GDP growth during the last decade, the island enjoys a high GDP per capita (US$ 20,000) and a well-developed infrastructure, when compared to other countries in the region (CIA, 2018). Curaçao has an excellent port that can receive large oil tankers. PDVSA, Venezuela's state-owned company, operates the island's only oil refinery (ISLA) under a rental regime established by the local government. Most oil is imported from Venezuela, and refining products are exported to the United States (CIA, 2018). The main activities of the small economy of Curaçao, which is very dependent on imports, are tourism, oil refining and the international financial sector. The top five employment sectors on the island are: trade (16%), healthcare (10%), catering industry (8%), public administration (8%), Financial services (8%) (Hermans & Koster, 2019). The largest employer on the island is the local ISLA refinery, employing about 2000 people directly and another approximately 2000 indirect contractors (CIA World Factbook, 2017).

Unemployment has increased every year in the last four years (2014, 2015, 2016 and 2017). In 2017, the Central Bureau of Statistics (CBS) set an unemployment rate of 14.1% percent (Curaçao Bureau of Statistics, 2012). Research shows that most people looking for work are looking for a job in the tourist industry (accommodation and restaurants), wholesale and retail, motor vehicle repair and construction. Half of the people looking for work indicate that they do want to work but cannot find work. One thirds of the people have been dismissed or had not gotten a contract extension. The reason they give for their unemployment, according to 34.6% of the respondents is that the economy is not doing well. 17.7% also think the requirements for the work are too high (lack of expertise).

Regarding the economy of Curaçao, a consistent deficit has been recorded on its balance of payments, attributed to the fact that the import of goods and services continually exceeds the exports (Centrale Bank van Curaçao en Sint Maarten, 2018b).

Curaçao has been dealing with financial problems for years due to a lack of economic growth and an inefficient government apparatus (IMF, 2019). The College financieel toezicht' (Cft), which monitors the budgetary policy of the islands, has 'serious concerns' about the financial and economic situation that exists on the island (Cft, 2018), because Curaçao is heading for a budget deficit for the third year in a row. If the Curaçao cabinet does not improve public finances, the Netherlands can impose a designation, due to the new constitutional relations from 2010. Curaçao already received a designation once in 2012, when the government of the country was led by former Prime Minister Gerrit Schotte, who was finally sentenced to a three-year prison sentence for corruption and money laundering last year (2018). Authorities previously warned that a designation could further harm the already weak Curaçao economy, which has shrank by 3.5% two years in a row (IMF, 2019). On the 14th of June 2019 the Kingdom Council of Ministers, in which the Kingdom Government meets, formally postponed a decision on giving a 'designation' by three weeks. After the meeting, State Secretary Raymond Knops (Kingdom Relations, CDA) announced that the Netherlands would like to help Curaçao to solve its financial problems more. This makes a punitive measure a step further away.

Curaçao acknowledges that the budget has not been in order for too long, but says it is already working on austerity measures and states that the crisis in Venezuela has a major impact on the Curaçao economy and public finances (Antilliaans Dagblad, 2019). Curaçao has to deal with an influx of Venezuelan migrants, and the oil production in the refinery Isla, in the hands of Venezuela, has almost come to a standstill. Although the decision to invoke this article was also postponed on Friday, Knops acknowledged that Venezuela "really has its impact" on Curaçao's economy and society (Amigoe, 2019).

This is also prevalent in the second order codes from the interviews. Most of the interviewees mention the Venezuela affairs, without me asking for it, which shows that it is on the top of their agenda. The interviewees expressed concerns about the situation and that it has already greatly affected the island as a whole and their own pockets (Interviewee #5, Energy Entrepreneur; Interviewee #10, Private Adopter). This shows concerns that they fear that it will only become worse in the near future.

ISLA situation

Oil was found in Venezuela at the beginning of the 20th century. Shell benefited from this because Curaçao is a short distance away (approx. 80 kilometers). It built a refinery on the island during the First World War that was opened in 1918. In the 1950s, the refinery offered work to around 10,000 people. Shell decided to withdraw and the license was taken over in 1985 by Petrleos de Venezuela (PDVSA). This license runs until December 2019. The future of the refinery remains unclear beyond this date. On the one hand, many residents and environmental activists see this as an opportunity to close down the heavily polluting refinery in the middle of the city. However, since the refinery accounts for almost 10% of the island's GDP, its closure would have a significant economic impact (Ellsworth, 2012).

An interesting episode in the history of Curaçao occurred in on the 30th of May ("Trinta di Mei") 1969. This was the date on which employees of the Shell Oil refinery in Curaçao violently went on strike. Reportedly, two people were killed, and dozens injured. This event was an

important turning point in the political, cultural and socio-economic relations on the island. In Curaçao, the economy went downhill in the 1960s. The rising prices were not sufficiently compensated by rising wages, which reduced the purchasing power of the population. The striking employees and the management of Werkspoor Caribbean N.V., known as "Wescar" (Amigoe, 1969), responsible for the development of the collective labor agreements. reached an agreement in principle on the evening before May 30, 1969 (Amigoe, 1969).

Much like in 1969 there is a growing concern about ISLA situation, which was very present throughout all of my interviews. Almost every interview and conversation on the street ended up on the ISLA situation. Inhabitants are concerned. It is not only the Venezuela situation, but also the fact that the contract is ending and there are not alternatives.

"You may reach the end of 2019 and you still have no partner, not even in PdVSA" (Prime minister Rhuggenaath, 2019)

In addition, Venezuelan trade unionist Heberto Ferrer indicates that a possible new manager of the refinery cannot count on crude oil from Venezuela (Amigoe, 2019). Dissatisfaction and concern is growing among the refinery employees and they show it: there have been strikes and the strikers have shut down roads and have burned car tires, etcetera (Amigoe, 2019). In line with this, an interviewee has expressed to have had personal experience with strikers that work at the ISLA refinery:

"Two years ago there was a strike at the refinery. I experienced them at the company I work at (UTS). I had to do the contract extension because they were about to leave us. I had drafted a new contract and they came to the door of UTS with 400 people. When I got there I thought; nothing should go wrong today, because these are the guys who don't talk, but act." (Interviewee #10, Private Adopter)

With only seven months left to find a new investor for the refinery (from July to December), the scenario of a Curaçao without a refinery is becoming increasingly realistic. The government is still trying to save everything at the refinery. In the meantime, PdVSA can guarantee the salaries of employees until July 2019. According to the Minister of Finance, around 4000 people depend on the Isla for their income. The Curaçao Port Authority CPA and the Curaçao Towing Company KTK and the Curaçao Refinery Utilities (CRU) plant will also be hit hard by a closure.

"Given our economic situation, years of economic stagnation and social decline, we will get a social situation after closure that I would rather avoid" (Prime minister Rugghenaath, 2019)

4.1.5 Summary: Landscape stabilizing and destabilizing influences

A number of major trends at landscape level influence the scope for developing a Solar PV-based energy supply system on Curaçao. Worldwide trends as well as major Curaçao- specific factors previously described play a role.

There is a lengthy history of oil refining, a general lack of environmental awareness among society members, and nearly a third of the population is living on the poverty line. However, Curaçao benefits from the Dutch-based judicial system and that there is an excellent intellectual potential of young talents, which are still leaving Curaçao for absence of possibilities at the current juncture. Despite these advantages, some structural weaknesses in Curaçao policy making capacity limit the emergence of a Solar rooftop PV-based energy system. The National Energy policy (adopted in 2017) does bring a collective vision, and has specific goals for Solar PV, but these are mainly aimed at a utility scale 'solar farm' (MW) level.

Landscape Stabilizing Pressures

Among Curaçao specific landscape factors, Curaçao's level of development is relatively good as compared to other SIDS. Based on the HDI of 0.801, Curaçao can be considered to have a high welfare development (CBS, 2014). However, 33% of the inhabitants, lived on or below the poverty line in 2008. This indicates that there is wealth inequality, leading to a shortage of buying power on a big portion of the island. This is creates a barrier for Solar PV adoption due to the high investment cost that comes paired with the technology.

This wealth inequality, in addition to a lack of education also leads to a lack of environmental awareness. This creates a stabilizing pressure on the Utilities, because consumers want the cheapest possible power, since 'energy is energy':

"I say no to myself, it should not cost me anything, if it is more expensive than Aqualectra, then I go to Aqualectra. If you say: 'listen, I am environmentally conscious and it may cost a little', okay, I say to myself: 'I look at myself and electricity remains electricity'." (Interviewee #2, Energy Consultant)

This lack of awareness leads to a lack of pressure on Utilities and the government to make green investments, which the Utility even admits (Hanst, 2018). Consumer-citizens are an essential component of the societal communication of sustainability, and a commonplace argument in both large companies and governmental responses begs the role of active consumers. By consumers not caring or being aware of climate issues and hence not placing pressure on the utility, strengthened by the fact that the utility company is a monopoly, they have less incentive to (quickly) move to a climate neutral energy supply.

This is further enhanced by the recent economic issues that the island is facing. The economy has been shrinking for the past three years and this is worsened by the recent developments in Venezuela. This situation has even caused companies to be reluctant in hiring new employees, leaving more people jobless. The unclear economic future cause people to be reluctant in making long-term investments needed for technologies like Rooftop Solar PV, with a payback period of 7-8 years.

The recent government initiatives, including the 'National Energy Policy 2017' and the 'National Development Plan 2015 - 2030', are good in principle, but the there seems to be a history of bad policy enforcement leading to lackluster implementation. Furthermore, governance standards will require improvement for these initiatives to work effectively. Solar PV

owners interviewed for this research consistently reported to have had issues in their dealings with the government. Most noted that it is important to have an understanding of the specific way that the government operates on Curaçao, as an expectation management in order avoid disappointment.

What brings potentially aggravating administrative inconvenience is the '80-20' rule - while exemptions are possible, it could potentially pose threats to highly specialized industries, such as Renewable Energy implementation (including Solar PV). The lengthy bureaucratic procedures as well as a lack of stable government - meaning that radical policy/tarrif changes can occur on a short term - can impose a barrier for Solar PV adoption. Additionally, even though there is a lack of evidence that there is corruption on the island, there are strong indications for it. Due to this, the people in power want to keep the current establishments and tend to hold back innovations. These are all examples of stabilizing pressure on the regime.

Landscape Destabilizing Pressures

Policies to boost renewable energy implementation have proliferated worldwide in recent years. By 2017, 150 countries had adopted renewable electricity generation targets; 126 had implemented dedicated policies and regulations (REN21, 2017). This is the same on Curaçao, with the new energy policy, a lot of different renewable are 'at least in principle' being promoted (National Energy Policy, 2017). Not only does this provide a collective vision for companies and the government to strive towards, but it creates a vision in a place where there wasn"t any in the beginning. Partly due to the first policy, renewable energy increased rapidly on the island. There is a direct correlation between the adoption of targets and the implementation of renewable energy. Due to this new influx of policy measures, based on REN21's 2017 report, "renewables contributed 19.3% to humans' global energy consumption and 24.5% to their generation of electricity in 2015 and 2016, respectively." Just like worldwide investments in renewable technologies amounted to more than US$286 billion in 2015 (IRENA, 2016). Globally, approximately 7.7 million people are employed in renewable energy industries, with Solar PV providing the most jobs (IRENA, 2015). Renewables also increased directly after the implementation of the 2011-2015 energy policy. If the trends are followed, the new policy can also lead to more investments and more Solar PV adoption.

Renewable energy systems are becoming increasingly effective and cheaper and increasing their share of total energy consumption (Deloitte, 2018) Globally, more than two-thirds of all newly installed electricity capability was renewable as of 2019 (IRENA, 2019). Growth in coal and oil consumption could end by 2020 as a result of expanded renewable energy production and natural gas production (The Guardian, 2017; Grantham Institute, 2017). This new sustainable energy policy also puts a destabilizing pressure on the regime, by promoting the implementation of renewables.

Another destabilizing landscape pressure is the dependence on Oil (mostly Diesel) for its electricity supply. At first, this oil used to be cheaply bought from Curoil, which would get this from the ISLA refinery on the island. With the uncertainty of the refinery and the instability of Oil imports from Venezuela, the oil prices will also increase due to more expensive imports of oil from the African continent. What's more is that the refinery also contains a utility for

its own electricity supply. The oversupply would be sold cheaply to Aqualectra, but due to ISLA's inactivity, this part of the supply is no longer guaranteed. Implementing solar PV could alleviate this problem substantially, while at the same time boosting growth.

Furthermore, among the worldwide trends, the oil price has been a major factor. While Oil-prices have peaked in 2008 and have gone been going down ever since, they are trending towards an increase in 2019 and in the future (Bloomberg, 2019). Closely related to this point, dependence on Venezuela which is increasingly considered to be a risk. These landscape developments in addition to the uncertainty for the future of the oil refinery put a destabilizing pressure on the oil dependent electricity regime, strengthening the movement towardbs development of sustainable energy sources that are independent of oil price fluctuations.

Lastly, the poor infrastructure in the more rural area of Curaçao can also work to the advantage of a solar rooftop PV energy regime. Electricity infrastructure is relatively poor. All electricity is generated in the east (through diesel generators), and the power lines are unreliable. Additionally, most of the supply from this area comes from the wind turbines that are located close by (playa Kanoa). If there isn't sufficient wind, there isn't sufficient supply. This results in regular power shutdowns. Rooftop Solar PV can be produced in a distributed way, which enables the rural areas of the island to be power by electricity in a decentralized way, reducing dependency on the present (lackluster) electricity grid.

4.2 Socio-Technical Regime of Curaçao

This section focuses on relevant developments within the electricity regime, which includes the energy sector and other directly related fields. For the Strategic Niche Management analysis, the central focal point of this section should be on Curaçcao's prevailing electricity regime because this affects the possibilities for using Rooftop Solar PV as an energy source, and the main goal is to uncover the potential for a shift in this particular regime. Yet, there are more regimes that can have an impact on a shift towards Solar PV-based energy supply and should also be considered. In particular, the energy regime and the transport regime.

The analysis is divided into four key areas: *Structure of the sector*, *incumbent technologies*, *electricity rates* and *recent policy developments* that directly affect solar PV. The goal of this chapter is to provide a detailed description of the electricity regime in order to lay forth the opportunities and barriers that rooftop solar PV has, in order to gain a larger share in this regime.

4.2.1 Energy Sector and Relevant Legislation

This section explores the specific energy sector of Curaçao and presents the current energy mix as well as the most important developments that have occurred in the energy sector.

Structure of the Energy Sector

The energy structure of Curaçao is relatively simple with a limited number of actors which are strongly interrelated. The six main stakeholders of the Curaçao energy sector are:

1. **Curoil**: The fuel import and distribution company;
2. **Aqualectra**: The electricity and water production utility;
3. **ISLA**: The refinery, for now operated by PDVSA, as main provider of fuels to Curoil and Aqualectra.
4. **The Government**
5. **Bureau Telecommunicaie & Post** (**BTP**): The Regulator.
6. **The Consumer**

Within the energy sector in Curaçao, the electricity market can be divided into the production, transmission, distribution and supply of electricity. The activities in these market segments are mainly developed by one dominant party, Aqualectra, on the basis of the concession granted to it. Aqualectra is a government owned Utility that produces and distributes water and electricity, which is operating in a naturally monopolistic environment, due to its delivery to 69.000 households and companies (95% of the island). Aqualectra is and will stay the primary operating firm in the foreseen future in transportation and distribution. When it comes to production, since 2011, Aqualectra is being complemented by a number of producers of renewable energy (mainly Solar). In the past, Aqualectra was the only electricity provider, but the entry of Independent Power Producers (IPPs) was permitted through legislative modifications introduced in 2011 (Government of Curaçao, 2011). Aqualectra also has Power Purchase Agreements (PPAs) with two utility-scale wind parks (31.5 MW and 15 MW) owned and operated by NuCapital (An independend company that has a PPA with Aqualectra). The bulk of other generation capacity on the island is owned and operated by Aqualectra. Before the Venezuela crisis, they supplemented their generation portfolio (about 30%) by contracting extra electricity from the refinery-related utility (CRU) (owned and operated by Refineria di Korsow (RDK)), but this is currently no longer being supplied due to the current shut-down of ISLA (there is no oil production).

Incumbent technologies

Curaçao has a base load electricity demand of around 100MW and a peak load of approximately 135MW. At present, the largest portion of the electricity generated on the island comes from installations powered by heavy fuel oil. The production mix comprises of diesel generators (168MW-80%) and the inclusion of renewable energy generation through PPA's (Power Producer Agreements with third parties - 46.5 MW of wind and approximately 10 MW of solar). The diesel engines use fuel oil supplied by Curoil, which the ISLA refinery previously supplied to

Curiol (when it was in operation). The system is sized to cover peak loads independently of renewable supply (168MW, while peak is 135MW) by the diesel units. Such conventional capacity is deemed necessary as wind and solar energy fluctuate during the days and months. The conventional capacity is also required to balance demand and supply, due to the intermittent nature of Solar and wind. Yet, they are not all in production because wind and solar energy take precedence. On average, Aqualectra produces a maximum of 60 MW per day, with its Diesel Engines.

Aqualectra also traditionally purchased electricity from a utility on the refinery (CRU) and purchases solar electricity from small Independent Power Producers (IPPs). The CRU plant mainly supplies the ISLA refinery with electricity - through two diesel generators located on the grounds of ISLA refinery. Aqualectra relied on an in-flow of at least 24MW of electricity into the grid, from overproduction of this plants. With the current ISLA situation, this supply has completely stopped. Due to a lack of security of supply, enhanced by the drop off of supply by CRU, Aqualectra needed new baseload. The company opted to invest 30 million ANG in a new 40MW diesel/gas power plant (DOKWEG II), which opened in February 2019 (Amigoe, 2019). This was part of their 'reinvestment plan'. According to the Utility company this investment was necessary to have a stable baseload and that renewables are too intermittent on such a large scale:

"Aqualectra also said that we just have to add some powerplants ourselves to be able to grant stability. Until a few years ago, ever so often, it happened that Aqualectra had too little capacity due to maintenance of the diesel generators at a moment that there was also no wind and the BOO central was not delivering. That meant that there was too little power, so then a neighborhood gets 2 to 3 hours of no power. You want to make sure that you want to meet the need of the population, therefore these power stations are really necessary." (Interviewee #15 (CLO at BT&P))

Thus, the vast bulk of the electricity generated on the island presently comes from heavy fuel oil driven facilities (80%). In Figure 4.1 the geographic locations of the power plants on Curaçao, including the power rating of each plant, are mapped.

In accordance with the ending contract with PDVSA there have been a plethora of negotiations for new contracts with different companies. One of the main negotiations has been with the Chinese company 'Guangdong Zhenrong Energy' (GZE) in 2016. The government decided to work with the Chinese company after it could not conclude a new agreement with the Venezuelan state company PdVSA for the operation of the refinery after December 31, 2019.

"All attempts by the Curaçao government to make concrete agreements with Venezuela for the lease from the oil refinery yielded nothing. The working visit that the prime minister recently made to Venezuela to sign an MoU also did not produce anything." (Whiteman, 2016)

In September of 2016, the government of Curaçao signed a Memorandum of Understanding (MoU) with the Chinese company for an investment of $10 billion in the energy sector, which included modernizing and operating the entire energy chain of Curaçao. This chain includes:

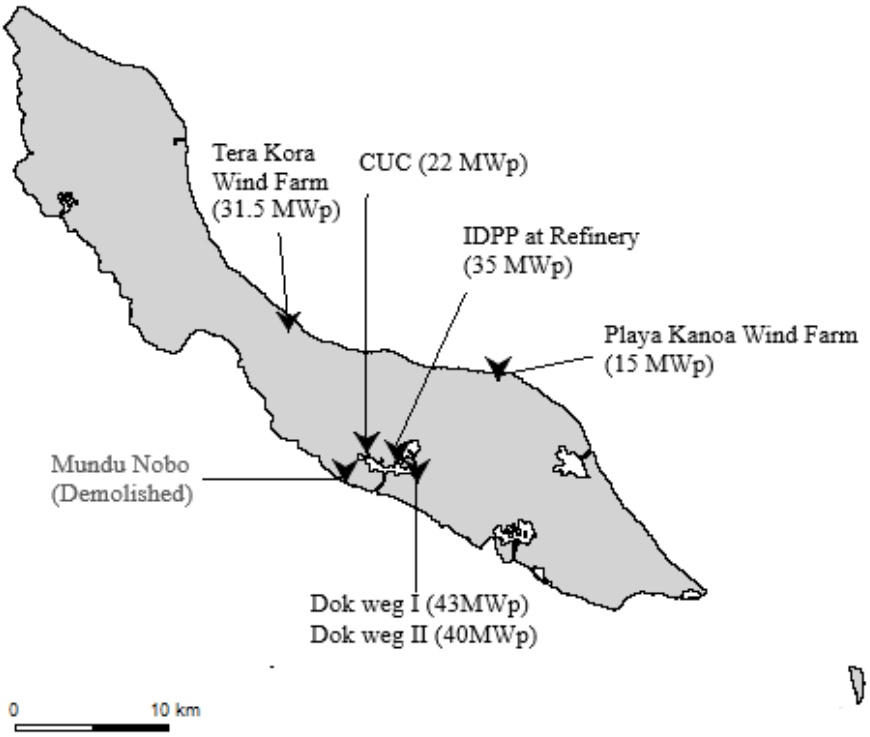

Figure 4.1: Geographic location of power plants in Curaçao including power rating

clean up and operation of the oil refinery, modernization of Aqualectra and the construction of an LNG export terminal on Bullenbaai (Amigoe, 2016). The introduction of natural gas as a main fuel for the refinery, would allow replacing heavy fuel usage in diesel plants of Aqualectra by LNG, which would result in important emission reductions and cleaner electricity production. But at the end of 2017, the government tore up the contracts with GZE: the company was alleged to have given a misrepresentation (Amigoe, 2018). However, through diplomatic channels and other sources, it became clear that GZE would have equity of just under 60 million dollars, which was not in proportion with the planned investments of $10 billion. Thus, these negotiations have since fell through, but Aqualectra has taken the transition to LNG into account when purchasing its new generation capacity. This has resulted in the acquisition of expensive machines and will cause the incumbent regime to be rigid for the coming years, due to high overhead costs over a long period of time, since the life expectancy of diesel generators is approximately 15 years (Worldwide Power Products, 2019).

Electricity rates and security of supply

Electricity rates in Curaçao are considered to be relatively high. This is also something that interviewees see as a major issue.

"The rates are just ridiculously high. If you look at what you pay here for electricity and also water, by the way." (Interviewee #10, Private Adopter)

Like many island nations, Curaçao is highly dependent on imported fossil fuels, leaving it vulnerable to global oil price fluctuations that directly impact the cost of electricity (NREL, 2012)).

"It only has to go wrong for a while now with ISLA and fuel on Curaçao is already a bit more expensive and boom you are on top of it. So it fluctuates, you see. But we still produce the cheapest with our own diesel units. But, if the prices of fuel go up, then your production price just goes up." (Interviewee #1, Program Manager at Aqualectra)

To showcase the fluctuations of prices due to the dependence on oil, Table 4.1 shows the electricity for households (up to 250 kW) from 2014 to 2017. The rate changes are directly correlated to variations in world market prices of crude oil. The high electricity prices up to mid-2014 represent a peak in world oil prices, hence the steep decline from the second half of 2014.

Table 4.1: Electricity tariffs development in ANG in period January 2014 to January 2017 (Source: BTP)

	Jan 2014	Jul 2014	Dec 2014	Jul 2015	Dec 2015	Jan 2016	Dec 2016	Jan 2017
Households low (250kW)	0.7373	0.7373	0.5916	0.5960	0.5017	0.4489	0.4688	0.5219
% Change	-	0%	-19.8%	+1.7%	-15.9%	-10.5%	+4.4%	+11.3%

In Table 4.1 it is also clearly visible that Oil prices reached a minimum in 2015 and since then prices have been rising steadily. During 2018, another peak in world market prices for oil products further increased the costs of producing electricity based on fossil fuels (Bloomberg, 2018). Due to the continuing rise in oil prices, there was a rising trend in the fuel clause as part of the regular end-user tariffs for electricity, despite the fact that this development is limited by the use of three wind farms. This rising trend has seemed to peak at the end of 2018. The regular rate for gasoline and diesel on Curaçao fell again on 2 July 2019. This consequently also makes electricity cheaper (BTP, 2019). Diesel now costs 1,435 guilders at the pump (first 1,502 guilders); almost 7 cents per liter less. Due to this, the lowest household electricity rate - up to 250 kWh - has now (Jul 2019) become 0.5841 ANG (Jan 2019: 0.6129 ANG); a decrease of 3 cents per kWh. The decrease in electricity rates is mainly caused by lower average fuel costs but also due to lower correction factors for electricity, concerning the deviation of the realized fuel and electricity costs compared to the May forecast.

For comparison, Table 4.1 gives an insight into the electricity rates of other Caribbean SIDS that have similar demand to Curaçao. For comparison, it also shows average electricity price in European Union (EU). Important to note also, when comparing rates of EU and SIDS, there is a big gap between purchasing power of EU citizens and SIDS inhabitants - e.g on average, Dutch workers earn around four times as much as an average Cura(c)ao worker.

From Table 4.2 it can be concluded that even with low oil prices electricity rates are still relatively high in Curaçao at Naf 0.5841 per kWh (= 0.30 euros per kWh). For comparison; in the Netherlands, a kWh costs on average 0.22 euros per kWh. The significance of the direct comparison electricity prices between countries is dubious, given that a big amount of local specific variables are involved (demand size, country area, geographical location, physical connection to other countries, etc.), especially when comparing SIDS to mainland countries (Interviewee #1, Program Manager at Aqualectra).

Table 4.2: Electricity rates (US$) in the Caribbean region in 2015 (CARILEC, 2018)

	Aruba	Bahamas	Barbados	**Curaçao**	St. Lucia	European Union
Price ($/kWh)	0.284	0.154	0.328	**0.389**	0.268	0.236
Peak (MW)	100	400	188	**130**	65	-

Contributing to the big difference in prices between the EU and Caribbean SIDS is the self-dependence of the electricity system. All electricity has to be supplied by the country itself. There is no connection to the mainland or to different countries to compensate for over or underproduction, like there is in the EU. Through interviews with Aqualectra this high electricity price is attributed to island specific issues, which include self-reliance, lack of local expertise and dependence on Oil (as explained above).

Self reliance means that the island has no grid connection with other (neighbouring) countries, thus making production more expensive. This expense comes from the fact that the sizing has to be in such a way that irregular peaks are also accounted for. This means that an island like Curaçao has to invest in more machines that it would have to if it were interconnected like a country like The Netherlands.

"Certainly not on an island like this where you have to be completely self-sufficient. In Europe and also in the States. In Europe all countries are interconnected to some degree - with energy networks - so there are energy exchanges. There is just trade in electricity, so at the moment that you are short of electricity, you can e.g. buy it in Germany. Here we are self-sufficient, we have to generate it ourselves, we can't just get electricity from Venezuela or Bonaire. There is no connection. That makes the energy supply here - on such an island as this - special compared to the mainland" (Interviewee #15 (CLO at BT&P))

Due to a lack of expertise that resides on the island, maintenance can be exponentially more expensive when experts have to be flown in from abroad. This is enhanced by the implementation of the 20-80% rule, which makes that there is a very bureaucratic procedure before he has his work permit to be allowed to work (Interviewee #1, Program Manager at Aqualectra).

Consequently, owing to the comparatively small scale of the energy system and the isolation of the island setting, the electricity tariffs are anticipated to be greater than in bigger, more effective - electricity generation - countries. However, the electricity rates are about 30% higher when compared to the cost-oriented countries within the region.

"If I talk to someone from the States and I tell you that we pay almost $ 0.40 per kWh here, they will look at you strangely" (Interviewee #5, Energy Entrepreneur).

Furthermore, the quality of the supply was inadequate until recently. Power outages happened frequently on the island. In 2018 the local utility company Aqualectra had to switch off the power every week for maintenance of the network. But, the power also regularly fails due to a malfunction or insufficient capacity. For some small entrepreneurs this has major consequences and the financial damage cannot be foreseen (Caribisch Netwerk, 2018). This is something that the utility acknowledges and has worked on improving in the past (Interviewee #1, Program Manager at Aqualectra).

4.2.2 Energy Policy

"Prior to its independence, Curaçao had no policy, no long-term vision, very obsolete legislation and lacked any kind of regulatory framework (or regulator for that matter) with regards to energy" (Schotte, 2012).

The government of Curaçao then set out to create the first energy policy framework - 'the renewable energy policy of 2011-2015' (Government of Curaçao, 2011).

Since the launch of the 'Curaçao Renewable Energy Policy 2011-2015', the share of renewable energy in electricity generation, particularly of wind energy, has increased significantly from roughly 5% in 2011 to 18% in 2015.In July 2017, with the capacity expansion of the Tera Kora wind farm, the share increased with 16.5 MW ultimately leading to a share of 27-28% on average. With regard to solar energy the installed capacity increased from almost zero MWp in 2010 to roughly 12 MWp in 2019.

When the former Curaçao Executive Council delegated the task of developing this national policy, in 2009, they also appointed the company 'Bureau Telecommunicatie & Post' (BTP) as an independent supervision of the energy sector, including electricity. This was a very progressive decision, since other Caribbean SIDS in the region did not have any regulatory entity in the energy sector. Nonetheless, there are still some improvements to be made; when looking at developed nations (in Europe or North America), it is highly uncommon that the policy and the regulator are the same agency. Independence of these organizations is essential in these (continental) developed nations (European Commission, 2019). Additionally, the regulator only has an advisory role towards the Minister of Economic Development, who is ultimately responsible for the Utilities and takes the final decision.

Within the framework of the Policy Document on 'Regulation Electricity Supply Curaçao 2011 - 2015', there is a separate policy for the generation of small-scale sustainable energy. This policy forms the basis of the applicable technical guidelines and certification programs in the field of electricity supply in Curaçao and deals with the regulations that apply to the connection of installations for non-commercial generation of sustainable energy to the public transport and distribution network with a view to on the feed-in of electricity (BTP, 2019).

Even though the policy proved effective, there was still an absence of a comprehensive, modern energy policy. Due to the landscape influence of a lack of political continuity within the country,

as well as the limited capacity available to the Government for the efficient development and subsequent implementation of the policy, progress by the 2011 policy has been stymied. Hence, the new energy policy (2017) is a good step forward to guide the country"s collective energy decisions. Initially all individual parties had to make policies themselves and get them approved, which lead to an incoherent vision for the sector (Interviewee #14, Energy Advisor).

"At one point, what you saw is that everyone had been in need of an energy policy for years. But because there was no energy policy, companies started to put things on paper themselves, then deposited them with the government and the government had to give individual permission for this. But everyone went their own way." (Interviewee #14, Energy Advisor)

Due to this, a new energy policy was published in 2017, which sets the objectives and priorities for developing Curaçao's energy sector, with an explicit focus on creating a sustainable energy system. The national energy policy does a great job in presenting the vision in a tangible way. The focus always stays on tangible, more actionable strategies by focusing on issues like Oil price fluctuations in light of Curaçao's dependence on imported fossil fuels. This was an explicit decision by the writers, claiming that people would not take action if the main issue was climate change. But the underlying ideas are always to reduce emissions and thus contribute to climate change mitigation.

"One of the conscious choices, when you read the document - you may ask yourself: 'Why don't they talk about global warming, emissions reduction?' - you hardly read that environmental aspect. But it is like a common thread. That has been a deliberate choice, because when you start talking about global warming and emissions, nobody says anything. At least the majority of the island does not understand anything of that. She reads it in the newspaper, but nothing else." (Interviewee #14, Energy Advisor)

This is in line with findings from the in-depth analysis of the focus group session. The Climate Change issue has to be formulated to more tangible issues.

Furthermore, the policy addresses a couple of key issues that the island faces (red tape etc) and claims are made that if this is implemented that Curaçao will be a leading country in sustainability. While this is a noble cause, I still see a lack of enforcement and coordination. Also, contradictory statements are made e.g. first the document claims that:

"Consumers in Curaçao are aware of the environmental impact of mobility and energy use and are therefore committed to use energy and potable water efficiently" (National Energy Policy, 2017).

Yet, proceeding this in the SWOT analsysis the document states as a weakness:

"Insufficient awareness among the general public and other energy end users on energy consumption and efficiency opportunities." (National Energy Policy, 2017)

From my contextual data, it seems that only the latter statement is true.

From this policy there are still some key deficiencies in the energy sector. There is still no single authority with the responsibility for strategic planning. Due to this, it is not immediately evident which organization has the authority to draft and integrate energy sector policies, sub policies and activities. Although some energy subsectors, such as electricity, water and fuels, fall under the (advisory) jurisdication of BT&P, policy development should not be the role of the regulator. In the interview with Interviewee #14 (Energy Advisor) this is acknowledged: he stated that the government is currently developing an "energy bureau".

"An energy bureau must be established and the energy bureau must come under the Ministry of Economic Development." (Interviewee #14, Energy Advisor)

Missing from the energy policy is the explicit mention of the integration of spatial planning systems that can serve as a way to show where solar electricity generation is optimal in order to reduce grid integration costs.

Furthermore, there is a need for transparent criteria to be taken into account when developing renewable energy projects. These will serve to reduce the transaction costs associated with project siting and environmental permitting. In addition, when developing Solar energy projects, the procedural criteria have to be clear. This will decrease transaction costs.

Nevertheless, the energy policy is a good starting point to bring a collective vision to the energy sector. It is important that this vision has enough support from the relevant stakeholders in order for it to be accomplished. According to Interviewee #14, (Energy Advisor), "There has been considerable coordination between all stakeholders and the stakeholders are all now happy that there is an energy policy, which means that companies also stand behind it." This is not something I have been able to verify, but through interviews it became clear that most people in the sector were aware of the policy and have read it.

4.2.3 Summary: Regimes stabalizing and destabalizing shifts

Oil Dependence

Oil price developments affect Curaçao's economy directly through higher electricity tariffs for all end users and through a larger share of foreign currency requirements for the imports of fuels. An energy transition towards the abundantly available renewable energy sources in Curaçao can help relieve of this dependence on Oil prices and thus make electricity prices unaffected by fluctuations. Due to the tropical climate on Curaçao, with high solar irradiance, Curaçao has sufficient potential for implementation of Solar PV to become independent of fossil fuels and oil imports in the coming decades The recent drop in world oil prices, from more than US$ 100 per barrel in the first half of 2014, to less than US$ 55 in 2017 has reduced the urgency of measures and investments in the energy sector. Nevertheless, a new surge in the oil prices has occurred with a peak in 2018. This is enhanced by the Venezuela situation, which has made Oil imports more expensive for Curoil, also increasing the costs for Aqualectra. It is therefore a very opportune moment to develop and implement a robust energy strategy.

Natural Monopoly

There is a need for expertise in dealing with renewable energy supply, especially with regards to system's sizing, due to the need to account for intermittency. Due to this fact, the 'lack of expertise', 'brain drain' and the '80-20 law' becomes detrimental to decision making in the electricity regime. This becomes apparent through the interviews and gets strengthened by the fact that Aqualectra operates in a natural monopoly. The monopolistic state of Aqualectra causes that there is a lack of outside (competitive) pressure on the company to innovate. According to interviewees, there is predominantly a 'conventional utility mindset' (Interviewee #14, Energy Advisor) within the Utility and the mindset of "why rock the boat if it operates sufficiently well" (Interviewee #2, Energy Consultant). Because of this 'conventional utility mindset' and the lack of expertise in dealing with renewable energy issues within the utility and the respective Government ministries and agencies has led to confusion, delays or unmotivated denials of approvals. This lack of expertise is clearly visible in the fact that all renewable energy comes from PPPs in which the utility does not have to have any in-house expertise of renewable energy systems and only buys electricity at a constant rate (regulation stays with the private company). This limits impact that the government and monopolistic utility can make. This is also visible in the fact that the Utility now also has a tender on PPPs for solar farms, which has proven more difficult and is being delayed.

Public Private Partnerships (PPPs)

There is a lack of a legal framework that specifies the exact guidelines for connecting new utility-scale renewables to the grid. This may discourage potential investors as every individual project needs the government's approval (and permits) and will have to negotiate its own PPA with Aqualectra on an ad-hoc basis. This makes planning for prospective project developers more difficult and adds increased financial risks to solar energy projects. This has proved to cause problems when it comes to the PPP format that the Utility prefers in contracting large scale renewable energy. This has proven to be the case due to the difficulties in finding a private partner for the Solar farm tender, which should have been done in 2018 and is still not under development currently. A dedicated energy office can bring some alignment in goals and expertise for renewable energy decision making. This is also something that different interviewees have expressed (Interviewee #14, Energy Advisor). Additionally, Curaçao has no energy data collection system in place, which complicates the analysis of energy consumption and production. This can also be solved by a dedicated energy office.

Small Independent Power Producers (sIPPs)

Adding to the lack of expertise and the red tape, solar systems need to be installed by certified installers, but there is a lack of trained installers. This affects private adopters in particular, since installers often provide advisory services to give advice on system sizing and panel types to be bought. If installers lack expertise or are not qualified, they can offer bad advice, which would have a negative impact on the system functionality and ultimately on user experience.

When it comes to rooftop Solar PV, like many other small-scale renewable systems, any administrative barriers increase transaction costs for adopters. The more authorities and administrative procedures are involved and the more complicated the approval procedure, the greater the costs become. Especially within a country like Curaçao, where availability of technical expertise is limited, which can lengthen the decision-making process and further increase costs. For Curaçao, particularly the following hurdles, have been identified and are deemed relevant:

- Lengthy procedure to implement and further develop renewable energy policy;
- Lack of coordination between various government agencies and organizations. Multiple ministries are involved, which makes decision making (Excecution) more difficult.
- Long lead times and high costs in obtaining authorizations and permits: The government of Curaçao is aware of this problem and is actively trying to limit bureaucracy for acquiring business permits as a first step to attracting more investments.

Regulatory agency

The implementation of a regulatory agency for the energy sector was a great first step for Curaçao towards better guidance of the sector. Yet, the regulators tasks are not yet explicit enough and thus this can lead to a conflict of interests between the government and the regulator in which the governments' decision gets precedence due to the mere Advisory role of BTP towards the minister on tariff setting. The role of BTP should become more decisive. Especially on Curaçao, where the political land- scape can be very volatile, leading to abrupt changes that can fundamentally damage the energy sector. Additionally, many Caribbean countries that have made progress in the regulation of their electricity sector have an independent regulatory agency for setting the tariffs and service standards. This is something that the government and the regulator have expressed and this change is in progress (Interviewee #14, Energy Advisor ; Interviewee #15 (CLO at BT&P)).

"In such cases you can see that we still only have an advisory role. It is still ultimately the minister who did not want to take this advise from social considerations. He did not want the bill to go to non-PV users. Which I can also understand." (Interviewee #15 (CLO at BT&P))

Incumbent Technologies

The recent 40MW investment in Diesel-generators stabalizes the incumbent technologies and further increases the 'carbon lock-in' (Duck curve - Efficiency loss) situation (Brown, Chandler, Lapsa, & Sovacool, 2007). with a too high degree of path dependence, meaning that these investments have an important impact on future historical trajectories (Edwards, in Edelenbos Monnikhof, 2001, p. 120). An option to stimulate innovation can therefore become embedded in such a way that innovation is blocked (Rotmans, 2006, p. 45). This problem is currently affecting the energy production on Curaçao: investments made in the current energy infrastructure further embed this technology in such a way that innovation can be blocked.

Energy Policy

Lastly, overall, The National energy policy 2017 is positive for the development of renewable energy on Curaçao, specifically Solar PV. The goals are quite specific, realistic and measurable. Yet, there are certain barriers that still need to be addressed within the policy, including explicit special planning systems. What might present a problem in the development of Solar PV is the current state of the electricity grid infrastructure. The improvement of the grid would be a massive undertaking and a long-term process. Furthermore, in its current vulnerable state, Aqualectra could be tempted to make conservative decisions in order to slow down the penetration of Solar PV.

4.3 Socio-Technical Niches of Curaçao

This chapter lays forth the historical developments of niches, which ultimately form the regime that is currently on the island. For the implementation of Rooftop Solar PV to be successful, it is important to know what the success stories were and what parallel developments are arising next to solar PV. From the literature it becomes clear, that a transition can never be achieved solely through the scaling up of one niche process.

Rob Raven investigated the crucial factors for the emergence of market niches and how niche and regime developments interact. In his dissertation, Raven (2005) presents three crucial factors for the emergence of market niches. First, market niches often arise through a parallel development pattern, resulting in a growing market share, broader and faster learning and enabling a backup strategy. Secondly, the development of market niches shows progress, there is increasing stability; Risks and uncertainties are declining, making it possible for actors to anticipate the future.

4.3.1 Important Niche Developments in Curaçao

Wind Energy

Today, Curaçao can be seen as a pioneer of wind energy in the Caribbean (Interviewee #14, Energy Advisor ; Aqualectra, 2019). The first development came in 1991, when the Dutch investment company 'NOVUM' approached Curaçao with the intention of investing in a Solar project. At this time utility scale wind power was more developed than solar power. As a result of that, along with the fact that wind is more similar to conventional utility techniques due to its AC electricity and a 24-hour supply of energy, this project was transformed into the first wind project between 1991 and 1993.

NOVUM approached Curaçao at a time when the Utilities company on Curaçao were divided into two separate companies: a distribution company called 'Kompania di Produkshon I Distribushon di Elektrisidat I Awa' (KODELA) and a production company called 'Kompania di Awa I Elektrisidat' (KAE). KAE produced water and electricity, delivered this to KODELA, which would then distribute it to industry and households.

KAE had vested interest in conventional fossil fuel power supply, due to its large investments in diesel engines and their expertise in this area. This further enhanced the 'conventional utility' mindset. Concurrently, KODELA had recently acquired a concession (license) to own a small part of the production, which would also be comprised of diesel engines. But due to the relatively small scale of their production units, KODELA's overhead was marginal. This paired with their recent start with production, they had not developed as much expertise with fossil-fuel production. This recent concession created an opening for KODELA to invest in windmills, as long as it delivered electricity at a reasonable rate (Interviewee #14, Energy Advisor). Due to the large overhead of KAE and their vested interests, it was critical at this point in time that NOVUM approached KODELA. Accoriding to Interviewee 14 (Energy Advisor), KAE would have most likely blocked such an innovation (Interviewee #14, Energy Advisor). Even within KODELA, it created fields of tension and it became a very political discussion.

A parallel development was the investment proposal of NOVUM itself. Due to the higher investment needed for Wind turbines, as opposed to Solar panels - NOVUM proposed a deal to provide as much subsidy to make the investment interesting for KODELA, but not to cover the whole investment costs. Due to Curaçao's unique position within the former 'Netherlands Antilles', KODELA could - with the necessary lobbying - acquire funding from the EU. Due to this, NOVUM, together with the EU, subsidized a total of around 49% for this project. This was enough to make it interesting for KODELA as a business case.

This led to the launch of the first wind farm ever build in the Caribbean. The 3 MW wind farm, located at Tera Kora (12x250kW), was taken in operation in 1993. According to the then renowned magazine 'Windstat' this wind farm was classified as one of the top five performers in the world. When this wind farm was in the process of being realized KODELA also negotiated with the supplier to setup a company on Curaçao to further boost wind development in the region. This company became Netwind Caribbean and later evolved to become NuCapital (still in operation) and is one of the main drivers of wind energy projects in the Caribbean region. They have developed parks in a couple of Caribbean and South American Countries, such as Jamaica, Colombia, Guyana, Aruba and new parks in Curaçao.

Success Story

With this success story, investors and individuals could see that it was possible, which created an opening in the renewable energy market and slightly shifted the 'conventional utility mindset'. Before this point, the were no concessions for connecting renewables to the grid, this success story created a shift in this. First there was a 'big field of tension' between production and distribution (Interviewee #14, Energy Advisor). There were concerns about grid stability within production. When the first wind farm started producing and delivering and showed the technical feasibility, these concerns were squandered. Despite the technical feasibility, there were still tensions and questions about financial feasibility, due to the fact that it was funded for almost 50%. Hence, the technology was there, but it was still an anomaly and not fully integrated within the operations of the company and the operational person, was not interested in adopting that knowledge.

But because of the success of the first wind farm, the market started gaining interest in investing in more renewable (wind) projects. The next step is that the private sector - partly

supported by NuCapital - has showed interest in building a wind park. The financial concerns of the conventional utility made KODELA look for new business models.

This led to the development of business models based on Public Private Agreements (PPA), where a private company owns and operates a wind farm. Through a PPA, the only thing the utility had to do was buy power from this private company for a tariff. That was a completely new development for Curaçao, which also caused for tensions and concerns, due to the fact that production would no longer be in the hands of the utility. Ultimately, money talks. The price setting was so interesting for the private investor and the utility that the distribution company could also justify the agreement from a political perspective.

This led to the development of business models based on Public Private Agreements, where a private company owns and operates a wind farm. Through a service level agreement, the only thing the utility had to do was buy power from this private company for a tariff. That was a completely new development for Cura cao, which also caused for tensions and concerns, due to the fact that production would no longer be in the hands of the utility. Ultimately, money talks. The price setting was so interesting for the private investor and the utility that the distribution company could also justify the agreement from a political perspective. Due to this, the distribution then expanded its wind generation with, yet another, wind farm located at Playa Kanoa, expanding from 3MW to 9MW of those unconventional windmills that were connected to the grid in 2001.

This park was one of the pilots that showed the technical feasibility of renewable energy into the main grid. Leading to a shift in the conventional utility vision on the island. It is precisely this success story of wind turbines, that made an opening in the regime for an increasing amount of renewables.

To showcase this, due to the success of the first two wind farms at 'Tera Kora' and 'Playa Kanoa', Aqualectra took on another PPA for the electricity of a wind park 15MWp (5 x 3MW) at Tera Kora. In 2017 this was expanded to 31.5 MWp, by contracting an additional 16.5 M (5 x 3.3MW). Finally, the Utility then expanded its wind generation with, yet another, wind farm of 15MWp located at Playa Kanoa, expanding to 46.5 MWp that is currently (2019) being supplied into the grid.

Electric Vehicles (EVs)

One more noteworthy development that is coming up currently is the promotion of Electric Vehicles (EVs). On Curaçao you can come a long way with 300 kilometers (the range of a regular EV), you can get from one end of the island to the other and back. Thus, with a charger at home you actually get away quite well with a fully electric car in Curaçao. The high price of electricity incentivices the charging of the batteries through (free) energy from solar panels.

One main barrier that the island currently has is that it does not have a charging infrastructure yet. The first technological niche experiment towards such an infrastructure launched in 2012, with a charging station and a single Mitsubishi i-MIE. The project investigated the effect electric cars have on the electricity grid. The charging station was made possible by Curaçao Airport and Aqualectra. After this experiment, there has been little to no development in the

field, until this year (2019). On April 24th 2019, the first commercial electric vehicle charging stations was installed in Curaçao.

This development, as well as the Utilitys commitment to promote electric vehicles. Illustrated by their collaboration on building a charging infrastructure and implementation of 9 EVs in their fleet. According to, program manager at Aqualectra Rudolph Garmes (2019), they want to set the example for the rest of the island. Aqualectra will be importing and putting into use at least 80 electric cars in the coming period (Interviewee #1, Program Manager at Aqualectra). The utility company is currently looking for good locations on the island to install charging points.

Further proof of the development comes in the form of a seminar about electric vehicles held on the island on the 15th of may of 2019. This seminar was organized by the Curaçao Business Council for Sustainable Development together with the Utility (Aqualectra). The prime-minister of Curaçao, Eugene Rhuggenaath, held the opening address of this seminar. Currently, there are about 35 EVs on the island, including both private and company cars. This number will only increase in the near future. The point of the seminar was to spread awareness about the advantage of buying electric vehicles on the island.

Electric vehicles are subsidized on Curaçao, owners of these cars do not pay import tax. For other vehicles an import tax of 27% applies. The government revenues on vehicles are: tax on gasoline and diesel (the Excise Tax - now ANG 0.4134 per liter, 6% Wholesale Trade Turnover Tax and 6% Retail Trade Turnover Tax on gasoline), the import tax (27%), motor vehicle tax (depending on type and age), OB (9%) on the import value of the car, car parts and maintenance services of garages, etc.

4.3.2 Summary: Niche destabalizing developments

Thus, to summarize, Curaçao can be seen as a pioneer of wind energy in the Caribbean (Interviewee #14, Energy Advisor ; Aqualectra, 2019), but this did not come without its parallel developments. It was a long process of spreading awareness and breaking free of the conventional method of energy supply. Very important in the succes of Wind Energy was the development of new innovative business models. It is precisely due to the success of the implementation of Wind through PPA's that opens a pathway for Solar PV to be accepted into the regime. The succes of the Wind PPA's explain the willingness for the Utility to put out a tendering scheme for the installation of a Solar PV Farm.

Another more recent parallel development is that of Electric Vehicles. This development concurrently supports the adoption of Solar PV, since the two technologies compliemnt each other in **two ways**. The first is that, especially with the high price of Utility electricity, decreases the payback period of an investment in Solar PV if one were to charge at home (financial incentive). Secondly, from a technical perspective, EVs put a lot of strain on the grid network, especially if multiple EVs charge within a certain node (district) simultaneously the limited grid capacity can be subjected with an overload (Bakker et al., 2014). In combination with Solar PV, the EVs can be charged at home without impacting grid stability.

Both the development of Wind Energy and EVs have destabilizing effects on the fossil-based regime. Wind Energy has had an immense historical impact and created opening into the regime

that Solar PV is currently benefiting from. Electric vehicles are still in a starting Niche phase, but due to its complimentary conjunction with Solar PV, it can prove to be a very important parallel development in the coming years.

4.4 Conclusion of Socio-Technical Overview of Curaçao

As gathered in Chapter 2, the essence of the multi-level perspective is that there is an interdependency between the niche level, the regime level and the socio-technical landscape, which all play a role in the success of the implementation of a new technology (Kemp et al., 2001, p. 277). Transitions are always the result of developments and events on a large scale (megatrends) and on a small scale (niche developments).

Technical transitions can only happen with the cooperation of all 3 levels. Transitions will only be realized if developments at the three different levels link together and reinforce each other in one and the same direction (modulation). The Solar PV innovation can only break out of the niche-level when the implementation is handled properly from a Niche dynamic perspective, as well as when current processes at the levels of regime and landscape give way for a window of opportunity. These windows windows are created by changes from within the Socio-Technical Regime or by pressure that the Socio-Technical Landscape puts on the regime. Some developments at landscape level stabilize the existing fossil fuel regime, while other developments create destabalizing pressure. Equally important is the simultaneous development of additional complementary Niche technologies to create opening into the regime from bottom-up.

In this chapter I have identified the most important developments with in Curaçao, with regards to the implementation of Solar PV. This is summarized in Figure 4.2. As can be seen in the figure, technical transitions do not only encompass technology and market shares but also alteration on deeper dimensions such as regulation, infrastructure, mentality, industrial networks.

Landscape

At the top of the image, the **Green** and **Red** arrows represent the most important landscape developments.

The **Red** arrows pointing downwards represent the stabalizing pressures on the fossil-based regime. These are the main barriers that Curaçao has to overcome in order to promote Solar PV adoption. Yet, these are long term processes that are only solved through long intricate approaches. Although there are many stabalizing landscape pressures (discussed in 4.1.5, the most influential ones found through my research are:

- 'Lack of a *green* mentality', which is re-enforced by 'Bad Economic situation', 'Poor infrastructure' and a 'Lack of environmental education'.
  - This causes there to be a lack of incentive for the Utility and government to change the current system.

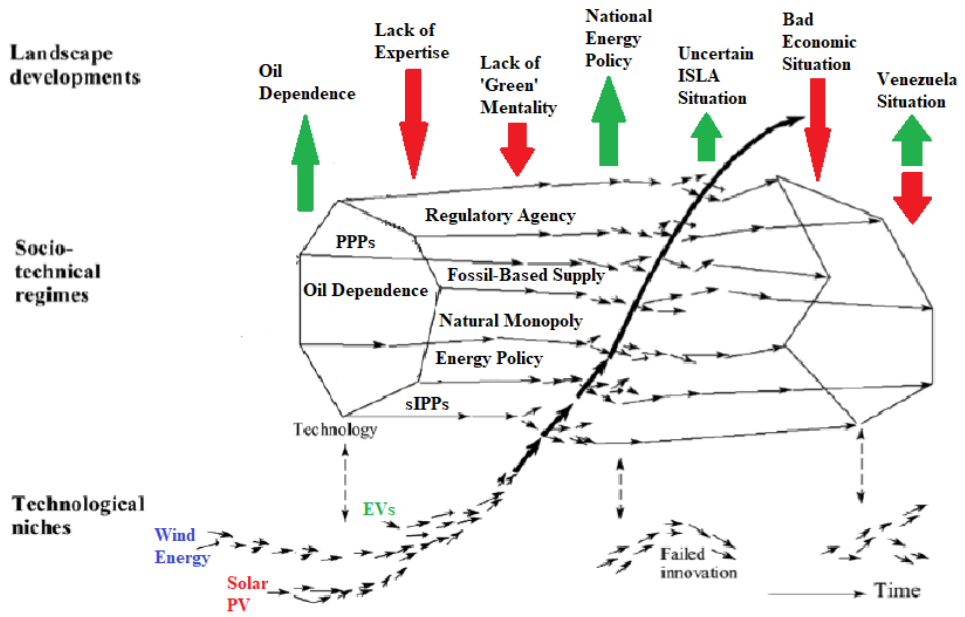

Figure 4.2: Summary of Stabalizing and Destabalizing pressures in Curaçao (Adapted from Geels & Kemp, 2000)

- 'Lack of expertise', which is re-enforced by the legislative change in the form of the '20-80 law' and the 'Brain Drain'.
  - Due to the increased difficulty of dealing novel and new technologies, like Solar PV, the 'Conventional mindset' causes innovation to be blocked.
- 'Bad Economic Situation', which is currently being re-enforced by the 'Venezuela Situation', because its financial impact on the island.
  - This is causing inhabitants to be more concerned about their finances. Because of the relatively large initial costs of Solar PV adoption, inhabitants either do not have the means to invest or they are more hesitant due to the uncertain future.

Overall, the Political instability is having a stabalizing effect on the regime, due to a lack of reliable legislative action.

The **Green** arrows pointing upwards represent the destabalizing pressures on the fossil-based regime. These are the main opportunities that Curaçao has in promoting Solar PV adoption. As opposed to stabalizing pressures, there are not as many destabilizing pressures in the Socio-Technical Landscape (See section 4.1.5), the most influential ones found through my research are:

- 'Oil Dependence', which is re-enforced by the 'Worldwide oil price fluctuations', the 'Uncertain ISLA situation' and the 'Venezuela Situation'.

  - This has an immediate effect on the electricity prices of inhabitants - if oil prices rize, electricity prices increase - which in turn has an immediately positive effect on profitability of Solar PV.

- 'National Energy Policy', which is re-enforced by the 'National Development Plan 2015 - 2030', due to its promotion of 'Sustainable Development' and the possibility it granted for the 'National Energy Policy' to be subsidized by the EU.
  - The immediate promotion of renewable energy in such fashion, has internationally been proven to increase the actual implementation of renewable energy.

Regime

As can be seen in Figure 4.2, the regime on Curaçao is characterized as having the following main aspects:

Main aspects Regime	
Oil dependence	Regulatory (advisory) Agency
Natural Monopoly	Incumbent Technologies
Public Private Partnerships (PPPs)	Energy Policy
Small Independent Power Producers (sIPPs)	

The main recent developments have been:

- Acquisition of a 40MW Diesel Engine park
  - stabalizes the incumbent technologies and further increases the 'carbon lock-in' situation.
- Appointing BT&P as 'regulator'.
  - Because of their advisory role, Curacao does not have a truly independent regulator.
- Energy policy
  - Although positive overall, still needs some improvement.

Niche

From the analysis two complementary niche developments have the biggest impact on the development of Solar PV:

- Wind Energy

  - Wind energy was the first niche development that created pathways to enter and ultimately establish within the regime. This succes story are caused a shift in the 'conventional utility mindset' to show that innovation can be positive. Even though this 'conventional Utility mindset' still persists, the development of wind energy created spaces for Solar PV to ultimately be more easily accepted.

- Electric Vehicles
  - EV promotion is a more recent development, as can be seen in Figure 4.2, but due to its complementary nature to Solar PV it can prove to be in important parallel development in the years to come.

Chapter 5

Strategic Niche Management of Rooftop Solar PV in Curaçao

5.1 Historical Overview

5.1.1 Technological Niche Phase (1980 - 2011)

Around the 1980s, the first (technological) niche Solar PV applications started to arise. The most famous application dates back to 1984, the year in which the radio station 'Radio Hoyer' - with their slogan 'solo di pueblo' (translated from Papiamentu: 'Sun of the people') - achieved a world first in 1984 by commissioning a transmitter that runs entirely on solar energy (Amigoe, 1984). After this, there were some more technological niches in the form of smaller individual projects, initiated by the first movers, who invested out of own merit. By 1990, at a starting stage, 1 or 2 companies were set up to test the market (Interviewee #14, Energy Advisor). They sold stand-alone (not connected to the grid) systems.

After the success of wind energy on the Island, along with improvements to Solar PV technology over the years, the private sector began to see possibilities with niche implementations. A good example of this is the well-known installation that was fully stand-alone In the neighborhood "Souax". Some small initiatives started to pop up (source), also in combination with wind, solar and batteries. It was not big business at the time, but there was some movement in the field.

After 1995, there were approximately 10 of those first satellites that appeared on the Island. Yet, at the time, the Utility still had low expectations for Solar PV. According to Interviewee #14, Energy Advisor, they were of the mindset:

"It is way too expensive and it is too difficult, thus you have no support"(Interviewee #14, Energy Advisor).

Nonetheless, the distribution company (KODELA) at the time started doing some pilot experiments, to research the technology. Soon after, the production company (KAE) also started to do pilot projects to experiment with Solar PV and learn how the technology works and what is the best way to handle implementation.

In 1995, KODELA installed the first solar grid connected pilot project to gain some experience with solar energy. This was a "one-phase pilot project" on their roof. This was a success and has since then KODELA also allowed some small private solar en wind projects to connect to their grid. In the mean time (1995 - 1998) this has grown to more than 20. In 1998 Solar powered streetlighting was installed. In 2000 KODELA decided to install a 20 killoWattpeak grid connected and roof integrated Solar system at 'Mundo Nobo'.

Little by little small projects arised, which through experimentation proved to be technically and financially sound. Before any large-scale implementation, those two companies (KODELA and KAE) were integrated in 2001, to become Aqualecta (Aqualectra, 2017). From within Aqualectra there were still internal tensions with regard to expectations towards Solar PV (Interviewee #14, Energy Advisor):

"Within Aqualectra you still had clear internal problems. You had one group, including myself, wanted to apply innovation and had put everything in place to start. But you also had the operational group, which said: 'Yes, but there is no grid code, there are many fluctuations, etc. We do not know how do we deal with it and it could become a problem. These internal tensions still persisted." (Interviewee #14, Energy Advisor)

After the merger in 2001, Aqualectra had started two experiment projects, apart from monitoring the individuals with their own stand-alone projects. At that point, Aqualectra had accepted that solar energy was also an energy form to meet their needs. This is verified by the fact that the roof of most of their substations - their buildings - are equipped with Solar Panels. Hence, it has become an integral part of their operation. Important are the strategies that have been applied in the past to break through those bottlenecks - particularly in the field of Wind Energy. In 2010 Aqualectra assisted the Carmabi with the realization of their privately owned grid connected 7KW solar plant.

But then, in 2011, before a Market Niche could be deployed, politics had become involved. The government at that time expressed that they wanted to promote Solar PV and that Aqualectra was holding implementation back. According to Ir. Tujeehut, former Prime Minister, Gerrit Schotte said: "And now it is enough, I think that solar panels should be applied and that they should be connected to the grid." More on this in the next section. That market has been opened, a tariff structure has been laid down how it should be done." Because Aqualectra is a government-NV, they have to abide by the rules set by the government. This lead to the next phase in the development of Solar PV.

5.1.2 Market Niche implementation phase of Solar (2011 - 2015)

On January 1st 2011, the 'Curaçao Council of Ministers has approved feed-in tariffs (FITs) for small Independent Power Producers (sIPPs) (households & Small Businesses). The FITs

were set for households at ANG 0.40 ($0.23) per kWh and for businesses at ANG 0.42 ($0.24) per kWh (Curaçao Government, 2011), applicable for both wind and solar energy technologies. These tariffs can be regarded comparatively high (particularly in comparison with European or American tariffs). Nevertheless, direct comparison of FITs with other countries is not completely feasible, as they are usually determined on the basis of a big amount of variables dependent on local circumstances, such as population size, required technological development and the abundance of renewable resources (Rymer, 2008). In the case of Curaçao, the rates were determined on the basis of the cost price of producing electricity, the costs incurred by the distributor and the purchase costs saved by not having to buy energy sources as a result of the supply of feed-in (Government of Curaçao, 2011, p. 3).

This netting caused a steep increase in the solar panel market. Due to the high resale price mixed with high sun-time on the Island (5 hours as opposed to 2.5 hours in the Netherlands), the payback period was in the range of 2 to 3 years, while the lifespan of such a system can go up to 25 years. This made investments very profitable, thus - due to the large wealth gap (section 4.1.3) - mainly the upper class and businesses started to adopt Solar PV rapidly (Interviewee #2, Energy Consultant; Interviewee #4, Energy Consultant):

"Then you really got a system that mainly the rich - which really happened - only the people with money invested in solar systems and the poor - who could not afford it - were actually presented with a bill for it, because they would then have to bear all the network costs."
(Interviewee #4, Energy Consultant)

Within a span of 4 years (2011 - 2015), the grid got an extra 8-10MW of rooftop Solar PV installations. Additionally, PV retailers started up very quickly (15+ companies started up in this same 4 year span):

"With 'Net metering', if you put a solar panel on your roof then you would have earned it back in less than two years. So, BOOM, that market went. In a short time they were on the net at 8MW. "(Interviewee #14, Energy Advisor)

5.1.3 Post tariff reform phase (2015 - 2019)

Due to the financial effect on the utility and mainly because of Aqualectra not being able to pay off fixed costs, in 2014, they lobbied to change the tariffs. These then changed on January 1st 2015, when the government switched. This is when the government (as advised by BT&P) implemented a 'fixed contribution' as well as a halving of the resale price (Naf 0.25 per kWh). This was calculated by BT&P in order to have an average payback period of 7 to 8 years for Solar installation. Thus, for private owners of solar panels, a 'netting arrangement' was abandoned at the time, whereby the self-generated electricity was offset against electricity taken from Aqualectra. Users who install solar panels to generate renewable energy would have to pay a fixed cost of ANG 16.00 per panel per month. For businesses, the rate was ANG 32.00 per panel per month.

In the meantime, on the 1st of August 2018, the 'fixed contribution' has been reduced from 16 to 8 Antillean guilders (NAf) for private individuals, from 32 to 16 Antillean guilders for commercial connections and from 32 to 24 Antillean guilders for industrial connections. The feed-in reimbursement has been at the same level since 1 January 2016, namely 0.25 Antillean guilders per kilowatt hour (kWh).

After the tariff change in 2015, investments in Solar PV by private adopters stagnated substantially. Additionally, after halving the 'fixed contribution' in 2018, investments have not picked up. For comparison, in the period between 2011-2015, Approx. 10 MWp was installed and in the period between 2015 and now (2019), 1-2 MWp has been installed.

In the period from 2015 to now, almost all solar panel companies that arised so quickly after 2011 have had to close doors. The main company that is still up and running is 'Dynaf Group', which can be attributed to their diversity in products (aside from solar panels). Currently, their main buyers are international companies and companies in the tourism sector (hotels etc.), due to ecotourism and the image of being green attracting more customers for these companies:

"I have had customers, who said: 'we want solar panels there' and I said 'yes, but there are a lot of trees there, which does not seem convenient to me'. Then they said 'I don't care, I want solar panels there, because that is on the side of the road and then everyone can see that we are being green.' I said 'Then it will deliver less than it could.' then they said: 'I don't care'." (Interviewee #8, CCO at Dynaf)

After the tariff change in 2015 and the drop off in adoption, Aqualectra has set up two niche experiments: the "free Zone project" and the so-called "school project".

Free Zone project

The free zone project is an initiative to install solar panels on the roofs of the sheds of the Free Zone (at Nieuwe Haven). In addition, Aqualectra also plans to install panels on the buildings of the utility building that will be concentrated around 'Dokweg' in the future. The project concerns the installation and maintenance of a solar park of around 10.000 to 15.000 square meters, or around 40.000 solar panels, which would have about 15 MWp capacity. The electricity generated via the solar panels will be supplied directly to the grid. Aqualectra will be renting the roofs for a price per square meter:

"The rent serves as compensation for the risk of damage to roofs in the event of an emergency" (CEO of Aqualectra, Jonis)

In December 2017 a tender for the construction of the solar power plant was opened. The tender procedure has since been outsourced to 'DNV GL', one of the largest classification society in the world. This first tender allegedly failed due to incorrect specifications (Amigoe, 2019) and has since been postponed. in December 2018, Aqualectra restarted the tender, and has yet to find a suitable partner.

For this project, Aqualectra has done some small-scale experiments at the Free Zone location and made some calculations of the potential yield and assessed acceptability of potential adopters.

School project

This experiment entails a project in which Aqualectra places solar panels on rooftops of schools. Similar to the "free Zone project", the schools get payment for the rooftop area that is being used and the electricity is supplied directly into the grid. Recently, on the 8th of July 2019, the minister of education signed an agreement with a Chinese supplier that another five schools on Curaçao will equipped with solar panels, which makes it a total of 10 schools that take part in this project.

5.1.4 Current state of Solar implementation (2019 - future)

In Curaçao, 757 PV installations have been registered with the Telecommunications and Post Office (BT&P) as of October 2018. The applications for PV installation are subdivided into Household, Commercial and Industrial categories. The installed PV capacity is 12 MWp in total. However, these 757 PV installations are not considered to be production units by Aqualectra, since these units are not under the control of Aqualectra. Only fossil generation units and wind are considered production units by the utility company. The distribution by number of installations is 620 for households (82% - 3.700 kW), 119 for commercial (16%) and 18 for industry (2%). Soon (Q4 2019) Aqualectra expects to be able to use 15-20 MWp large-scale PV systems as production units. The solar panels for this extra contribution will come from the 'Free Zone project' and 'the school project', placing the solar panels on the roofs of schools and sheds spread across Curaçao, with the solar energy being supplied directly to the public grid. Thus, presently, there is 12 MWp of Solar PV linked to the grid, which is primarily produced and owned by the private sector (individuals and businesses). As aforementioned, Aqualectra only owns three small-scale Solar PV pilot plants, which comprises of an assembly of 1.1 kWp and one of 20.1 kWp directly connected to the grid as well as a stand-alone unit of 3.8 kWp providing their water reservoirs with power.

5.1.5 Conclusion of historical overview

Solar energy on Curaçao has a peculiar history. Three very important shifts of renewable energy implementation can be distinguished in Curaçao (1980-2011 & 2011 - 2015 & 2015 - 2019). Between 1980 - 2001, before the merger of Aqualectra, the focus was on small stand-alone technological niches by 'fanatics' and later also by KODELA and KAE to experiment with the new technology. After the merger of Kodela and KAE to Aqualectra in 2001, the internal tensions held back a market niche implementation, but more pilot project were deployed for experimentation, particularly grid-connected technological niches (to experiment with the effect on the grid). This lead to Solar Energy becoming a viable technology for their own core operations, since at this point 3 small-scale plants were in operation with a capacity of about 25 kWp. The biggest shift occurred in 2011, when politics entered the picture and a net metering scheme was introduced, in which Aqualectra had to buy electricity from sIPPs at the same rate as the selling price of electricity. This caused a boom in the market, which lead to an increase of 10 MWp on the grid, solely by the private sector, in a span of only 4 years (2011 - 2015). Due

to the quick increase and large costs for Aqualectra, this net metering was abruptly changed in 2015, introducing a fixed contribution and a halving of the resale cost of electricity, leaving a dent in the market that has yet to be recovered. From 2015-2018 comparatively only 1-2MWp has been installed. In 2018 the fixed contribution was halved, but the market has not improved after this change.

Several questions emerge from this historical overview. **First**, why did the development of stand-alone technological niches continue until essentially 2011, while the majority of these experiments were successful and were already implemented as early as 1984? **Second**, why did Aqualectra only focus on grid-connected technological Niches for that long of a period between 2001-2011 while it was clear that the technology worked well for their internal operations. Hence why did politics have to step in so that Aqualectra was forced to deploy a large-scale market niche, while being ill-prepared? **Third**, why did politics step in and implement the net-metering scheme? **Fourth**, why did the government implement the fixed contribution in 2015? **Fifth**, why exactly did the investment in solar have a sharp decrease after 2015? **Sixth**, why did this decrease not improve back after 2018, when the tariffs were made more profitable?

In the following section, I answer these questions by analysing niche development in terms of visions and expectations, the social network involved and learning processes. The niche dynamics cannot explain everything, since Regime and Landscape dynamics also play a significant role. In the sections below, I will sometimes refer to landscape and regime dynamics and in the final section I will relate the effect that these have had on internal niche dynamics.

5.2 Analysis of Niche Dynamics

5.2.1 Voicing of Expectations

Expectations 1980 - 2001

For the expectations in this time period (1980 - 2001), there is not much information to be found, due to the fact that Curaçao is a SIDS, especially in this time period not a lot of information was provided. Thus, this part of the analysis will mainly be comprised of textual data from an interview I did with Interviewee #14 (Energy Advisor), who was one of the main experts in the field of renewable energy in this time period and worked for Kodela and after the merger, for Aqualectra. This is validated through other interviews with experts in the Energy field:

"Via Aqualectra, Karel Tujeehut (Interviewee #14, Energy Advisor) was one of the people who stimulated the wind farm at the time - he is, by the way - I dare not say the only one - but he is one of the very few who has a positive view of the development of alternative energy states on Curaçao ." (Interviewee #3, Energy Consultant)

The data is validated by checking statements with factual data in literature in that time period.

As mentioned in the historical overview, Solar energy was less developed in the 90's, it was more expensive than wind energy and less efficient. What's more is that the Utility had not experimented with technological Niches before 1990 and thus had less experience with the technology. Additionally, since wind energy produces electricity for 24 hours (Solar PV only produces during the day) and thus more closely resembles the conventional utility, the conventional utility mindset made the implementation of Solar PV more difficult than wind (Interviewee #14, Energy Advisor).

At the time (1990 - 1995), the technology was mainly being implemented in very niche stand-alone installations by a handful of interested individuals (Or 'fanatics'). There were some pilot projects that mostly had positive outcomes. One of the major barriers was Aqualectra"s reluctance to let solar systems feed into their network before 1995. The expectations for grid connectivity at the time were still doubtful, since the conventional Utility had technical concerns, mainly in the form of frequency instability. Interviewee #14 (Energy Advisor) attributes this to the conventional utility mindset that is still - in a lesser form - in place today:

"We know the boiler and the gas turbine, we know that, we master that. And all that is new is a problem and reliability, loss or load probability that skyrockets, etc. The concept as the utility man is raised, safety and things. This means that innovation within that organization is simply difficult to move." (Interviewee #14, Energy Advisor)

Consultant and advocate of renewable energy has the following to say about the concerns that were present at that time, showcasing the tensions between innovation and conventional mentality:

"Solar Panels had inverters that synchronize perfectly to the wavelength of the net, so those concerns were pure ignorance." (Interviewee #3 (Consultant))

In this period, it is clear that the only reason for implementation of solar was technological. There were no additional concerns with regards to Climate change or Oil price fluctuations. In the period between 1990 and 1995, mainly KODELA, but KAE. also, started to monitor the private installations that were independently popping up on the Island. This could be considered the start of the technological niche experimentation phase. Because of the success of the stand-alone installations, expectations become more positive. Because of this, in 1995 KODELA implemented their first private grid-connected technological Niche, which was also a success. This lead in 1998 to an expansion of the experiment to street lighting and in 2000 to a 20 kWp grid connected and roof integrated Solar (Interviewee #14, Energy Advisor, 2015).

Before any large-scale implementation, those two companies (Kodela and KAE) were integrated in 2001, to become Aqualecta. With the merger of the company, there were still clear internal conflicts when it comes to expectations regarding renewable energy:

"There was the one group, among which I fell, who tried to apply innovation. This group had put everything in place to start a market niche. You also had the operational group, which said: 'Yes, but there is no grid code, there is no this, there is no that, there are many fluctuations, how do we deal with it, it becomes a problem, etc etc.' ultimately It was still internal." (Interviewee #14, Energy Advisor)

This expectation misalignment explains the relatively slow experimentation phase for Aqualectra. This then led to the fact that in the period between 2001 and 2011, still no Market Niche was deployed, despite the success of most technological Niche experimentation. In line with theory, Technological niches enable society to learn about the characteristics and possibilities of alternative technology, as well as to improve technology (Kemp et al., 1998; Weber et al., 1999, Hoogma, 2000). Research by Hoogma (2000), Hoogma et al. (2002), Van Mierlo (2002) and Raven (2005) shows that technological niches indeed fulfill those functions, but that learning is very partial. Much is learned about instrumental issues such as technical functioning as well as about user appreciation. Things about which little is learned are:

- what exactly people want and what their willingness to pay is for that;
- the conditions for wider distribution and use;
- the effectiveness of (possible) incentive measures;
- alternative solutions and configurations;
- sustainability aspects.

Due to Aqualectra's internal tensions preventing a market niche to be deployed, they were not yet ready to open up the market for Solar PV in the form of a market niche. Despite this, due to Aqualectra being a government NV, they have to comply with government policy. Hence, because of the political move in 2011 ('net metering' scheme), Aqualectra had some technical as well as financial hurdles. The technological state of the infrastructure - to this day - does not to an optimum effect allow decentralized in-feeding of electricity by medium or large producers of electricity. Aqualectra was in the process of developing a 'masterplan' to facilitate non-plant in-feeding via the transportation network (Aqualectra, 2012). As a result, according to the interviewed experts, there was - and currently still is - a high risk of infrastructure failures (Guda, 2012). Because of the internal tensions, the plans for a smooth introduction of Solar PV was slowed down and now, due to the political move Aqualectra would have to open up the market in an abrupt and sub-optimal manner.

"That market has been opened, a tariff structure has been laid down how it should be done and in fact that was another example of: 'You must not have the politicians in it.' What did the politicians do, who said: 'I am going to promote solar panels' [...] 'the rate is set in such a way that Aqualectra subsidized solar panel developments'." (Interviewee #14, Energy Advisor)

Expectations 2011 - 2015

The introduction of a 'Net metering' system in 2011 caused a boom in the market. This can be attributed to the profitability of investments in this period, with a payback period of about 2 to 3 years, for a lifespan of approximately 25 years. From interviews with adopters, it becomes clear that the main motivation for adoption was the profitable investment opportunity, it was less about climate change or the environment. This is showcased by the observation that a lot of

private adopters filled up their roofs with panels instead of sizing appropriately to their specific needs, suggesting that they want to have as much overproduction as possible, to sell back to the grid (to Aqualectra). The environmental friendliness was merely seen as a welcome bonus, but not the main reason for adoption, which could also be explained by the lack of awareness or care for climate change issues, as explained in section 4.1 (Landscape Analysis):

"My main motivation for adoption was because the rates for electricity on Curaçao are so incredibly high and therefore the investment would provide cost savings. In second place I also did it to contribute to sustainable energy or alternative, clean, green energy." (Interviewee #10, Private Adopter)

"I say no to myself, it should not cost me anything, if it is more expensive than Aqualectra, then I go to Aqualectra. If you say 'listen, I am environmentally conscious and it can cost a little more', that's fine, but I say to myself 'electricity remains electricity'." (Interviewee #2, Energy Consultant)

The utility, government and regulator had different views on this matter. The expectations of the government (supported by BT&P(at the time of introduction was the promotion of Solar PV purely by providing financial incentives (in the form of high feed-in tariffs). On the other hand, the Utility's expectations were that PV technology should be supported by investors, mainly due to it being a 'green' alternative to fossil fuel-based energy. Citizens should not make profit out of the investment, while the Utility has to be a 'back-up' and has to 'subsidize' the private adopter's profits (Interviewee #1, Program Manager at Aqualectra; Interviewee #15, CLO at BT&P). To the contrary, according a Program Manager at Aqualectra (Interviewee #1, Program Manager at Aqualectra), private adopters should invest in solar even if it costs them more, because of the technology's sustainable nature (misalignment of expectations):

"The payback period is usually 7 or 8 and sometimes 10 years. Here on Curaçao you could earn back your money from a solar system in about 2.5 to 3 years. That"s absurd - absurd in the sense that if you just look at reality, that should not be the case. Why was it like that? Because at that time it was simply introduced by the government. It was introduced in the form of; invest in this and within 2.5 to 3 years you will have your money back and then you can make money. Worldwide you just see that nature lovers, people who are activists, people who are also just care about the world, the environment, they think like; 'I am going green, even if it may cost me a little more'. That was also the slogan for years in the Netherlands, also when I lived in the Netherlands 15 years ago: 'It costs you a little more, but then you have something for the future.' And here it was: 'It's just a business, you can just make money with it'." (Interviewee #1, Program Manager at Aqualectra).

As aforementioned, this abrupt implementation was a political move, for reasons about which there is a lot of debate. According to the government at the time, the abrupt introduction was necessary, due to a lack of vision on the Island, which needed changing.

"Prior to its independence, Curaçao had no policy, no long-term vision, very obsolete legislation and lacked any kind of regulatory framework (or regulator for that matter) with regards to energy" (Schotte, 2012).

The implementation caused a steep increase in the rate of adoption in the market, which had **two major impacts** on the Utility. **Firstly**, Interviewed experts (interviewee # 1; interviewee # 2; interviewee # 3; interviewee # 4; interviewee # 6; interviewee # 14), claim that the 'net metering' scheme was financially devastating for Aqualectra, since Aqualectra had to buy electricity for the same amount that they sold it, while the scheme did not take the utility company's fixed costs into account, hence they were making losses due to the quick rate of over-capacity adoptions by private adopters (Interviewee #1, Program Manager at Aqualectra):

"What happened then, Aqualectra does not have those production costs, but it does have certain costs of the distribution network. Furthermore, there are people employed there, there is a building and there are subtractions. All these costs are fixed costs. The only thing you don't have is the actual production of that kWh. So what came about as a result; Aqualectra had to deliver the kWh, while it does have the fixed costs, which were no longer being covered by PV users. What subsequently happened here on Curaçao due to this construction, the payback period of such an installation became 3 years." (Interviewee #15, CLO at BT&P)

Secondly, due to the regime's dependence on diesel engines and an absence of any type of energy storage - after hours of high solar energy generation - the Utility has to rapidly increase energy production around the time of sunset to compensate for the loss of solar generation. This phenomenon is called the 'Duck-curve' and is internationally the main concern for fossil fuel-based countries where Solar PV installations have rapidly increased (See Section 5.2.3 for a more in-depth explanation). The back-up position is very expensive for any utility. Additionally, due to the decrease in demand during the day, the diesel-engines were producing at suboptimal efficiencies - due to usage below 85% of capacity - meaning that more diesel had to be used for less energy - further increasing costs.

Net metering works in other countries, because the government subsidises this, and they do not leave it to utilities to pay for this amount themselves. Additionally, it is usually a transitional arrangement to boost the technology, which is announced from the start that the metering will stop after a defined period of time, like in The Netherlands and The United Kingdom.

As the theory also shows, backlash effects occur when a renewal is introduced too abruptly or without thought, which may cause defects in implementation (Rotmans, 2006). Due to these implementation problems, public opinion about the renewal can deteriorate. This leads to a lack of support, which makes a continuation of the transition more difficult. This is precisely what occurred on Curaçao, due to the abrupt (political) implementation.

Expectations 2015 - 2019

New expectations about Solar PV emerged in 2015. Due to the financial impact of the implementation on Aqualectra, the utility company lobbied for a change in tariffs in order to compensate for the fixed costs that are not being covered with the 'net metering' scheme:

"In practice, Aqualectra simply went to the regulator and said said: 'we think you made a mistake, you calculated like that and it should be like this, because you just take us as a backup'." (Interviewee #1, Program Manager at Aqualectra)

These changes came in 2015 when the government changed, in the form of a monthly 'fixed contribution' (Naf 16 per kWp per month) and halving of the resale price (Naf 0,25 per kWh). The expectations from the Utility were that the technology had potential and should remain a part of the core business of the utility company, but with the current tariffs, Aqualectra would go bankrupt or electricity prices would rise substantially for citizens who could not afford solar panels:

"Users want a PV unit at home and for the same rates as we sell it, they want to sell it back to Aqualectra, but Aqualectra must always be available there as a backup. And THAT is our problem, because in our opinion: 'If you invest in your own installation and so on, fine. But we have constructed that infrastructure and we must also ensure that that infrastructure remains good'." (Interviewee #1, Program Manager at Aqualectra)

All interviewed experts align with Aqualectra's statements that the tariffs had to be changed, hence there is a consensus that the 'net metering' scheme was not a viable business model for Aqualectra, which would inevitably lead to the company's bankruptcy or an increase in electricity prices for non-PV owners (Interviewee #14, Energy Advisor; Interviewee #15, CLO at BT&P; Interviewee #7, CEO at C.D.M.; Interviewee #6, Professor at UoC; Interviewee #2, Energy Consultant; Interviewee #4, Energy Consultant):

"At first it was not fair for Aqualectra, however you look at it, you still need them as a backup. You use their network and you don't pay for it and then all other users on the network who do not have solar energy pay." (Interviewee #4, Energy Consultant)

"You have to imagine: "Let's say you can make bread and you make bread for 30 cents and you will buy it from me for 50 cents - it doesn't make sense. That was what happened with Aqualectra". (Interviewee #2, Energy Consultant

Nevertheless, there is also a consensus that the implementation of the new tariffs in 2015 was not handled properly - mainly due to a misalignment of expectations between government, the regulator, the utility and the consumers - causing backlash effects within the Solar PV market:

"BT&P did it very carelessly - very carelessly. The start when they started it was very sloppy. That is why I say it was a total mess." (Interviewee #2, Energy Consultant)

"It was necessary, incidentally, because it could no longer continue like this, but yes it was quite abrupt." (Interviewee #15, CLO at BT&P)

Abrupt implementation
Three main reasons are given for this, namely 'Lack of communication' (Bad voicing of expectations), 'New tariffs are bad' and 'Lack of a transitional period':

"The way it was introduced and the rate itself is simply not well done. I do not want to step on the toes of people who have made these decisions. But in retrospect when you look at it is just not well communicated at all, not well done, the pricing structure is not correct etc. Again, there are plenty of experts in the field and they have made these decisions. In retrospect I say: 'They did it all wrong, I would never have done it that way'." (Interviewee #14, Energy Advisor)

The **first** reason could thus mainly be attributed to bad communication from the part of the government. If the expectations are communicated properly from the start, then you can mitigate a misalignment of expectations in the future (source). There seems to be a consensus that the communication from the government towards citizens (private adopters) was bad. The 'net metering' was initially not introduced as a boosting measure (that would inevitably stop).

"When they introduced it, they did not report that it was a temporary arrangement to 'boost' the technology." (Interviewee #14, Energy Advisor)

"Also the communication around it was - what I say - a mess. It didn't go well." (Interviewee #2, Energy Consultant)

This means that people invested with a certain calculated return on investment (ROI). This ROI would look totally different after the tariff changed in 2015. According to some of the PV owners, they would either not have invested if they had known from the beginning that the tariffs would change, or they would have invested in less capacity (Interviewee #10, Private Adopter; Interviewee #2, Energy Consultant; Interviewee #3 (Consultant)):

"I probably would not have invested in solar panels with the current tariffs. It is a discouragement policy. They say; 'yes, we allow that'. You are actually just being punished for installing sustainable energy on Curaçao. They cannot substantiate why they could not give another feed-in rate. As I said, it is a discouragement policy. First Aqualectra says; 'yes, we are open and you can install solar panels', but then afterwards 'its not viable'. It is half the truth."(Interviewee #10, Private Adopter)

"I was completely prepared to invest in Solar panels for my home, I even installed brackets to put them on, but then the tariff change came. I recalculated and I said: 'No, at my age it is not worth it anymore for me to invest'." (Interviewee #3 (Consultant))

This was also partly due to the political move on the part of the government, leading to them not properly communicating that the 'Net metering' arrangement was a temporary arrangement to boost the technology, since it was 'obvious' that such an arrangement is not viable as a business model in the long run. At least, not with the current cost of electricity (similar to NL and UK):

"They should have said 1 year - or 2 years or 4 years - but then everyone knows in advance where they will be. And people are angry about that." (Interviewee #2, Energy Consultant)

The **second** reason is the fact that tariffs are currently interpreted as being too high. Interviewees express that even though the tarrifs used to be too profitable for the consumer and devastating for Aqualectra, they have become too profitable for Aqualectra and devastating for the consumer (Interviewee #2, Energy Consultant; Interviewee #14, Energy Advisor; Interviewee #3 (Consultant); Interviewee #5, Energy Entrepreneur ; Interviewee #11, Curaçao Resident; Interviewee #6, Professor at UoC):

"I think what they have done now - the first time they privileged the users too much and now they - I think - privilege Aqualectra too much. Just like Aqualectra used to make its own sandwiches for 50 cents and had to sell them for 30 cents, it now is the other way around. I sell it for 25 cents, it costs me 40 cents and if I have to buy energy, I have to pay 60 cents, so 'it does not make sense'." (Interviewee #2, Energy Consultant)

The **third** reason is the fact that there was no transitional period for those who has already adopted Solar panels in the 'net metering' scheme (Interviewee #10, Private Adopter; Interviewee #2, Energy Consultant; Interviewee #4, Energy Consultant; Interviewee #14, Energy Advisor). Since the new rates also applied to already realized solar installations, adopters made long-term investments which now looked completely different. This made it that those who had already invested could interpret the change as a fine for their initiative (Interviewee #14, Energy Advisor). It went from a payback period of 2 to 3 years, to 7 to 8 years:

"I was presented with a picture with a certain payback period at a time when it was interesting to purchase solar panels. After I placed the order, really right after that the tariffs changed. I placed my order in November 2014, before that I had to orientate a few months, negotiate and I believe it was on January 1, 2015 that the arrangement was changed. Then they introduced a so-called 'service fee'. In addition, the feed-in rate has also been halved. So the whole outlook was completely different at first." (Interviewee #10, Private Adopter)

This plays into the Landscape analysis findings that show that SIDS including Curaçao can have abrupt policy changes:

"And that too is the Caribbean - where in the Netherlands, or in many countries, there is a bridging period to restructure or adjust certain policies, it can just be different here tomorrow. So what had a great deal of influence at that time was the solar tax of 8%, which made the ROI (Return on investment) for many people just look completely different." (Interviewee #2, Energy Consultant)

This was especially devastating for individuals that took out loans at the bank to make these investments:

"You have to imagine that a lot of people went to banks and, on the basis of the old ROI calculations, took out loans and thus purchased solar panels and installed them on their roofs. That change in rates has had very adverse consequences especially for these people." (Interviewee #8, CCO at Dynaf)

Aftermath of the tariff change

Because of this abrupt implementation, multiple lawsuits followed. Most notably, the Association for Sustainable Energy (VDE) and Supermercado Luz bv (Goisco) filed a lawsuit against the government of Curaçao and Aqualectra. The plaintiffs filed a lawsuit precisely because the initially favorable investment on Curaçao for solar panel owners was drastically reduced as of 1 January 2015 without any warning or transitional arrangement. As interviewees also expressed, this caused their ROI to be drastically different than the ROI upon which their investment was based. According to the court, it is logical that there are extra costs for Aqualectra that can be attributed to the use of solar panels. This would include administrative costs and inspection costs. According to Aqualectra, solar panel owners cannot therefore be equated with other customers who take saving measures, because for customers with, for example, LED lighting, no standby power needs to be maintained in case their demand increases again. Their electricity consumption is constant, while it fluctuates with solar panel holders.

On the 20th of May 2019, the final judgment was given in the case in which the Court of First Instance ruled in favor of the government of Curaçao and Aqualectra. In the judgment, the Court attached the greatest importance to this payback period. Based on reports from the experts engaged by both parties, it has been calculated that the payback period for solar panels is on average 7 to 10 years:

"I wanted to calculate that, which I have now done, and it seems to be correct. So, when BT&P says: 'The feed-in time is from 3 to 4 years, which it was at first, to 7 to 8 years, which is common', at least the payback period is correct." (Interviewee #2, Energy Consultant)

The Court of First Instance ruled that this was in line with the internationally applicable payback period (7 to 10 years) and rejected (partly for that reason) the claims of the VDE and Goisco.

In the interview with the regulator BT&P, the interviewee did mention that they suggested a transitional arrangement for already realized installations, but due to their advisory role, the minister could reject this and opt to implement the change for everyone.

"We have proposed a transitional arrangement to the minister for the people who had already invested at the time and that minister did not accept this. Ultimately, the minister did not want that for social reasons. He just didn't want the bill to go to non-PV users. There is also something to be said for that." (Interviewee #15, CLO at BT&P)

Hence, it's not only that the tariffs became less profitable, but more about the way that the change was managed, and a misalignment of expectations between the government/Aqualectra and Private adopters/Commercial adopters, due to improper voicing of expectations. The fact that there was no transitional arrangement - especially because there was no warning beforehand - damaged the investment climate and created a trust gap. Thus, in line with theory (Rotmans, 2006), the abrupt implementation of a 'fixed contribution' in 2015 had its own 'backlash effects'. This fee was most infamously called "solar tax" (CBS, 2015) or even "solar fine" (Rob, 2019) by the general public. This shows the negative connotation that the implementation of this fee had:

"Many call it the 'Solar tax', but some have an even more negative name for it: 'Solar Fine '." (Interviewee #4, Energy Consultant).

Therefore, almost all installation came in the period between 2011 and 2015 when the rates were high. This can be contributed to the fact that it's all about financials for people on the island (10 interviews). Additionally, it could be that the people that really wanted to invest, already did so in that period, hence they would not buy it now even if the investment climate was not damaged. But it is undeniable that these abrupt and political changes have caused these "backlash effects":

"You can still feel it there - because no matter which developer, owner you talk to you will only hear negative stories. Rightly so, but the way they interpret it is not correct. That is all I want to say to you. I totally agree with their feeling, their emotion, but not with the way they interpret the changes." (Interviewee #14, Energy Advisor)

Due to the 'backlash effects' from the implementation of the Solar Tax in 2015, leading to a lack of support for the technology (trust gap), the investments in Solar PV stagnated substantially in the period between 2015 and 2018. This caused long-term damage to the sector, which explains the fact that most Solar Panel retailers went bankrupt after the tariff change was implemented in 2015.

Tariff reform after 2018

In 2018 the government attempted to make investments more attractive by halving the 'fixed contribution' (solar tax). The fixed connection costs have been reduced from the 1st of August 2018 from 16 to 8 Antillean guilders (NAf) for private individuals, from 32 to 16 Antillean guilders for commercial connections and from 32 to 24 Antillean guilders for industrial connections. The feed-in reimbursement has been at the same level since the 1st of January 2016 (Naf 0.25 per kWh). From the data on investments from 2018 to May 2019, this tarrif change has not had any effect on improving the investment climate, since investments have not picked up (Interviewee #3 (Consultant); Interviewee #2, Energy Consultant; Interviewee #15, CLO at BT&P; Interviewee #4, Energy Consultant; Interviewee #6, Professor at UoC; Interviewee #14, Energy Advisor):

"So in terms of investment climate that is very bad - that was so incredibly bad. And the scheme is now far from favorable. And you also see that there is almost no development anymore. It is again slightly improved, because the rate that you pay for connecting to the network, it has been halved. But profitability has declined considerably and NOBODY is investing - I think almost nothing is happening anymore. Many companies were established and all companies are gone, except - I think - Dynaf Group." (Interviewee #4, Energy Consultant)

"They are also trying, because the rates - if I am not mistaken - were adjusted again in January last year and have fallen slightly. But you don't see that on the effect on new projects. So the projects have not become more since the adjustment."(Interviewee #6, Professor at UoC)

For comparison, in the period between 2011-2015, Approx. 10 MWp was installed and in the period between 2018-Now, 1-2 MWp has been installed.

This trust gap is also visible due to the fact that Curaçao is not the only country that introduced "Sun Tax". Several other countries and some states in the U.S. charge a fee in order to maintain grid stability. Supplier and installer of solar panels Eco Energy lost almost all of its business in Curaçao, after the introduction of "Sun Tax" in 2014. The retailer recognizes the need for this fixed contribution for the use of solar PV.

Several other countries and some states in the U.S. pay a fee to preserve grid and grid stability.' Solar panel supplier and installer Eco Energy lost nearly all of its company in Curaçao after the implementation of Sun Tax in 2014. The business recognizes the need for the use of solar facilities for this monthly fee.

"The fee itself is not the issue', but we do think it is too high" (GM of Eco Enegry, Eelco Baak).

The lack of alignment in expectations enhanced the backlash effects that we currently see in the Solar PV market. Consumers just have profit expectations and have a 'lack of trust' to invest in the long term, due to the unstable nature of the political sphere on the Island. So, it is not the sun tax itself that is bad, it is the way that it was introduced, which caused these backlash effects.

This 'lack of support' goes beyond the tariffs being bad, because, as the lawsuit and other experts established, the rates have become less profitable, but the investment in solar panels is still worth it from a financial perspective (Interviewee #6, Professor at UoC; Interviewee #2, Energy Consultant; Interviewee #1, Program Manager at Aqualectra; Interviewee #15, CLO at BT&P):

"Many people think 8 or 9 years is too much, because it used to be 2 or 3 years. So, I think people should be better informed, since I think investing in solar panels is still a good thing. You get money back - you just have a profit - it takes a bit longer, but it's not bad." (Interviewee #6, Professor at UoC)

"For some people who might take a more realistic view of it, like: 'Ok, I expected 3 years, but I already have them, now my ROI is 6 or 7 years, but in the end, I'll still earn it back.' Look, the benefits of sun, they are completely separate from this; it mainly has to do with investment and payback time." (Interviewee #2, Energy Consultant)

The revision of the rates after a relatively short period also makes investors reluctant to invest in renewable energy systems. This could be prevented by developing a system that provides sufficient guarantees to investors (households, businesses). For new tariff adjustments, it could be envisaged that these would only apply to new projects.

The bad communication and the abrupt implementation created a shift in expectations of consumers. Because of the initial 'Net metering', consumers now have an expectation that Solar Panels can and should be very profitable by having a pay-back period of 2 to 3 years, which is very ambitious. Most interviewed consumers find 7-8 years too long, even though experts say that it is still a profitable investment:

"It is an investment. You only have to earn it back and it would be ideal if, just like in a company, you earn back the investment between 3 and 5 years. That is normal. If you have to earn something back in 10 years, you have to think about it 2-3 times. In 10 years, you don't even know if you are still alive. Many people want to invest, but they say look; 'If I am going to install on-grid with the current facilities and costs, then I have a return on investment of 8 to 10 years and that is very long'." (Interviewee #5, Energy Entrepreneur)

Expectations 2019 - Future

New expectations about Solar PV were expressed in 2017 with the introduction of the National Energy Policy 2017. In this policy it is clear that the government of Curaçao and Aqualectra will not be incentivizing Rooftop solar PV:

"Commercially it is much more interesting than residential, unless you are just a nature lover or just someone who also wants to see your own children healthy on the island - even in the world - only then you shoud go along with something like that." (Interviewee #1, Program Manager at Aqualectra)

The majority of the new development of Solar from 2019 to 2055 will be in the form of two PPA Solar Farms, one of which currently has a tender and is expected to be done at the end of 2019.

"Ultimately we are just going to implement a Solar farm. It does not really make production cheaper, but what we are fighting to get very competitive prices in the form of a PPA (Power Purchase Agreement) - so that we can still purchase power at the lowest rate possible from Solar Panels." (Interviewee #1, Program Manager at Aqualectra)

This lack of support for Rooftop solar PV can be attributed to two main reasons. Due to the abrupt implementation, the grid was technically not ready for so much in feeding of electricity and the fact that so many sIPPs are connected to the grid, the duck curve effect is very prominent.

General expectations are that the current tariffs are going to change and if they do, that Solar PV installations will pick up once more:

"Anyway, the situation is now how it is. I know they are working on it, energy is now a hot topic, especially among inhabitants on the island, but also with the government. Everyone knows that this is going in one direction and that the future will look different. The only question is how all parties can organize this well together, so that it is good for everyone." (Interviewee #8, CCO at Dynaf)

But, even so, some believe that even if the tariffs stay as they are, it is a matter of aligning expectations with better communication and educating the public. For example, the expectation of professor Bulbaai is that it is a matter of communicating the expectations better and trying to bring alignment in this:

"I think people need to be better informed. Why? Because a solar panel - the entire system - has a lifespan of 20 to 25 years. You may have to change the inverter after 10 to 12 years, but let's say the solar panels work between 20 and 25 years. As it is now, the payback time is around 8 to 9 years. So that is not so bad for a project that actually takes 20 or 25. I think if we explain people well about the payback period - that you have all your money back within 8 or 9 years and a project takes 20 to 25 years - I think if people are well informed, then I think people will start thinking differently about it". (Interviewee #6, Professor at UoC)

Conclusion for Expectations

I draw the following conclusions on dynamics in expectations and visions:

An abrupt political implementation shaped visions and expectations of adopters, which made rooftop Solar PV adoption a profit enterprise, which was in line with the government's expectations for the technology at the time. The expectations of government and adopters were misaligned with those of the regulator and the utility, which caused the tariff structure to change abruptly in 2015. With this change came its fair share of backlash effects, leading to a lack of support of the technology. Even though the tariffs in and of itself are not bad, the misalignment of expectations left a dent in the market that the country has yet to recover from. Interestingly enough, the dynamics in visions were mainly caused by internal circumstances to do with tariffs and policies and none whatsoever with the innovations in the technology itself. Thus, the result from the abrupt implementation for the 'net metering' scheme (market niche experiment) had an immensely negative effect on the perceptions and expectations of the technology.

5.2.2 Network Building

In this section I mainly discuss the role of the utility company, technology suppliers and private adopters during the historical development of Solar PV in Curaçao. An emphasis is placed on the period after the deployment of the first market niche (2011-2019), particularly what effect the tariff change in 2015 had on 'Network Building'.

In the concluding paragraph of this section I discuss the composition and alignment of this social network during different periods, and how these aspects provide an explanation for niche development.

Public Authorities

In the period from 1980 to 2011, the government was uninvolved with pilot projects in the Solar energy niche. It wasn't until 2011 that the national government mandated the 'Net metering' scheme. Moreover, this did not entail any government funding. The electricity was to be bought by Aqualectra for the same price that the utility company sold their electricity. It was during this time that BT&P was assigned as regulator of the energy sector on the Island, with an advisory role for the minister responsible for energy. During this period BT&P has been in charge of determining the electricity prices and thus also the resale prices:

"We have an advisory function in the energy market and for the most part it is aimed at the pricing of energy services or energy products, so electricity and water. By electricity I also mean the rates for the delivery by end users to the distributor on the basis of those solar installations" (Interviewee #15, CLO at BT&P)

According to BT&P, even with their advisory role, it is an anomaly if the minister in charge does not take their advice on tariffs and regulatory changes. Chief Legal Offices (CLO) at BT&P, attributes this to the fact that BTP makes it easier for politicians to bring forth changes with the backing of an independent agency, especially due to the small community in Curaçao:

"Even though we currently only have an advisory role, I have not seen the government official disagree with our advice in the last 8 to 9 years (aside from the time in 2011). Because everything is calculated by an independent body, politicians can more easily communicate to the public why e.g. rates have to increase, while not being the one to blame." (Interviewee #15, CLO at BT&P)

This has only happened once since their start in 2015, when the minister of Finance (Jardim) who was responsible for the energy sector at the time, did not opt in for a transitional period for private adopters who had already invested based on an ROI that is calculated with a 'net metering scheme' in mind. This was because the minister did not want the costs to be beared by those who could not afford panels:

"At the time Energy was in the portfolio of the minister of Finances, mr. Jardim at the time. He did not take our advice of a transitional period out of social considerations. He simply did not want the bill to be with non-PV users." (Interviewee #15, CLO at BT&P)

Furthermore, the changes in tariffs in 2018 were also calculated by BT&P. This calculation is based on a Payback period of 7 to 8 years, depending on PV panel quality and system size.

Important in network building here is the relationship between Aqualectra and the government. Due to Aqualectra being a government NV, making them dependent on the government (through BT&P) for their electricity rates and tariffs, it is important for the Utility to establish good relationships with the national government. This network building or lack thereof showed its importance in 2011, when the 'net metering' was suddenly introduced. If the network was in place with the government at the time, the Utility could have aligned its expectations with the national government and postponed the implementation. This did not take place, leading to an implementation that was not based on enough evidence from experimental data.

Equally important was the network building between Aqualectra and BT&P. Due to BT&P's new jurisdiction in the energy market, it was important for Aqualectra to establish a relationship with this public legal person. This proved especially important in lobbying for a change in tariffs in 2015 ("Solar Tax" introduction). So much so, that many argue that the tariffs were changed to be made too favorable for Aqualectra (Interviewee #2, Energy Consultant; Interviewee #6, Professor at UoC; Interviewee #14, Energy Advisor; Interviewee #3 (Consultant)):

"I think BT&P and the government started to protect Aqualectra too much." (Interviewee #14, Energy Advisor)

Technology Suppliers

Before the implementation of the 'net metering' scheme in 2011, there were no dedicated solar panel companies in Curaçao. In the period between 2011 and 2015, multiple companies started up and had a profitable business. Most companies were small and offered an advisory role as well as a supplier role.

Established in late 1990's (1999), 'Dynaf Group' was the largest supplier of generators and subsequently became the largest supplier of solar panels (after 2011). Between 2011 and 2015 the company supplied a majority of the 10 MWp of solar panels. In addition to solar panels, the company kept its focus on the supply of generators, which is what they started with in 1999:

"We also focus on generators, which is what we started with. Currently, you can say that we are market leaders. We also have 24-hour service attached to this." (Interviewee #8, CCO at Dynaf)

Other companies, e.g. 'EcoEnergy', were also large retailers. These companies were specifically started up as solar panels retailers. These companies had no prior experience with other technologies and often could not react adequately to the tariff change and the market decrease that followed in 2015, causing most of them to go bankrupt if they were only established in Curaçao. Dynaf is the only major company that survived the lack of adoption in the market, which the company attributed to its diversity of expertise:

"Because the change in rates has caused that - I think - 90% of the companies that were started then are no longer there. We are actually the only one, perhaps there are 2 other smaller parties, but we are the only party at the moment who can handle large-scale projects." (Interviewee #8, CCO at Dynaf)

"For us, the tariff change has also caused a downfall in our turnover - of course. But if your other product groups just go through positively, at the end of the ride your business is still healthy." (Interviewee #8, CCO at Dynaf)

Curaçao, being is Caribbean SIDS, faces its specific challenges when it comes to this particular internal niche dynamic. Because Curaçao is an isolated Island, it is substantially harder for companies to establish network connections with quality partners. Firstly, because there is a lack of expertise on the Island and secondly because of the barrier of establishing networks with international partners. Even within the Caribbean region, there is a limited amount of options for retailers like 'Dynaf Group'. In an interview the company's CCO (Interviewee #8, CCO at Dynaf) expressed that it is important to broaden the network, while keeping good networks intact:

"Because we are an island in the Caribbean, it is always a search for reliable and good partners. If you have found them, even though they are also scarce, you also want to give other potential partners a chance too. Because everything is somewhat on a smaller scale on the

island, the resources are somewhat limited in that sense. We work with all A-partners - 'Sneider electric', 'ABB', 'Victron Energy'. We do this consciously, because we also stand for a certain quality of our products. They are all not located here on Curaçao, so that is also accompanied by slightly different business operations." (Interviewee #8, CCO at Dynaf)

Additionally, logistics plays a role, making everything take longer than it usually would in mainland countries:

"We have suppliers in the Netherlands, France and America for our various product groups. That must of course all be organized. These products must come to Curaçao, Aruba and St. Maarten and from here we have a warehouse for storage - St. Maarten and Aruba also have storage options - that then supplies the specific locations, where we mainly ensure that it is installed and delivered properly. We are also dependent on other parties in this, and that does not always go well, because you still live on an island in the Caribbean (which also has its benefits). (Interviewee #8, CCO at Dynaf)

On a Caribbean SIDS like Curaçao it is important to form partnerships with local specialists, especially, due to the small scale and therefore lack of expertise. This is also what a company like 'Dynaf Group' expresses to be of utmost importance, to be aware that projects require collaboration and thus national network building is important on Curaçao:

"Dynaf is a company that really seeks cooperation. We cannot do it alone, so we never tackle 100% projects ourselves - from A to Z - but we seek help where necessary with local installers or other parties. There is, in that respect, a real link between the end users and the supplier, so to speak." (Interviewee #8, CCO at Dynaf)

Due to the relative smallness of the energy regime on Curaçao, companies are very dependent on certain agencies, hence the importance of positioning a retail company as an intermediary network. By having a diverse network and including the biggest number of actors, through dialogue, expectation can be aligned, and projects can be rolled out more successfully:

"The way in which we want to position ourselves is especially as an intermediary party to see exactly which connections we can bring together. We also need to be in conversation with Aqualectra regarding EV chargers, but also with the government, just to look for collaborations in this. Because we think: 'we can start with that tomorrow ', but cooperation is pivotal - because, that is also Curaçao, things can take longer than necessary. this is why we do want to tackle things together with all stakeholders." (Interviewee #8, CCO at Dynaf)

As aforementioned, companies were providing advisory roles, aside from supplying the technology itself. Yet, following the tariff change in 2015, most of these companies went bankrupt, leaving their customers with a technology, about which they had little knowledge. Because of this, Dynaf - being one of the only big companies that survived - has taken the responsibility of providing technical support to Solar PV adopters, further expanding their personal network:

"Many companies and private individuals have been faced with a strange situation, because many suppliers where they bought their panels had to stop their business operations shortly afterward the tariff change. Ultimately, customers can no longer go to their supplier, so we are still getting phone calls from adopters asking if they can drop by because: 'my system no longer works', all of systems that we did not install because the companies that did, now no longer exist." (Interviewee #8, CCO at Dynaf)

Private Adopters

Private adopters who participated in the Solar PV niche in the early 1990's were activiely involved in testing and experimenting with the technology. They operated and controlled their own plants, often monitored by Kodela and KAE. Some adopters designed and constructed stand-alone systems together with wind energy and storage (Interviewee #14, Energy Advisor). Adopters also provided feedback to the utility on technical aspects of their installations. After 2011 the role of private adopters changed slightly, due to the mass adoption the connection to the utility was not as prevalent. Yet, the utility did continue to monitor the installation to observe yields and the effect on the grid, which is currently done automatically, thus not through direct contact with the adopters.

The same SIDS specific issues that the technology retailers face, are also faced by the private adopters. Because Curaçao is an Island state, it can be expensive to buy solar panels from abroad, especially since it becomes hard to get guarantees from companies that the product will arrive, which can be an issue for such a large investment as Solar panels:

"The problem is; where do you buy it and from whom do you buy it. I mean if you talk about $ 1000 or $ 1500, okay. But if you talk about $15,000 or $20000, it must be a bit serious" (Interviewee #11, Curaçao Resident)

This uncertainty paired with the novelty of the technology increases the importance of local companies. This made that these companies also provided advisory services prior and post installation, to add value for (potential) adopters. The sense of security, paired with a service system, made it a better value for locals to buy from local companies:

"When I asked some offers locally, I came to the conclusion that I could actually order it locally as well. Then I made a deal with a local provider or a company that supplies and installs. Based on consumption, we have calculated the capacity." (Interviewee #10, Private Adopter)

The benefit of this, is that private adopters and local companies formed cooperation beyond mere implementation. This provided the opportunity for these companies and private adopters to have discourse about their expectations, granting better alignment. Through dialogue, companies could tell customers what the best sizing is and what the main reason should be for adoption. Also, companies could show customers how to properly interact with their system to e.g. minimize electricity consumption and maximize profits, which is beneficial for everyone (incl. utility).

This network somewhat deteriorated after the implementation of the 'solar tax' in 2015. Many companies went bankrupt, once more, leaving potential customers with concerns of where to buy from:

"You must be certified to be allowed to install. There are only a few companies in Curaçao that have this permission."(Interviewee #10, Private Adopter)

A popular location to buy from on Curaçao, is from China, due to the cheap prices and high quality, as opposed to the US, where quality is good, but panels are expensive. The main issue is that the investment is relatively high and there is no guarantee of delivery:

"This is because the Chinese companies do not dare to guarantee supply. I do want a guarantee if I order from them. With the American companies you can say that it is a lot more expensive, from what I have gathered so far, I thought it was - certainly - almost 50% more expensive. There were others that were more than 50% more expensive, while the Chinese quality is generally no longer that bad." (Interviewee #11, Curaçao Resident)

There are potential initiatives that can eliminate this fear, but they are not yet developed enough:

"Alibaba has a system that guarantees supply; So you pay Alibaba and Alibaba only pays the company when it is delivered on Curaçao. But not all companies are included in that system. Unfortunately, it appears that many have not yet been included - very unfortunate, because that would be a good solution." (Interviewee #11, Curaçao Resident)

The lack of local retailers shifted the power dynamics on the Island slightly, since retailers were becoming scarcer, people with reliable network connections abroad (specifically in China) have become valuable on the Island:

"If you have someone who has connections, you have to pay extra for that. But yes, that is less bad than if you don't get anything. Then you can say; okay, he's here on the Island and he has to deliver. If he does not deliver, then he will get into trouble. But that Chinese company, who is all the way in China, that will be a difficult situation if he decides to not supply. So, if someone on the Island has contacts with Chinese suppliers, I would be prepared to pay for that." (Interviewee #11, Curaçao Resident)

Nevertheless, a drawback from not having enough local retailers, with a preference for Chinese panels, the already lengthy installation process gets lengthened by the long shipping time from China to Curaçao:

"Ordering takes a long time. Ordering and delivering can take between 3 to 4 months." (Interviewee #5, Energy Entrepreneur)

Conclusion of Network Building

In the early 1990s the social network only consisted of private adopters and the utility companies present at the time, KAE and KODELA. Information between the actors mainly flowed unidirectionally from private adopters to KODELA (and KAE). This information was used by the utility companies to monitor the stand-alone PV systems of private adopters all over the Island. There was little to no cooperation in design or development of these systems.

Thus, the network was small, since only intrinsically motivated enthusiasts invested in the technology but due to similar motivation for adoption, alignment within the network was high. Private adopters were enthusiastic about promoting the technology.

The high alignment enabled relative rapid roll-out of experiments in the Solar PV niche in the 1990's and thus allowed the Utility companies to compare local experiments and through learning processes, later set up their own successful centralized (technological) niche experiments, including grid connected system experiments in 1995 and 1998.

In the early 1990s, the composition of the social network for stand-alone PV systems was characterized by cooperation between private adopters and the Utilities: Network alignment, although limited, was present. This support of private adopters towards the Utilities partially explains the success of the pilots that were later set up by KAE and particularly KODELA.

Right before 2011, the network composition expanded to a handful of retailers, private adopters, the Utility, the government and a new regulatory agency: BT&P. In 2011, the misalignment between national government and Utility explains the abrupt implementation of a 'net metering' scheme. This implementation went contrary to the semi-successful experimentation phase of Aqualectra, which established that the grid was not yet optimal for large scale Solar PV feed-in. Additionally, due to the absence an established network between the Utility and the Government at the time, experiment results and expectations about the reason for adoption could not be aligned.

5.2.3 Learning Processes

Learning in 1980 - 2011

In the 1980s the government, utility and private adopters had no experience with solar panels. It was around this time that these stakeholders started to construct stand-alone plants to assess the effectiveness of the technology. These first satellites resulted in the gain of basic technical knowledge including the yield of these systems. After this, in 1995 and 1998 the utility implemented the first grid connected experiments to assess the effect on the grid and whether it was suited for large scale feed-in. These experiments gave the necessary insights into the technological and economic feasibility of solar panels; the utility and individuals learned detailed lessons about the implications of stand-alone and grid-connected solar panel installations. Additionally, they learned about different niches that could be implemented alongside solar PV, such as wind and storage. Actors also reported about advantages and disadvantages of these different components, like storage and windmills of stand-alone solar PV installations to the distributor

(KODELA). This period of experimentation can be considered successful in generating technical knowledge.

The experiments also contributed to lessons about the economic feasibility of solar PV installations. In the late 1980s, there was limited knowledge about economic parameters. The stand-alone systems were implemented by (environment or technology) enthusiasts and experimentation showed that the installations' economic feasibility at the time was relatively poor, compared to the electricity rates. Thus, these experiments showed that the technology would be in need of substantial market protection in the form of financial incentives (subsidies) in order for it to be an attractive investment for the general public. This was simply because of the expense of investments; solar panels were still too expensive when compared to utility rates.

In this time period, there was limited learning about societal embedding in the energy regime. Most learning was **first-order**, with a focus on technological and economic learning. By 2011, a large amount of data had been collected on the grid implementation of Solar panels.

In this period, the Utility did a comprehensive assessment of the electricity grid on the Island. The main lesson from this research was the grid 'seemed to be qualitatively sound', with a great variation between districts (Government of Curaçao, 2011, p. 23). Through experimentation it was concluded that the grid can allow for small scale in-feeding of wind or solar. However, that the state that the grid was in at the time was not optimally suited for medium nor large in-feeding producers (i.e. >1MW) (Government of Curaçao, 2011, p. 24). Aqualectra acknowledges that one of the primary problems of future development is the level of 'smartness' (which is currently too low) of the electricity grid in Curaçao (Interviewee #1, Program Manager at Aqualectra), and is currently making strides towards working on this issue. Nevertheless, this is especially a prospective barrier to intermittent renewable energy technologies (i.e., Solar PV).

Despite this technological and economic learning, due to internal tensions within the Utility these lessons could not be applied for the construction of a market niche before politics interrupted and mandated the 'net metering' initiative in 2011.

Learning in 2011 - 2015

Before the grid's 'smartness' could be improved, politics stepped in and mandated the 'net metering' scheme. This would turn out to be the first 'market niche' implementation, which was the start of an intensive learning process for a multitude of stakeholders, both on technical as well as on an implementation level.

In the time between 1980 and 2011, from a financial perspective the technology improved substantially. In the period between 1976 and 2016 the cost of Solar PV has decreased more than 100-fold (Lafond, et al., (2017); Irena, 2017). Interestingly enough, the technology itself has not changed since the 1960's and it is a relatively simple technology, due to its static nature. Thus, the main learning processes from a technical perspective, revolved around the effects on the grid that come with such a quick increase of in-feeding electricity from Solar PV. Due to the abrupt deployment of such a lucrative market niche, the utility quickly learned about the advantages and disadvantage of having a large amount of solar PV installations, while having a dominantly fossil fuel-based production. One disadvantageous effect that occurred, is referred to as the

duck-curve effect. This is globally one of the main concerns with large scale implementation of Solar PV in a largely fossil fuel-based energy regime. In utility-scale electricity generation, the duck curve is a graph of energy production over the course of a day that shows the imbalance of time between maximum demand and renewable energy production. In many energy markets, as like on Curaçao, peak demand occurs after sunset, when solar energy is no longer available. In places where a substantial amount of solar electric energy has been installed, the amount of energy that must be generated from sources other than solar or wind energy shows a rapid increase around sunset and peaks in the hours of the evening, producing a graphic that resembles the silhouette of a duck (Denholm, et al., 2015; Wirfs-Brock & Jordan, 2014).

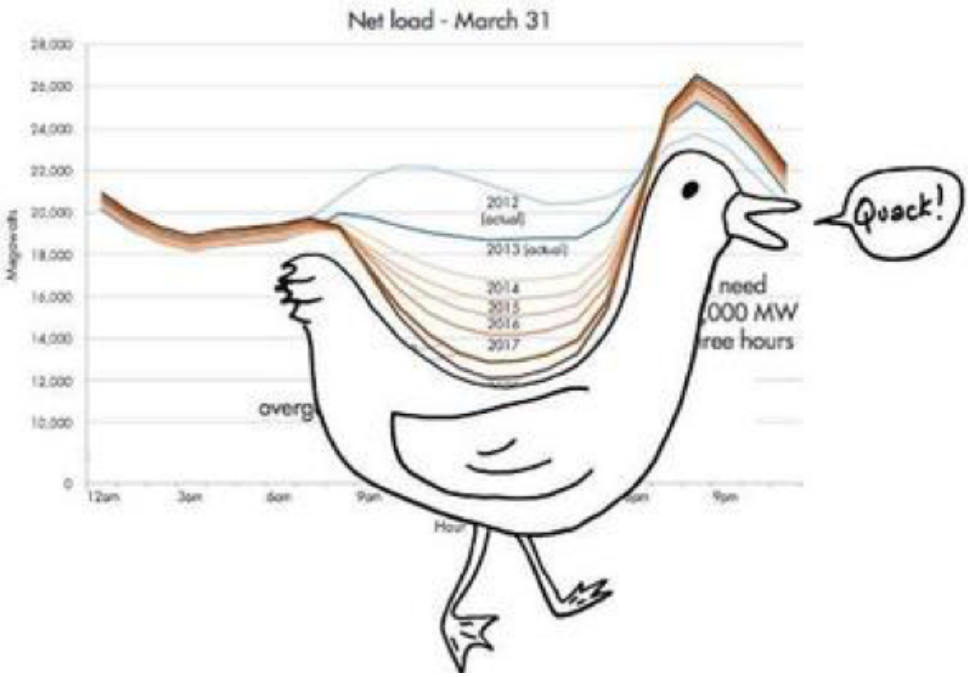

Figure 5.1: Duck Curve Taken from Wirfs-Brock (2014)

Without any type of energy storage, after hours of high solar energy generation, companies must rapidly increase energy production around the time of sunset to compensate for the loss of solar generation. This is quickly becoming one of the main concerns of network operators where there is a rapid growth of PV energy (California ISO, 2016), which also happened in Curaçao. Storage can solve these problems if it can be implemented. Flywheels have been shown to provide excellent frequency regulation (Lazarewicz & Rojas, 2004). Short-term use batteries, at a sufficiently large scale, can help flatten the duck curve and prevent generator fluctuation and can help maintain the voltage profile (Lazar, 2014). However, cost is an important limiting factor for energy storage, since each technique is expensive to produce at scale. This is causing the Utility to want to limit the growth of Solar PV.

The advantage is that this influx of Solar PV helped to decrease the energy demand of certain parts of the Island, leading to better security of supply for the rest of the island. Additionally, the learning experience for users has been that the adoption of solar panels has made them more

aware of their energy use, decreasing their energy demand (Interviewee #10, Private Adopter; Interviewee #8, CCO at Dynaf):

"We notice this especially from people who have taken the step, that people who now have solar panels on their roof, are going to consciously keep track of their electricity use via an app. It is just like your bank account, you just become much more aware. I have now had a visit from my brother and his children for 10 days. They used the air conditioning; my bill is already 60 guilders higher - you can immediately see it. In addition, you start to wonder: 'Do I also like it in the air conditioning or am I satisfied with just those fans' [...] 'Or do I put my air conditioning at 18 degrees or 24 degrees.' You can see it all on the app and on your bills. I do think that if you take solar panels - with the app and with the insight that you are going to get - that will already do a lot with knowledge and understanding, but ultimately also with your wallet." (Interviewee #8, CCO at Dynaf)

Still, the technology poses differences for stand-alone and grid-connected systems, for which a lot still has to be learned and it is important to be more energy conscious than one would normally be:

"A friend in Suriname lives in the jungle, which has a complete off-grid system, but within a year his batteries were broken. Because now you can just connect everything and Aqualectra takes care of it. But at home, he noticed, when they wash clothes, his wife couldn't bake bread - they have an oven - and she couldn't make coffee, because then it drains the batteries immediately. So, if you are off-grid you must already have in mind 'I must be a little more economical and pay attention to what I do, otherwise I will get stuck.' While when you are on the grid it doesn't matter, if possible; you don't know where it comes from, but in the end, it comes to the Aqualectra power plant and they have to make sure that they start a new generator." (Interviewee #2, Energy Consultant)

The market niche implementation was especially interesting with respect to learning of private adopters. The actors that were actively involved learned totally different lessons than previous to the 'net metering' scheme. Suddenly, a Solar Array on your roof is technologically and economically very easy to implement, due to the rise of retailers and the investment was very profitable.

Learning in 2015 - 2019

After the implementation of the Solar Tax in 2015 learning was driven by an enormous pressure to adapt. Positive expectations had been formed in the period between 2011 - 2015 and this had to be radically adapted in 2015. The technology stayed exactly the same, but the economic profitability decreased almost without warning. This, despite the regulator advising against such a radical reform without a transitional period.

The biggest retailer - 'Dynaf Group' - that is still active in the Solar PV market, actively views this abrupt tariff change as a learning experience. The company has learned the importance of

product diversification on an Island such as Curaçao, where policy can be unstable (See Section 4.1). Additionally, by looking at advantages of the tariff change, now the company can take the time to adapt and improve their operations for the future, in case the technology inherently becomes cheaper or the tariffs decrease once more:

"We were able to use that experience - of a downfall in sales - to learn from it, to become better and now slowly - actually organically - to strengthen your team. This is actually much better for the long term than what happened then and immediately go all-in, say."

Due to this learning process, they have adapted their approach for future projects. This has been implemented in their approach to setting up an EV (Electric vehicle) infrastructure on the Island. The company actively seeks collaboration with the Utility to align expectations and visions in order to circumvent abrupt changes after implementation (second order learning):

"But this is a good example, as a result of which we now, with those EV chargers, are looking for a dialogue with the government or with Aqualectra to determine the rules of the game together. Due to the abrupt implementation of Solar and seeing that the goverment did not correctly implement the technology, we then made the decision to enter into dialogue, to be able to control and regulate the implementation of EVs more." (Interviewee #8, CCO at Dynaf)

From a technical perspective, there were a couple of main learning processes that took place. In the time period between 2011-2015 - in the 'net-metering' scheme period - Solar PV was such a profitable investment that it lead to multiple private adopters investing in as much solar panels as could fit on the area of their home roofs:

"At first, people simply switched over to solar panels when they wanted to switch, without calculating their precise consumption." (Interviewee #5, Energy Entrepreneur)

This would lead to more overproduction, meaning that adopters could sell more electricity back to the grid, increasing profits. This was detrimental to grid stability and these adopters were most severely affected by the tariff change in 2015. Due to this, users and the utility learned the importance of having proper sizing to circumvent overproduction as much as possible:

"What you have to do; seizing based on consumption nowadays. Exactly so that you have no overproduction. They didn't used to do that; they just filled their roof - but that time is over." (Interviewee #2, Energy Consultant)

Curaçaoan advocates of Solar panels (Private adopters, technology retailers) emphasized these benefits when talking about Solar PV :

- Independence from Aqualectra (since the utility has had issues with security of supply and due to changes in tariffs there is a lack of trust in the company);

- Independence of Oil price fluctuations (Especially now, with the Venezuela situation that currently exists);
- Improved awareness of energy consumption (Due to the app that comes with the installation of solar panels, on which - just like a bank account - the adopter's energy consumption is tracked live, through which the immediate financial consequences become prevalent);
- Reduced air pollution (because the air around the Utility (And refinery) is heavily polluted);
- Reduced greenhouse gases (Solar energy is a form of renewable energy without CO2 emissions);
- Cost savings (Even with the current tariffs, the costs over 25 years are less than buying from the grid, this is solely by assuming electricity prices stay relatively steady).

On an institutional level, within the energy regime, the main lesson of the abrupt implementation was the need for an independent regulator:

"The function of the regulator - BT&P - it must be better defined. We are also working on that now. That is all laid down in legislation" (Interviewee #14, Energy Advisor)

Learning from the "Free Zone Project"

This section concerns all the learning processes that were involved in the experimentation phase, leading up to the 15MW Solar Park tender. This is a tender that the Utility has made available for the placing of 15MW worth of Solar Panels on the roofs of warehouse buildings that are managed by the company "CURINDE". These are warehouses located at the nieuwe-haven Free Zone, the airport (HATO) Free Zone and the industrial park in Brievengat. For this project, Aqualectra has performed some experiments, from which they have acquired second order learning in the form of extra benefits that come from Solar panels.

Due to the hot climate on Curaçao, the area right beneath the roof of a building can become very hot:

"Here, your attic - the space above your ceiling - just gets incredibly hot. When you simply put your hand near the ceiling in the afternoon, you can feel that it becomes very hot. It is only around 8 PM that it starts to cool down again. Thus, when you turn on your air conditioning, it needs to cool down the area underneath the roof. Only after that is cooled, the rest of the room will start to cool down." (Interviewee #1, Program Manager at Aqualectra)

According to calculations done by Aqualectra, by placing solar panels on the roofs of these buildings, the panels act like isolation, causing the inside temperature of a building to drop. Due to this learning process, Aqualectra is of the opinion that this is also something that has to be taken into account when calculating the net costs of solar panel installations, since they reduce the total amount of consumed energy for e.g. air conditioning:

" We did some calculations with the solar PV installations that are being placed here at the Free Zone at 'Nieuwe Haven' on the roofs of the buildings. We concluded that if you have solar panels on your roof, this makes a very big difference in the heat that enters the building." (Interviewee #1, Program Manager at Aqualectra)

"So, we made calculations there and there is a huge difference in terms of heat in buildings if there are Solar Panels places on the roofs of these buildings. So, when the people saw that; 'Energy is produced on my roof, then I myself will consume less because I do not have to cool down that space as much because those solar panels serve as insulation'." (Interviewee #1, Program Manager at Aqualectra)

This is something that the utility has also used in negotiating the contract with CURINDE, since they have cost savings aside from the payment per rooftop area that they rent out to Aqualectra:

"But in addition to the financial amount that is given, they will benefit even more, they will also have savings in their own energy consumption." (Interviewee #1, Program Manager at Aqualectra)

Next to these cost (savings) related benefits, Aqualectra has also learned more about the effect that Solar panels can have on the image of a company. Which is something that CURINDE is using to attract more businesses to their Free Zone areas on Curaçao:

"And it is also good for your image, that is commercially something that is being looked at as well at the moment, that you can say; 'We are green'. That of course also sells as a company. Curinde themselves are already using that as a bit of a slogan; 'Do you want to do offshore business, we have properties that we rent out, that is completely green, renewable.' But that does sell worldwide." (Interviewee #1, Program Manager at Aqualectra)

The main takeaway for Aqualectra as a learning process from this experiment was the extra beenfits that Solar PV has, next to the primary financial payments, though which the benefits of adoption become even greater:

"So, what about being more energy efficient and understanding what it is about and then ensuring that you use less. Then you will also have a better effect of all the sustainable energy that you want to introduce on the island."(Interviewee #1, Program Manager at Aqualectra)

Learning from the "School Project"

By learning from the benefits of the Free Zone experiments and calculations, the Utility set up another initiative to rent the roofs of schools and place solar panels on those roofs. This was partly done because there is not a lot of rooftop area left for the Utility to utilize, especially since Aqualectra does not want to use natural grounds to place solar panels:

"We have currently covered almost all the roofs of large buildings (we do not want to use natural areas for zone energy). The only spots that are left are open parking spaces, homes and schools."

Similar to the Free Zone initiative, the roofs are being rented out per square meter and the electricity provided by the panels are being supplied straight into the main grid. The project took 5 years to set up (and was finally realized in 2018) and will be subsidized by the government. The total capacity of these Solar panels is around 2 MW and is spread over 5 schools. The contract that Aqualectra has with the National Government is that the produced power (Wh) will be bought by Aqualectra and that money will be paid to the national school board and this money will then be divided among the schools again (Interviewee #1, Program Manager at Aqualectra)

Much to the surprise of Aqualectra, this initiative has sparked up some controversy within the education community. This can mainly be attributed to a lack of expectation alignment between the teachers that work at these schools and the Utility. The teachers held strikes, according to the Utility, their stance on the Rooftop Solar panels was along the lines of:

"That is nonsense, we are getting robbed, solar panels are put on our roof, but that money does not return to us. The money goes to all other schools on Curaçao. We want the energy to come to us immediately, then we can put air conditioners in the school building, so that the children can sit in air-conditioned buildings." (Interviewee #1, Program Manager at Aqualectra)

Aqualectra had differing expectations for this school project. According to the Utility company, the reason for the project was to find a way to implement more renewable energy on the Island and through positive externalities learned from the Free Zone project, reduce the amount of heat that enters school building and thus reduce the electricity use for the schools. Yet, the opposite happened; Schools wanted to be able to use more electricity, since the panels were producing electricity on 'their' roofs:

"I say, 'Wait a minute, you already have a high consumption of energy, and now we are looking for a way to reduce that because your school is producing energy' and then you think: 'you know what, now I'm going to consume consume energy because I produce energy myself. I think that this is a wrong way of looking at things." (Interviewee #1, Program Manager at Aqualectra)

Thus, expectations of the Utility were that schools would benefit in two ways. Firstly, the schools would have cost savings and Secondly, they would benefit from the positive externalities from the technology itself. Program manager at Aqualectra (Interviewee #1, Program Manager at Aqualectra) expresses that an explicit learning process for the Utility has been the fact that Solar panels are very beneficial on an Island with a climate like Curaçao, since it acts like isolation against the sun. Due to this he feels that there needs to be a shift in mentality of citizens:

"Because inhabitants complained about high electricity rates, we have been very busy reducing the electricity rates. But, after an analysis, we found out that as we started reducing it, consumption started to rise. Apparently, consumers thought: 'Ok, I pay 300 guilders every month and suddenly it gets less and less, now I suddenly pay 200 guilders. Well, you know what I leave the air conditioner on for longer or I put an air conditioner on. Now I'm also going to put one in the living room, etc.' So, I'm a victim of my own success. I ensure that the rates are lower, then the consumption becomes higher. Mind you, due to lower rates, my income as Utility is now lower, but I need a higher investment because people are now using more electricity. Everyone around the world is using less energy and we have something like: 'Oh, it's getting cheaper, we're going to use more.' So, in my opinion there must be a mind shift that people just become more energy conscious." (Interviewee #1, Program Manager at Aqualectra)

Conclusion of Learning Processes

In general, learning in Curaçao was mainly first-order technical and economic learning, with limited attention for a large number of potential Solar PV benefits (Decreased energy demand, costs savings, security of supply, independence). Learning through stand-alone experiments was sparse and unorganized in the case of early stand-alone solar PV installations, through an overseeing of private adopters and some grid connected system experiments of the distributor (Kodela) and the producer (KAE). This process generated some technical knowledge of such systems. Learning in this period, even though quite successful at the start, because it produced the basic technical knowledge necessary for plant operation, stagnated and stayed at first order learning. This stagnation can be explained by a lack of internal alignment after the merger of Aqualectra in 2001.

In the case of the market niche implementation, this knowledge could not be used, because of internal tensions slowing down decision-making and the abrupt political implementation of a market niche, before these tensions could be resolved. Thus, it was not only the abrupt implementation, but also a too little participation on the part of the utility to construct its own market niches. Even though the time for learning was relatively long, there was only first-order learning of technological and economic issues through technological niches. Taking this into account, learning was overall unsuccessful over the first period from 1980 to 2011.

After 2015, learning processes were interesting and quick. In this period, first-order techno-economic learning was taking place to gather more data on specific yields on Curaçao. Due to the influx of installations, more precise data could be gathered. Additionally, second-order learning was taking place by private adopters and retailers as well as the Utility. Private adopters and retailers express extra benefits from Solar Panel adoption aside from financial benefits. In addition to the, the Utility started to set up successful learning experiments. Learning continued to focus on building up operational experience, learning about Solar PV yields and learning to improve economic feasibility. Yet, with these experiments, the utility did learn more about extra benefits of the technology, about the expectations of citizens and willingness to accept.

Finally, learning in the last period (2015 - 2019) is illustrative for the fundamental way in which politics work in Curaçao. Companies have become aware that abrupt changes in legislation

can occur, which could have serious implication in a specific market. Retailers have learned the importance of diversification and the necessity for active network building and alignment of expectations. Overall, learning after 2015 was successful, due to a mix of first- and second-order learning.

5.2.4 Quality of Internal Niche Processes

In this section, I analyze the Quality of the Internal Niche Processes, based on the v.d Laak's (2007) criteria, discussed in the literature review in section 2.2. Table 5.1 sums up the quality criteria (van der Laak, 2007):

Table 5.1: Van der Laak Quality criteria

Van der Laak Quality Criteria	
Expectations	**Robust**: Supported by more actors **Focussed**: Clear and specific goals **High Quality**: Supported by sufficient evidence such as experiment results.
Network Building	**Semi-functioning**: If diverse actors particiate **Highly-funtioning**: More diverse actors participate and alignment between actors increases.
Learning Process	**First-order Learning**: the existing facts and data about different aspects such as technological infrastructure, industrial development, environmental impact, policy and user practice are learned and optimized. **Second-order Learning**: a reflexive learning method that is focused on basic assumptions such as the social values and norms of the technology, and the willingness to change course if the technology does not match these assumptions to reformulate expectations, redesign the technology and reconstruct the network

According to Schot (2008) the learning process can only be considered to be **sufficient** when it includes both **first-order** and **second-order learning**

Quality of voicing of Expectations (1980 - 2011)

*Between 1980 and 2001, there was alignment between Utilities and private adopters (**Robust**)*

The period between 1980 and 2001 (before the merger of KODELA and KAE), reasons for adoption and experimentation were aligned, in as far that expectations were relatively low, and experimentation was the main reason to move. Private adopters, invested for personal reasons, mainly for environmental reasons or simply because of interest in the new technology. Prior to installation, adopters were aware that it was more expensive than utility electricity rates, hence there was a consensus that it was not about economic savings. At this time global warming was not yet on the average person's agenda (source). For the Utility, Solar PV was regarded as an additional (unconventional) electricity production technology that was quickly developing.

From the Utility's point of view, Rooftop Solar PV posed infrastructural challenges, hence experimentation took place. The environmental aspect was not on the Utility's agenda at this point.

*Between 2001 and 2011, there was misalignment internally within the Utility as well as externally between the Utility and the Government.(**Not Robust**)*

After the merger in 2001, the Utility had internal misalignment of expectations. The majority of the employees had bad expectations for Solar PV and were not in favor of implementation due to a conventional utility mindset, which lead to technical concerns. A smaller group within the company, wanted to innovate. This led to internal tensions and a halt of experimentation and action towards lessons learned from previous experiments, particularly of an unstable grid, which needed improvement. Additionally, there was also a misalignment for reasons as to why Solar PV should be adopted by private adopters between the Utility and the Government. The government wanted to provide financial incentives and the Utility was more in favor of keeping the technology a Niche for environmental of technology fanatics, who would be willing to pay more for sustainable energy.

*Between 1980 and 2011 the implementation of Rooftop Solar PV was aimed at a certain goal, mainly for experimentation to find out what the technical yields and economic feasibility was (**Focused**).*

Both the Utility and first movers implemented Solar PV installations, purely to experiment with the technology. The goal was not to replace fossil-fueled electricity. For adopters it was mostly installed in addition to their grid connection for experimentation. This is validated by the fact that adopters were willing to share information with KODELA at the time. The utility also implemented their own pilots purely for experimentation.

Overall the Voicing of Expectations in this period was mixed.

Quality of Building Social Networks (1980 - 2011)

*Even though unidirectional, there was contact between Utility and private adopters, which lead to some alignment in expectations and arguably lead to experiments based on more evidence for the Utility. Yet, there was little contact with the government and thus a lack of alignment took place between these stakeholders, which ultimately caused an implementation that was not based on sufficient evidence by the government in 2011 (**Not Functioning**).*

In this period two main stakeholders had well-functioning network connections when it came to experimentation; the Utility and private adopters. Through the active involvement of these actors, alignment of expectations increased, which lead to better experiments for the Utility. Yet, the government had little interaction with the two parties at this time and retailers were scarce. Hence, there was an increase in alignment between certain actors, but actors were not diverse and not large in numbers.

Overall, the network building in this period was limited.

Quality of Learning Processes (1980 - 2011)

*There was only first order learning and due to internal tensions, this period was extended for far too long, therefore, nothing was learned about social values and norms of the technology. (**Insufficient**)*

The learning process in this period, was primarily **first-order learning**. Through experimentation between 1980 and 1995, adopters improved user practices and the utility learned about technical yields of stand-alone systems. After grid-connected experimentation in 1995 and 1998, the Utility also accumulated facts and data about the technological infrastructure with regards to grid-related effects. Due to internal tensions and lack of expectation alignment after the merger in 2001, no **second-order learning** took place. There was no room for market experimentation, hence there was no reflexive learning method that was focused on basic assumptions such as the social values and norms of the technology. Since this process can only be considered to be sufficient when it includes both first-order and second-order learning (Schot, 2008), it was insufficient, which is also evident by the events that followed after 2011. Overall, the Learning processes were of high quality, but 'insufficient' due to a lack of second-order learning.

Quality of voicing of Expectations (2011 - 2015)

*In this period, the implementation of rooftop solar PV was not supported by each of the actors involved (**Not Robust**) and was not aimed at a common goal (**Not Focused**). Additionally, the implementation was done in a way that was not 'supported by enough evidence' (**Low Quality**). The implementation went against experiment results on the impact of the Rooftop Solar PV from a technical perspective.*

The government's intention was to boost the implementation of Solar panels, by providing abundant financial incentives.

Private adopters mainly adopted with financial motives in mind. From their point of view, their initial investment would be paid off in 2 to 3 years, after which they would be free of any electricity costs for a minimum of 20 years, since production with Solar PV requires no fuel and is in essence free of charge. These motives were enhanced by the perception that Utility prices are relatively high in Curaçao. The Utility essentially did not support 'net metering'. They were in favor of implementing solar panels, but not at such favorable rates. Their expectations for implementation looked at the technology from an environmental perspective, in which they would want adopter to be willing to pay more for the renewable technology (which mitigates CO2 emissions).

In general, there was no common goal. The main goals were replacing fossil fuels, independence of oil, diversifying production units, independence of utility (lack of security of supply) and profitability. Additionally, a number of research results on the impacts of the Rooftop Solar PV to society needs to support the expectations of the actors. Even though the experimentation phase was a lengthy one, the implementation of a 'net metering' scheme went against the research results, since the grid was not ready for large scale feed-in. Additionally, the tariff itself was not calculated properly, since it was detrimental to the finances of the Utility.

Quality of Building Social Networks (2011 - 2015)

*The network building in this time period was **Semi-functioning**.*

Retailers built relationships with adopters by providing advisory services, which meant that expectations of how to use the technology properly (e.g with energy saving) could be aligned over an extended period of time (essentially until the companies went bankrupt after 2015). Additionally, retailers sought out international partnerships with quality partners, like Schneider electric, which is essential on an isolated island like Curaçao. The utility sought out dialogue with the regulator BT&P and successfully aligned expectations with them. So much so, that the rates after 2015 are perceived as being too much in favor of the Aqualectra. Nevertheless, Network building between Utility/BT&P and private adopters was lacking. Private adopters express to have a perception of not having been consulted before the tariff change in 2015 was implemented. No information sessions were organized by either of the parties to come in contact and exchange ideas to come to a consensus that would benefit all parties. This lack of network connection between these two parties, aside from other Landscape and Regime consideration, to a large extent explains the continuation of backlash effects that extend to the following period (2015-2019).

Thus, network building was **Semi-functioning**, because not all actors participated and even tough alignment between Aqualectra and BT&P increased increased, those between Aqualectra and private adopters were not addressed (van der Laak, 2007).

Quality of Learning Processes (2011 - 2015)

*In this period, learning was of relatively high quality and could be considered 'sufficient' when it comes to private adopters, due to a mix of first order and second order learning. For the Utility, second-order learning was not possible, hence learning for them was **'insufficient'**.*

Due to high rates of adoption, a lot of data was accumulated, and a lot was learned both by utility and adopters from a technological as well as an economic aspect. From a technical perspective, the Utility learned about implementation aspects, such as 'duck curve'. Additionally, experts could accumulate enough data to calculate average yield of solar panels on Curaçao and also determine the effects of the hot Curaçao sun on the efficiency of panels. It was also learned how panels should be installed to increase efficiency (**First-order learning**)

Users learned that there are extra benefits to buying solar panels. Users' assumptions about solar panels shifted after adoption. They learned about extra benefits that it has, particularly with regard to energy consciousness, which leads to energy savings (thus cost savings). Additionally, users appreciate the independence from Utility on days where there are power outages (**Second order learning**).

Yet, due to the financial impact of the 'net metering' on the Utility, they did not perform any experiments, which lead to a **lack of second-order learning** in this time period.

Quality of voicing Expectations (2015 - 2019)

*Particularly visible through the strike of school teachers as a result of the 'school project', it becomes clear that the general population of Curaçao still has different expectations for Solar PV installation than the Utility (**not Robust**).*

In this period, due to the steep decrease of implementations, there is little information about the reasons for implementation from private adopters. A logical explanation is that, similar to the first period, only 'fanatics' are still implementing, which is in line with the expectations that the Utility has for reasons to move for private adopters.

When it comes to experiments performed by the Utility, particularly with the 'School project', it becomes clear that there is still misalignment of expectations between the Utility and School teachers. While the Utility expected schools to be content with external benefits of Solar, like isolation, leading to less hot buildings and a decrease in energy use for schools, while the country benefits from more 'green energy'. Teachers expected to have direct access to more electricity, which lead them to want to install more energy intensive appliances, including air-conditioning.

This misalignment can partly be explained by bad voicing of expectations by the Utility. Arguably if school teachers had more explanation of the reason that panels are being installed on their school roofs, along with the extra benefits that come with it, the backlash effect would be far less severe. Yet, there are more regime and landscape factors that need to be considered in order to fully comprehend the backlash effects in this particular case. More on this in the next section (Section 5.4).

*The goal with regards to Solar PV seems to not have changed since the last period (**not focused**).*

When analyzing the quality of internal niche processes of this period (2015 - 2019), it becomes evident that the goal with regards to implementation of Solar PV has not shifted from the second period. Even though the lack of adoption is attributable to multiple factors, including lack of support due to the bad implementation and a trust gap due to unstable government, it is evident that this is because for private adopters on Curaçao, financial benefits from implementation plays a bigger role than environmental considerations. Again, landscape factors (including economically unstable times due to Venezuela situation) also play a role and have to be considered.

Quality of Building Social Networks (2015 - 2019)

*Quality of Building social networks in this period can be considered **highly-functioning**.*

When it comes to retailers, they have actively taken action to form networks with both potential private adopters as well as with the government and the Utility. By organizing events and conferences, all actors are brought together for the sole purpose of expectations alignment. In 2018 alone, in the period that I went to Curaçao to conduct interviews (May 2019), there were three of such conferences based around Solar PV and EVs. Additionally, there is mutual contact between the retailer 'Dynaf Group' and the Utility 'Aqualectra' to work together and share visions for the implementation of an EV infrastructure on the Island. The main reason for this was learned from experiences with the lackluster implementation of Solar.

Thus, in this period, especially after 2018, actors are diverse in types, abundant in number and are actively seeking alignment. This means that this period of network formation can be considered **highly-functioning**.

Quality of Learning Processes (2011 - 2019)

*Learning in this period can be considered **sufficient** for most actors.*

Retailers have learned that the importance of expectations alignment. Retailer 'Dynaf Group' for example has implemented a reflective learning method (**second-order learning**) and shown a willingness to change course and actively reconstruct the way in which they form social networks. They learned that cooperation and expectation alignment is essential, especially on an island on Curaçao where policy can sometimes be unstable and can suddenly change.

The Utility has performed experiments from which they got a different perspective of the technology. This learning was focused on basic assumptions about the technology (**second-order learning**). They learned about the extra benefits and has used this learning process for negotiations, including technical aspects (isolation) and social perception (positive perception of a 'green' building).

Summary of Quality of Internal Niche Processes

In the first period, even though expectations were focused, they were not robust, which slowed down technological niche experimentation. The network building in this period involved a small number of actors and did not expectations alignment was not happening. Due to internal misalignment, the learning processes, even though they were high-quality, were kept purely first-order due to a lack of market experimentation (learning was insufficient). This prolonging of the learning process and bad network formation between Utility and Government, expectations could not be aligned. Table 5.2 summarizes the results from this inquiry.

Table 5.2: Quality of internal Niche dynamics 1980 - 2011

Period	**Internal Niche Process**	**Quality of Internal Niche Dynamics**
1980 - 2011	Voicing of Expectations	Not Robust Focused
	Network Building	Not Functioning
	Learning Process	High Quality, but Insufficient

In the second period, the lack of alignment in expectations between government and Aqualectra lead to an abrupt implementation of Solar PV took place, which deemed the majority of the experimentation phase irrelevant. Therefore, this implementation was not 'based on enough evidence (Low Quality). Additionally, there misalignment between private adopters/government persisted (Not Robust and Not Focused), which explains the backlash effects in the following

period (2015-2019). Network building, although between some actors (Aqualectra & BT&P) improved, it cannot be considered highly-functioning due to the neglection of other actors (Aqualectra & Private Adopters). Learning Processes was also mixed, due to it being sufficient for some actors (Private adopters), yet insufficient for others (Utility). Table 5.3 summarizes the results from this inquiry.

Table 5.3: Quality of internal Niche dynamics 2011 - 2015

Period	**Internal Niche Process**	**Quality of Internal Niche Dynamics**
2011 - 2015	Voicing of expectations	Not Robust Not Focused Low Quality
	Network Building	Semi-Functioning
	Leaning Process	Insufficient

In the third period (2015-2019), through feedback loops and better learning processes, experiments have been set up with better quality of niche processes (see Table 5.4. Experiments by the Utility are improving and leading to better learning (sufficient). Still, communication has been lackluster (Not Robust), which has led to a strike by teachers in the "school project". This shows that communication between different actors has to improve in the future. But overall, communication is better. Through conferences an effort is being made by the private sector to build social networks in order to align expectations. These conferences are purely focused on sharing information and visions (expectations alignment) about Solar PV and other technological niches, like EV. Additionally, due to the learning process that followed the steep decline after the tariff change in 2015, retailers are actively seeking dialogue with a broad range of stakeholders, including the Utility and the Government, through which they want to align expectations (Highly-functioning Network Building).

Table 5.4: Quality of internal Niche dynamics 2015 - 2019

Period	**Internal Niche Process**	**Quality of Internal Niche Dynamics**
2015 - 2019	Voicing of Expectations	Not Robust Not Focused
	Network Building	Highly-Functioning
	Learning Process	Sufficient

I conclude that overall, the quality of niche processes in Curaçao was Lackluster, which is is big contributor to the backlash effects that are still visible on the Island today (see Appendix D for a comprehensive summary of the Internal Niche Dynamics between 1980 - 2019). This will be further explored in the next section (Section 5.2.5).

5.2.5 Conclusion of analysis of internal niche dynamics

The dynamics in expectations, network formation and learning can explain some of the puzzles I addressed in section 5.1.5, but not all. Some of the issues have to be considered within the Multi-Layered Perspective (MLP), since they are effected by specific Landscape or Regime dynamics of Curaçao. In this conclusion I will address the puzzles from section 5.1.5 from the perspective of Niche internal processes of SNM within the MLP.

Question 1

*The **first question** was why the development of stand-alone technological niches continues until essentially 2001, despite successful experiment results from private adopters as well as the Utility dating back to as early as 1984.*

Niche internal processes

The Niche analysis shows that expectations were moderate about the yields of the installations and Solar PV was essentially a novelty product, especially between 1980 and 2001, meaning that only intrinsically motivated people and environment/technology fanatics were the first movers. While technological feasibility was there, on an economic level, substantial market protection (in the form of financial incentives) was still needed for the investment to be interesting. Expectations from both Utility and private adopters thus legitimized continuation of technological niche implementations for experimentation, especially since the technology was quickly getting cheaper after the 80s.

Regime Influences

On the level of regime dynamics in this period, wind energy was preferred over solar energy, due to wind's resemblance to conventional technology. Before the merger of KAE and KODELA, there was a rigid difference in the mindset of the two companies. KAE, due to its expertise and large investments (vested interest) in Fossil-based Diesel Engines could be classified as having a 'conventional Utility mindset'. Conversely, KODELA had recently acquired a license to operate a small part of production. Due to their relative infancy in the field, they had more interest in providing electricity regardless of the source, as long as rates were reasonable, hence they had more of an 'innovative mindset'.

Due to KODELA's experimentation with wind energy in 1993, experimentation was expanded to Solar PV, with the allowance of some private adopters to feed into the grid. Yet, this remained for experimentation purposes. These experimentation results, paired with tensions between the two Utility companies prevented technical improvement of the grid, which further legitimized concerns for market niche implementation, due to the experimentation phase showing that the grid was not technically optimal for large scale in-feeding of Solar electricity.

Landscape Influences

In this period, there was a lack of landscape pressure on the regime, especially in terms of lack of urgency, since climate issues were not on the agenda of the Utility or with private adopters. When there is a low sense of urgency among the population, Utilities have less incentive to change quickly, hence leading to a prolonging of the experimentation phase (Rotmans, 2006, p. 142).

Question 2

*The **second question** was why Aqualectra only focussed on grid-connected technological Niches for that long of a period between 2001-2011 while it was clear that the technology worked well for their internal operations. Hence why did politics step in, forcing Aqualectra to deploy a large-scale market niche, while being technically ill-prepared.*

Niche internal processes

As addressed in the first question, there was a misalignment in expectations between KODELA and KAE. After the merger of these two companies in 2001 to become Aqualectra, these misalignments persisted internally. A big part of the employees still had a 'conventional Utility mindset', causing concerns about the implementation of Solar PV. This misalignment caused internal tensions that caused the learning process to stagnate after 2001.

Furthermore, the government and the Utility also had different expectations towards 'reasons for adoption' (Not robust). Aqualectra's general mindset was that adopters should invest, only from altruistic considerations, meaning they should be willing to pay more for green.

The government had more positive expectations towards Solar PV and took note of Aqualectra's relatively slow roll-out of experimentations, expressing that the Utility had a 'lack of vision' towards renewable energy (incl. Solar PV). According to the government, there needed to be more financial incentives for people to invest. Due to poor performance of network formation, these misalignments in expectations between Utility and Government could not be aligned.

Regime Influences

Because of a lack of outside pressure on the utility, mainly due to its monopolistic position on the Island, there was a lack of internal incentive to move on their part.

Aqualectra is a government NV, so government could mandate the rates to which Aqualectra has to abide. Especially, because there was no independent regulator, who could do the proper investigation.

Landscape Influences

From inhabitant's perspective, even though people started to become more aware of climate change issues. The same low sense of urgency persisted among the population, especially since

it was difficult to measure the consequences of the emission of harmful substances, so there was little support. It was also not clear who the problem owner is, so that there was no incentive to change for Aqualectra.

Yet, around this time, climate change issues started to be on the agenda of the government, which ultimately lead to the first national energy policy 2011-2015. This national energy policy caused the government to want to promote renewable energy in an abrupt fashion. Due to the perception amongst the public that there is corruption in politics on the Island, there are differing opinions about the intentions of the Government at the time, nevertheless, there is no proof of this and the important aspect is that promotion of renewables occurred from within the government.

A landscape aspect that can be observed here is the notion that legislative changes on Curaçao can be abrupt, which can cause implementations to not be supported by enough evidence or calculation (more on this in the answer for question 3).

Question 3

*The **third question** was what effect did the political implementation of the 'net metering' scheme have on the Solar PV market?*

Niche internal processes

The immediate impact of the 'Net metering' scheme is that the rate of adoption of Solar PV experienced a sharp increase in adoption (between 2011 - 2015), due to the profitability of such an arrangement.

The abruptness of the implementation in combination with bad communication expectations between Aqualectra and private adopters further deviated. Now, users have purely profit-based motives for the technology, but because of the (bad) financial impact on Aqualectra, their expectations started to lean more towards environment-based motives. This was enhanced by the lack of communication between the two parties.

This period did substantially increase first-order (technical) learning for users as well as the utility, purely due to the increased amount of data that was available. Because of the negative financial impact of the political implementation on the Utility, network building between Aqualectra and BTP were key in what followed in 2015, which is addressed in the fourth question.

Regime Influences

From a financial perspective, they investment was more interesting for private adopters, due to the high electricity prices of the Utility. This contributed to decision-making of private adopters.

In this time period, BT&P was recently appointed an advisory role in the energy regime (2011). They had yet to establish good network connections with Aqualectra. Due to this lack

of network connection, expectations could not be discussed and potentially aligned prior to the net metering implementation. Furthermore, even if they would have advised against the decision, due to their advisory role, they would not have the authority to decline the government's ultimate decision. But they could have arguably influenced it.

Landscape Influences

Two major landscape developments played a role in the steep increase of Solar panels due to this 'netting arrangement':

1. Due to a 'lack of green mentalilty' on the Island, these financial incentives finally provided the necessary motivation for more people to invest in the technology.
2. The wealthy inhabitants (wealth gap) saw this as a good investment opportunity to make profits, causing them to fill up their roofs with overcapacity to sell more electricity back to Aqualectra. This meant that the feed-in increased more than necessary. But because of the unemployement rate in combination with the historically bad economic situation, less wealthy inhabitants saw this as an opportunity for business to have some much-needed additional income. They took out loans at the bank specifically to invest in Solar panels to sell electricity back to Aqualectra. Further increasing the rate of adoption of Solar PV.

Question 4

*The **fourth question** asked why the so-called 'solar tax' was implemented in 2015?*

Niche internal processes

The implementation of the 'net metering' arrangement was implemented based on a 'lack of evidence'. The implementation was abrupt and disregarded the first period of experimentation almost completely. This abrupt implementation came at a time that aqualectra had internal misalignemt, which was hindering implementation. The government expressed that the Utility had a 'lack of vision' and thus took matters into their own hand.

This abrupt implementation was 'based on a lack of evidence'. There was severe misalignment between Government expectations and Utility expectations, which through a lack of social networks (and other factors) could not be aligned before the implementation. From a technical perspective the grid was not adequate for large scale feed-in, which is what happened due to the large influx of feed-in after the profitable tariffs were implemented. From a financial perspective, the 'net metering' arrangement was not favorable for Aqualectra.

Through the learning process between 2011 and 2015, Aqualectra also learned about exta drawback of having increading in-feeding of solar, while have a completely fossil-based supply (without any storage) in the form of the 'duck-curve' effect. This, in addition to efficiency reduction of diesel engines, further impacted Aqualectra's financial situation.

Through good network building between the recently assigned 'regulator' BT&P and Aqualectra, the Utility company could lobby for a change in tariffs that would be more beneficial for them. Aqualectra did this by aligning expectations with the BT&P, by explaining that their 'back-up' position for PV users was expensive and that fixed costs were not being covered though a 'net metering' arrangement, which could mean that electricity rates could increase for non-PV users. The regulator communicated this to the minister in charge of energy, who then through social considerations that prices should not increase for non-PV users to change tariffs. The 'fixed contribution' was chosen in order for Aqualectra to cover their 'fixed costs of operation'.

Regime Influences

As explained in the regime analysis, there are two additional reasons why the implementation of Solar PV needed to be slowed down. The first relates to the large-scale investment in 40MW of diesel engines. Studies show that the duck-curve effect is enhanced when the Utility is fossil-fuel based, due to the expense of having running reserves to compensate for the increase in demand and simultaneous decrease of solar energy around sundown. The second is that the current grid is not optimal for large scale in-feeding of solar PV, hence it was in the best benefit for the Utility to have adoption rates slow down.

Additionally, due to Aqualectra's monopoly position on the Island, they could establish a good social network with BT&P and lobby for rates that favor them and cover their fixed costs. Due to the recent acquisition of Diesel engines and an aging grid, overhead and maintenance costs are relatively high, meaning that the 'fixed contribution' for PV owners would also have to be high. Due to alignment between the regulator and the Utility, rates have arguably become too favorable for Aqualectra.

The reason why precicely a fixed contribution was chosen, is because the tariff structure on Curaçao is al all-in structure. This means that fixed and variable costs are paid by consumers in one tariff with a lack of a base price. So, if users suddenly use 0 kWh, they are also free of costs. The fixed costs of Aqualectra are covered in the variable rates. To compensate for this, a fixed constibution was chosen, so that if PV users do not use the grid's electricity, they do pay for the luxury of using the grid for in-feeding and for back-up.

Due to BT&P's advisory role, their proposal for a transitional period for previous adopters could be denied by the government (More on this in the answer to question 5).

Landscape Influences

From a landscape perspective, the implementation is a prime example that policy and legislation on the Island can be unstable and can be subject to abrupt changes when the government switches. Additionally, even though the 'net metering' was proposed by the government, no subsidy was provided to Aqualectra as a way to promote the development of renewable energy. This enhanced the need for a tariff reform in the form of a fixed contribution.

Another factor in the period between 2011 and 2015, contributing to the financial hit on Aqualectra were world oil price peaks around 2014. Due to Aqualectra's dependence on Oil, this increased price of electricity production.

Question 5

*The **fifth question** was why exactly the investment in solar had a sharp decrease after 2015?*

Niche internal processes

When analyzing the niche dynamics, the sharp decrease can be attributed to very poor niche dynamics performance at the start of the second period (2011-2015). Bad communication lead to severe misalignment of expectations between the utility and private adopters. Additionally, because of the abrupt and low quality (not backed by enough experimentation and evidence) implementation of the 'net metering' scheme in 2011, the new government in 2015 had to make a hard decision. They opted for harsh reform of tariffs without a transitional period for prior adopters.

This radical reform of tariffs led to its fair share of 'backlash effects', resulting in a lack of support from prior adopters as well as potential adopters. Through the analysis, it became clear that the main decrease in adoption stems from very poor communication and lack of alignment of expectations. This became increasingly evident when the payback period after the implementation of the 'solar tax' was still profitable and cheaper than utility prices. Even though there is more to it than only financial over a span of 25 years. Yet, tariffs and the payback period were not unreasonable by any means, when compared to the backlash effects and lawsuits that followed.

Regime Influences

Because of the 'advisory' role of BT&P, even though they advised the government to implement a transitional period, this could be rejected by the responsible minister. Even though this choice come with its social considerations, this is one of the major factors that caused a lack of support from potential adopters. This caused a 'trust gap' when it comes to the investment climate, since the outlook on the ROI can come to look totally different from one moment.

Landscape Influences

This cannot solely be explained by poor niche dynamics performance (bad alignment of expectations), but also has to be seen in the light of landscape influences. As established in the landscape analysis, inhabitants of Curaçao generally lack a 'green' mindset or have a lack of care for the environment. This causes inhabitants to have less willingness to pay more for electricity, regardless of the source (renewable or not). This enhanced the restraint from investing after tariff reform and contributed to the decrease in rate of Solar PV adoption.

Furthermore, since Curaçao has a reputation of having unstable policies, the 'backlash effects' were more severe, than if it were an anomaly. Inhabitants would be more willing to accept or listen to reasonings by the Utility and Government for why the reform was necessary. Currently, due to a political corruption history, private adopters were immediately skeptical after the reform.

Question 6

*This bring me to the **sixth and final question**, which was why the decrease in rate of adoption did not improve back after 2018, when the tariffs were made more profitable?*

Niche internal processes

Firstly, the 'backlash effects' from the abrupt tariff change in 2015 were still very present at this time. The niche analysis shows that expectations had yet to be aligned in 2018, potential investors still consider the fixed contribution to be a 'Solar Tax' and a payback period of 7-8 years is too long. For the Utility and as an outcome of the lawsuits, the government as well as Aqualectra believe that a 7-8-year payback period is still profitable.

Although the tarrif reform in 2018 was a step in the right direction, it did not get to the core of the backlash effects that occurred after 2015. The core was the misalignment in expectations between Utility and Private adopters. Due to the lackluster niches dynamics, especially in network building between Utility/Government and private adopters, the misalignment has not been fixed, causing a continuation of the 'lack of support' (backlash effects).

Landscape Influences

As mentioned in question 5, the severe (long lasting) backlash effects also stem from a history of abrupt one-sided changes in policy from the government. Explaining why adopters react more severely than if it was an anomaly. This further increases the need of better communication between actors (network building).

Among citizens, there is still much to be 'learned' in terms of environmental awareness, before inhabitants are willing to pay more for clean energy. Increasingly, companies are taking own initiative to organize information sessions and seminars in order to bring together different stakeholders to share expertise and expectations for different Niche technologies, including Solar PV and Electric Vehicles. From the government and BT&P there is still little initiative. The university believes that alignment is essential but lack financial means to contribute.

Also contributing to the lack of investment is the critical economic situation that the Island has resided in for the last three years (balance of payments not met). This was already present in 2016, but uncertainty has radically increased from 2018 onwards due to the Venezuela situation.

Chapter 6

Conclusion and Discussion

6.1 Conclusion

This thesis started with the Research Question (RQ):

Table 6.1: Main Research Question

RQ	"How can the government of Curaçao overcome the main obstacles of rooftop Solar PV for the technology to be successfully implemented?".

This was subsequently subdivided in 5 Sub-questions (SQ):

Table 6.2: Sub-Questions

Sub-Questions	
SQ1	"What has been the progress in decarbonization of the electricity?"
SQ2	"What does the current electricity infrastructure of Curaçao look like?"
SQ3	"What are relevant aspects of the local (social) context to consider when designing rooftop Solar PV infrastructure on Curaçao?"
SQ4	"Who are the relevant actors that participate in the electricity sector (with respect to expectations and network building)?"
SQ5	"How can the implementation of rooftop Solar PV be stimulated in the (renewable) electricity infrastructure of Curaçao?"

All of these questions were individually answered by using two intertwined frameworks: Strategic Niche Management (SNM) (Micro-level of analysis) within the Multi-Layered Perspective (MLP) (Macro-level of analysis).

With the concept of the Multi-Layered perspective (MLP) the specific context of Curaçao was analyzed in order to answer SQ 1 to SQ 4. In order to answers these questions, the context of Curaçao was analyzed primarily through 15 in-depth interviews (primary source) with the most important stakeholders, on site (on the Island). As a secondary source, news articles were used for additional validation and expansion. These 15 interviews were analyzed through several rounds of coding to ultimate get the first- and second-order codes attributing to the aggregated codes relating to Landscape and Regime developments. These developments were then validated and expanded with the use of news articles.

For Strategic Niche Management (SNM), the same interviews were used as primary data, with validation of news articles, to answer SQ 5. Important in this part of the research was the need for subjective opinions and experiences of stakeholders, rather than objective facts. Hence it was pivotal that interviews were done face-to-face and with diverse stakeholder types in the field.

By revisiting the main RQ, it can be answered by taking into account the conclusions of both the micro- and macro-levels of analysis. The main obstacles in the MLP analysis are identified by the Landscape and Regime 'Stabilizing shifts', which re-enforce the fossil-based regime and block pathways for Solar PV to scale up. The SNM analyses how the implementation of Solar was handled and identifies the pitfalls/shortcomings in the past and how that effects the current expectations from different stakeholders. The obstacles here can be seen in the 'Lackluster Quality of Internal Niche Processes' and the 'Backlash Effects'. It is pivotal to take past shortcomings - which have shaped current expectations of all stakeholders - into account and take that as the starting point for any future development.

6.2 Recommendations

This thesis found that Curaçao has numerous obstacles to overcome on a macro- (MLP) as well as a micro-level (SNM). Therefor I strongly recommend that the relevant stakeholders address the issues with internal niche processes on the micro-level, while the government simultaneously finds the best way to address the more fundamental issues such as the 'bad economic situation' or 'lack of a green mentality'.

Ideally, (the government of) Curaçao should try to address all of the identified obstacles from the MLP as well as the SNM analyses. In practice, these obstacles - especially those from the MLP analysis - are usually deeply embedded within the structure or culture of the Island. Therefore, it is of utmost importance to invest resources into conducting in-depth research into the proper way of combating the barriers that Curaçao faces. In section 6.5, some recommendations are given for future research that can be conducted.

6.3 Theoretical Contribution

when looking at the theory on transitions, this thesis contributes to the understanding that a combination of Strategic Niche Management (SNM) and the Multi-Layered Perspective (MLP)

can effectively contribute to the analysis of the implementation of Niche technologies to uncover barriers/pitfalls that can hold back this implementation (and ultimately, a transition in the regime). Through the MLP analysis the specific local context of experimentation (learning, network building and expectations) can be analyzed within the dominance of the specific regime and landscape developments. This thesis clearly shows the importance of this local context in the roll-out of new technology, successful innovations do not arise in a vacuum, but they are influenced by current regimes and the social context. A well-designed experiment should exploit (temporary) instabilities in the dominant regime or landscape (MLP) by looking at 'destabilizing shifts' and taking advantage of those. As can be seen by the analysis of the implementation of Solar PV in Curaçao, it is important to create protected spaces. Yet, even though protection by financing can contribute to a technology's adoption, this thesis also shows that it is equally as important to communicate expectations well - so that adopters' expectations can be aligned - before such funding is provided.

Additionally, there is a lack of research for Small Island Developing States (SIDS). Within this limited field of research, most of the research on SIDS is performed for Mediterranean islands. More specifically, the research that has been performed on Renewable Energy implementation in SIDS has focused on technical aspects like energy supply (Zsigraiov et al., 2009); Techno-economic feasibility of Renewable Energy Technologies (RETs) (Bueno Carta, 2006), while neglecting the social impact and conditions (Jaramillo - Nieves and Del Ro, 2010). This thesis adds to the literature on (Caribbean) SIDS by providing a unique in-depth insight into the social conditions with regards to renewable energy supply of a specific Caribbean SIDS. This is done by analysing the historical implementation of introduction of a renewable energy technology (Solar PV) and analysing the *expectations*, *learning processes* and *network building* (SNM) surrounding this implementation to analyse how it was handled how the relevant stakeholders reacted to this, within the bounds of the Socio-technical landscape of Curaçao (MLP). This is unique to this thesis, since the literature predominantly focuses on technical aspects of implementation (feasibility) while disregarding the social dynamics. Additionally, due to the broadness of the MLP analysis, the qualitative data gathered for this thesis can be used by other researches covering Curaçao specifically and other (Caribbean) SIDS (see section 6.3.1). This data is especially suited for the analysis of other renewable energy sources but can also be utilized in different fields of research.

6.3.1 Generalizability to other SIDS

As addressed in the introduction other SIDS face common barriers due to their geographic location and other factors (e.g. Oil dependence, Bad Economic situation, etc.). Additionally, there is a lack of literature, specifically on Caribbean SIDS. So, even though this research has been conducted specifically (in-depth) for one SIDS, this (especially MLP) can be used as a basis for research on other SIDS. Furthermore, the information gathered in Curaçao showed that Curaçao's features correspond with some of the overall features of SIDS mentioned in the literature.

Yet, in terms of dimensions, cultures and geographical location, the SIDS group is not completely homogeneous. Even within the Caribbean, there are big differences, especially because

Curaçao is an Island in the Dutch kingdom, with its ties to EU. Also more heavily affected by the Venezuela situation due to close proximity. So, the research can best be used as comparison material or as a basis. Thus, for SIDS with similar Landscape and Regime (Incl. Aruba, Bonaire, St. Maarten, Saba, St. Eustatius), the SNM research can be used as an example for other SIDS who have yet to implement Solar PV, since many of the obstacles faced during the implementation can be attributed to SIDS related aspects (unstable policy, monopoly, etcetera).

6.4 Societal contribution

From an academic point of view, it was interesting to analyze if the current plans regarding rooftop Solar PV in Curaçao have set the right precedence for large scale implementation.

This is specifically useful to the government and the society of Curaçao. The SIDS will be able to take aspects sketched in Table 6.3.

Table 6.3: Societal relevance

Societal Relevance	
1	The role the population of Curaçao can play to improve their energy situation
2	What the relevant aspects of the local (social) context is, to consider when designing rooftop Solar PV infrastructure on Curaçao
3	Who are the relevant actors that participate in the electricity sector (with respect to expectations alignment and network building)
4	Other stakeholders can now realize the potential and how to mobilize the environment for deployment of Solar PV

6.5 Limitations and Future Research

This research provided useful findings, especially when it comes to identifying the specific obstacles. Yet, due to the complexity of these obstacles (mentality, bad economy, Venezuela/ISLA situation), due to time restraints, this thesis cannot give concrete recommendations on specific actions to take. Future longitudinal research into overcoming these specific barriers is necessary.

From the research there are two main findings that require future research on how to overcome these obstacles.

1. On the level of **Landscape** developments, 'Lack of a green mentality' is been observed. While an in-depth analysis of a focus group session has been performed on the reasons why there is a lack of awareness/care for the environment, there is no clear answer on how to solve this issue. It is clear that other landscape developments, such as 'Bad economic situation' and 'bad infrastructure' contribute to this mentality. Hence, solving these intricate issues first will most likely help shift the mentality. Yet, future research is required to identify ways to bring a shift in this issue, since it is important for the promotion of Solar PV. Through the research several potential solutions were identified,

namely by providing more education on environmental topics in schools and/or starting an active campaign to bring more awareness. Research needs to be done to identify the most effective solutions.

2. On the level of the **Regime**, it was identified that Curaçao's Utility operates as a monopoly. Throughout the in-depth interviews a lot of concern from the public came from the 'lack of competition' and 'too much dependence on Utility'. While the monopolistic nature of the energy regime has been identified as a 'Stabilizing Regime Pressure', due to lack of incentive to take risks, it is not clear whether breaking open the market for competition is the best option for such a small Island. Therefore, further research has to be done to uncover what the best mode of operating is for SIDS - *monopoly* or *competition*. For example, this can be done by analyzing other SIDS (with good performance) and uncovering how their market operates.

Furthermore, by looking at the results of Chapter 4, most of these issues, especially the 'Stabilizing pressures' can be subject to further and more (longitudinal) research.

6.6 Reliability

As previously identified, Curaçao being a Caribbean SIDS, means that the availability of data is lower than in developed countries. Due to this, news articles were primarily used, next to the in-depth interviews, while in developed countries, this information could have been gathered from more credible sources, such as research papers. This was especially prevalent in the MLP research (Chapter 4), where news articles had to be used for expansion on in-depth interviews.

Nevertheless, due to the qualitative nature of this research - especially with SNM (chapter 5) - the impact of questionable sources on the final results is reduced due to the focus of this study being on subjective experience rather than facts, which was then validated with secondary sources to generalize statements.

One hampering aspect is the fact that subjective experience from some large stakeholder groups had to be gathered from a relatively small sample of in-depth interviews and then be generalized to fit the experience of the whole group. This is however minimized by interviewing multiple stakeholders from each of the stakeholder groups and cross-relating their experiences, leading to all of my results being supported by numerous interviews. Important here was the validation through secondary sources (especially news articles) and the on-site gathering of data. By going to Curaçao, I could talk to a multitude of people from the Island (off-record) to validate the in-depth interviews.

6.6.1 Neutrality

As aforementioned, due to Curaçao being a SIDS, there was a lack of literature, especially on historical details. Because this research involved historical analysis dating back to 1980, the data was gathered through interviews from experts who were active in the Energy sector at

the time. Yet, due to their personal involvement there could be some bias towards some of the developments, since some aspects cannot be verified with literature. This is minimized by cross-relating multiple interviews and talking to multiple people that were active in those time periods.

6.6.2 Personal Bias

The personal interpretation of the qualitative data might have affected the reliability of results. This was mitigated as much as possible by bringing 'qualitative rigor' by using the Gioia methodology (Gioia, 2012). By using 'grounded theory' several rounds of coding were produced to ultimately get first-order codes from the in-depth interviews, determine second-order codes based on common themes and finally boil that down to Aggregate codes based on the theoretical analysis (see code trees in Appendix B). As a consequence, numerous interviewees support literally all main results of the case study analysis. Due to the inductive nature of the research it was of utmost importance to add qualitative rigor to the approach.

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Appendix A

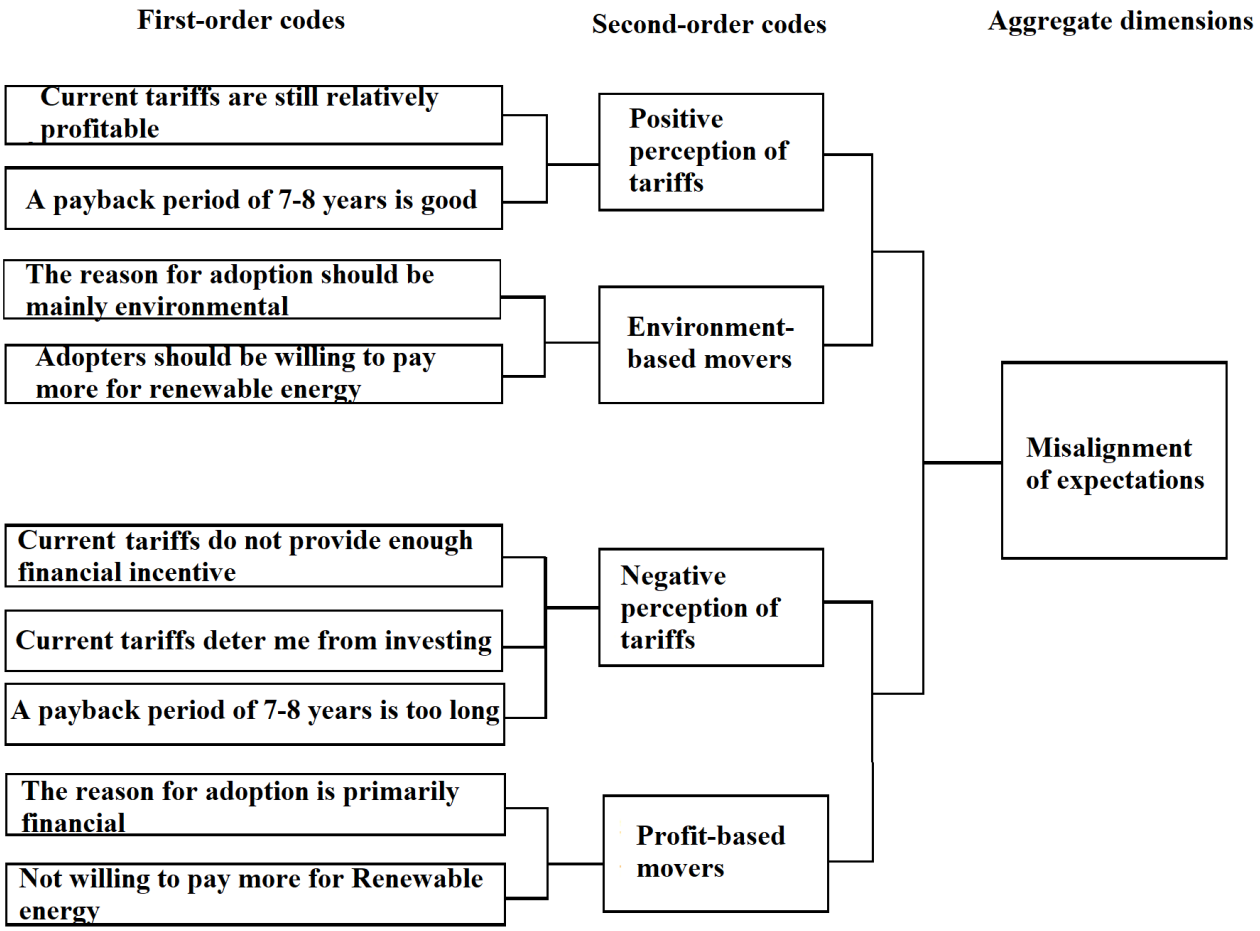
List of Interviewees

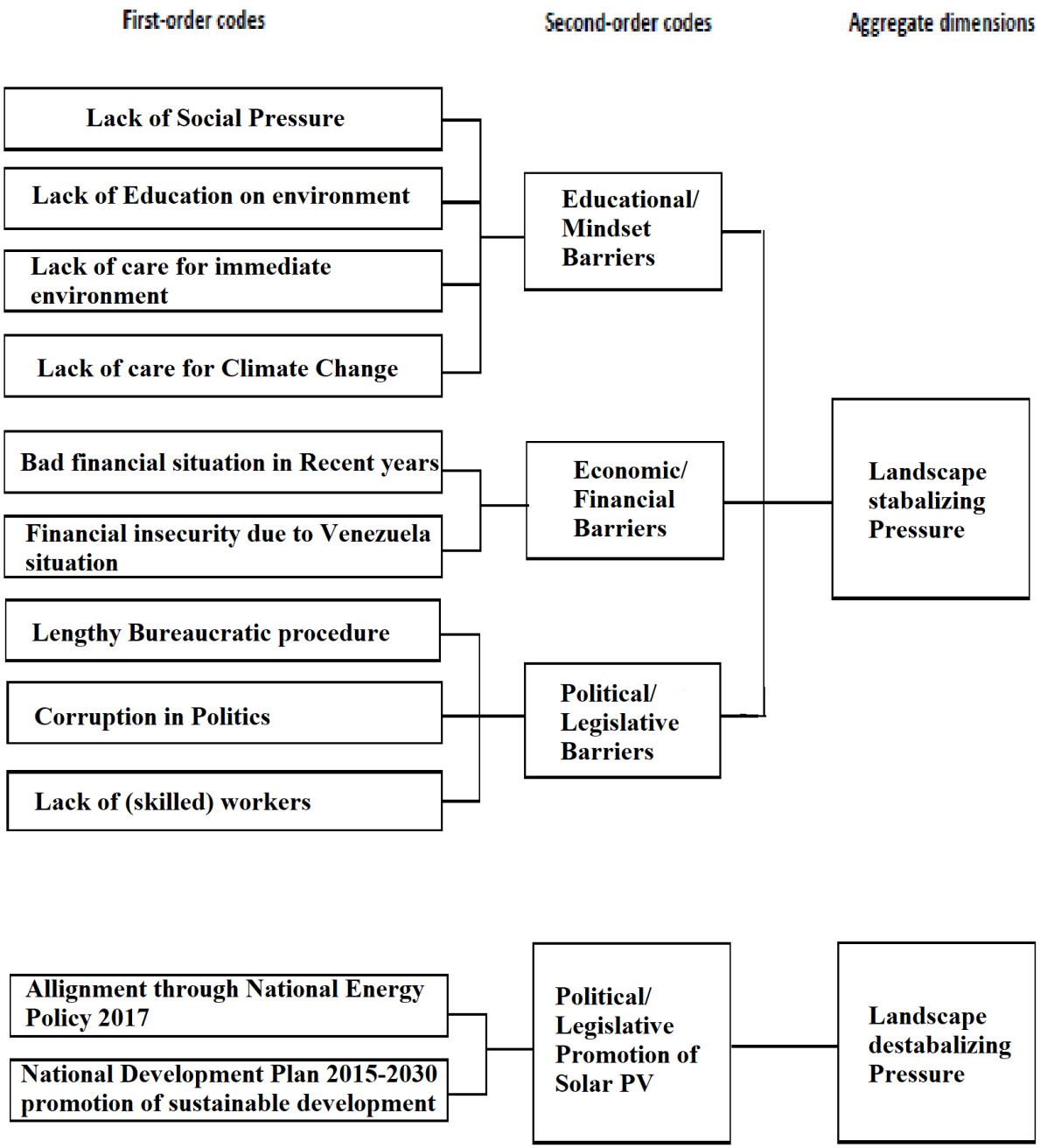
Interviewees		
Number	In-text Reference	Function
1	Interviewee #1, Program Manager at Aqualectra)	Program Manager at Aqualectra - Curaçao Water and Power Company
2	Interviewee #2, Energy Consultant	Consultant and managing director of Next Step Consulting
3	Interviewee #3, Energy Consultant	CEO and Consultant at Energy & Automation
4	Interviewee #4, Energy Consultant	Senior (Energy) Consultant at EcoVision **Additonal**: Private adopter of Solar Panels
5	Interviewee #5, Energy Entrepreneur	Managing Director at Energy & Water savers Ltd. **Previously**: Rotating Equipment Reliability Engineer at Refeneria ISLA Curaçao B.V. **Additional**: Private adopter of Solar Panels
6	Interviewee #6, Professor at UoC	Associate professor Electrical Engineering at University of Curaçao (UoC)
7	Interviewee #7, CEO at C.D.M.	CEO at C.D.M. Holding Inc **Previously**: Superintendent Civil Maintenance at Refeneria ISLA Curaçao B.V.
8	Interviewee #8, CCO at Dynaf	Chief Commercial Officer (CCO) at Dynaf Group
9	Interviewee #9, Consultant	Macro economist / Consultant / author of '100% zonne-energie op Curaçao'
10	Interviewee #10, Private Adopter	Private adopter of Solar Panels **Previously**: CEO at Digicel
11	Interviewee #11, Curaçao Resident	Interested in Solar Panel adoption
12	Interviewee #12	Economist in Curaçao
13	Interviewee #13	President of the Board of Supervisory Directors at CUROIL N.V **Previously**: Managing Director at Refeneria di Korsou N.V.
14	Interviewee #14, Energy Advisor	Senior Policy advisor of Economic Development at the Ministry of Economic Development **Additional**: Co-author of the 'National Energy Policy 2017' **Previously**: Manager at Aqualectra
15	Interviewee #15, CLO at BT&P	Chief Legal Officer (CLO) at Bureau Telecommunicatie & Post (BT&P)

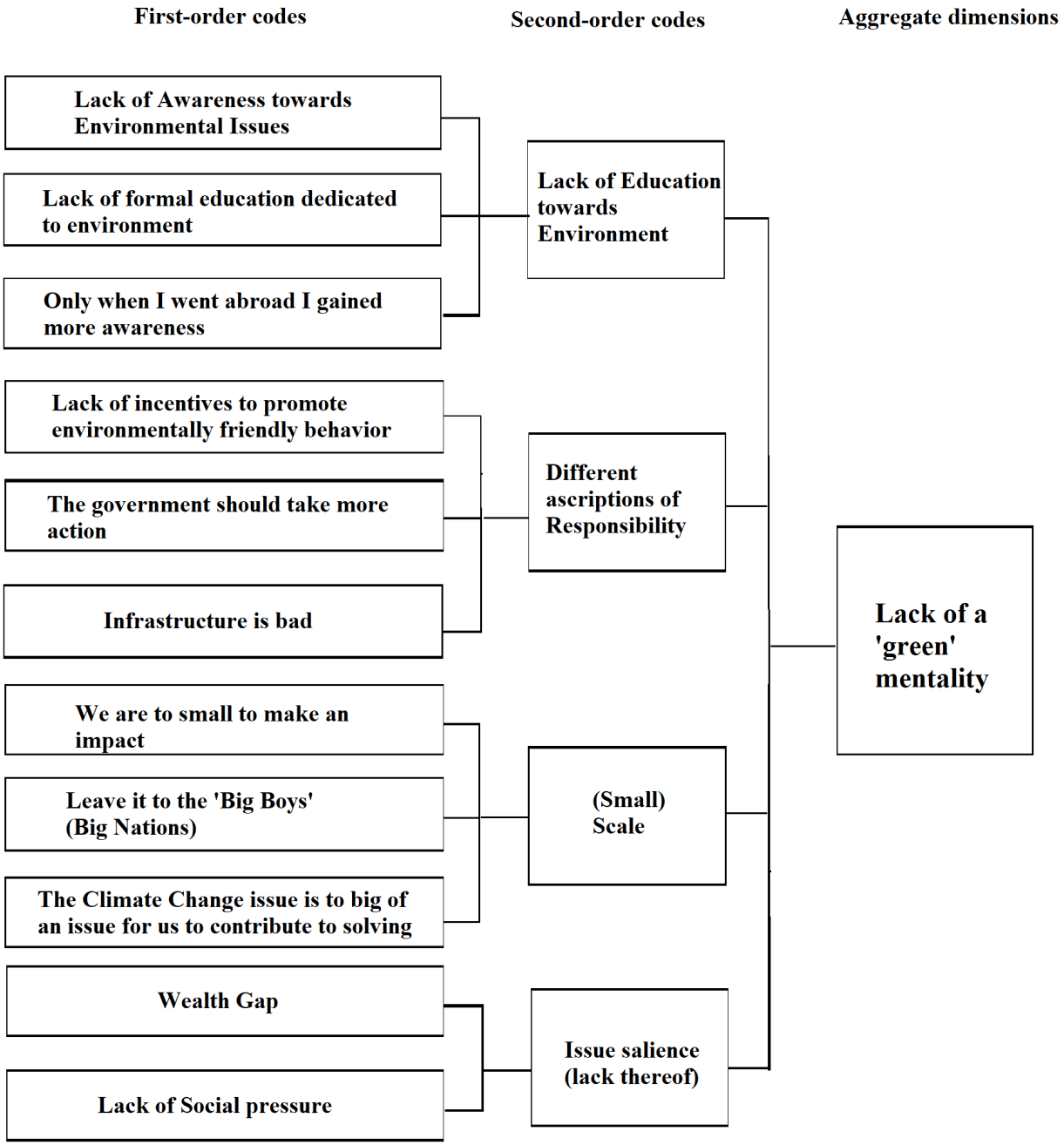
Table A.1: List of Interviewees

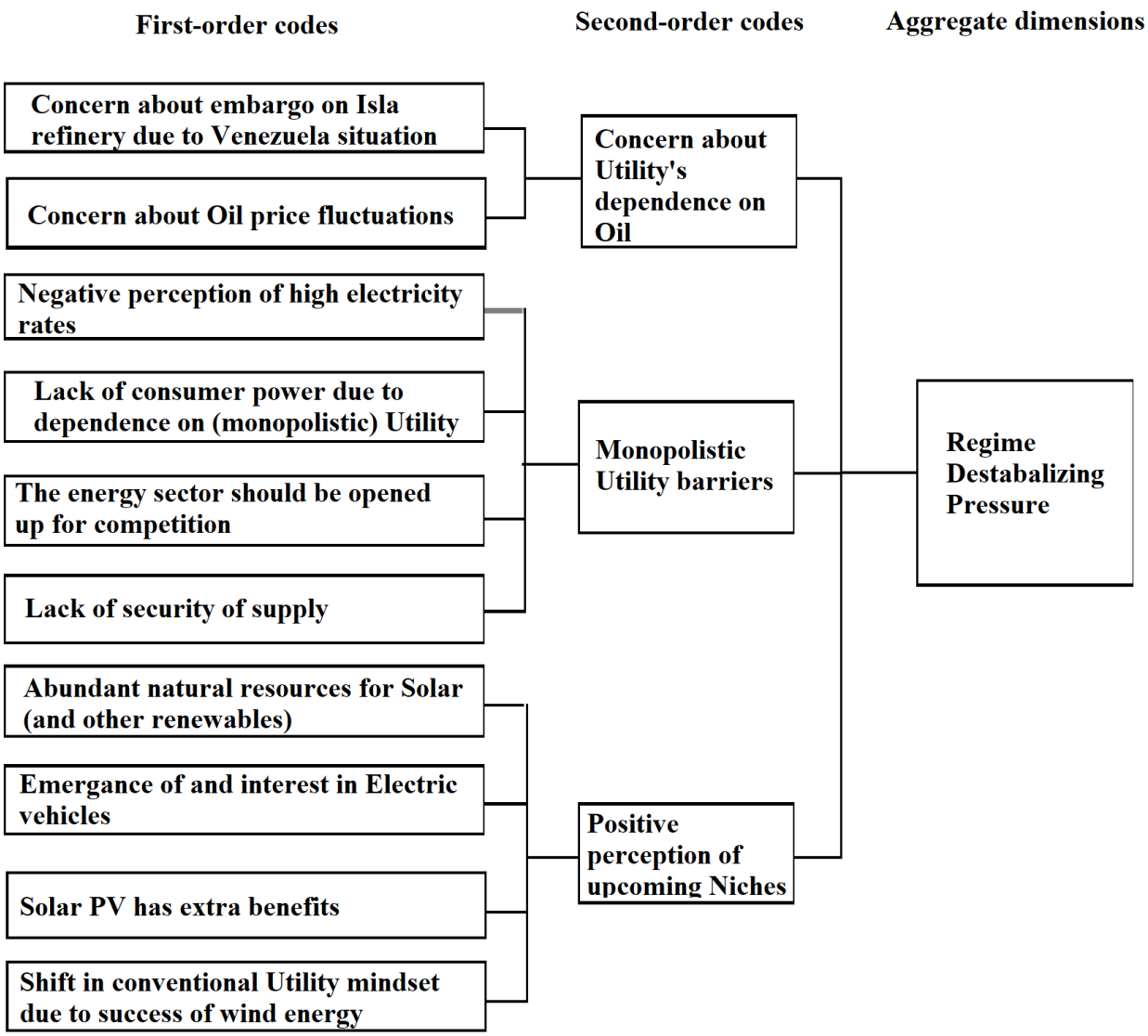
Appendix B

Coding Schemes for Themes




First-order codes
Second-order codes
Aggregate dimensions
Lack of Social Pressure
Lack of Education on environment
Lack of care for immediate environment
Lack of care for Climate Change
Educational/ Mindset Barriers
Bad financial situation in Recent years
Financial insecurity due to Venezuela situation
Economic/ Financial Barriers
Landscape stabalizing Pressure
Lengthy Bureaucratic procedure
Corruption in Politics
Lack of (skilled) workers
Political/ Legislative Barriers
Allignment through National Energy Policy 2017
National Development Plan 2015-2030 promotion of sustainable development
Political/ Legislative Promotion of Solar PV
Landscape destabalizing Pressure


First-order codes
Second-order codes
Aggregate dimensions
Lack of Awareness towards Environmental Issues
Lack of formal education dedicated to environment
Only when I went abroad I gained more awareness
Lack of Education towards Environment
Lack of incentives to promote environmentally friendly behavior
The government should take more action
Infrastructure is bad
Different ascriptions of Responsibility
We are to small to make an impact
Leave it to the 'Big Boys' (Big Nations)
The Climate Change issue is to big of an issue for us to contribute to solving
(Small) Scale
Wealth Gap
Lack of Social pressure
Issue salience (lack thereof)
Lack of a 'green' mentality


First-order codes
Second-order codes
Aggregate dimensions
Concern about embargo on Isla refinery due to Venezuela situation
Concern about Oil price fluctuations
Negative perception of high electricity rates
Lack of consumer power due to dependence on (monopolistic) Utility
The energy sector should be opened up for competition
Lack of security of supply
Abundant natural resources for Solar (and other renewables)
Emergance of and interest in Electric vehicles
Solar PV has extra benefits
Shift in conventional Utility mindset due to success of wind energy
Concern about Utility's dependence on Oil
Monopolistic Utility barriers
Positive perception of upcoming Niches
Regime Destabalizing Pressure

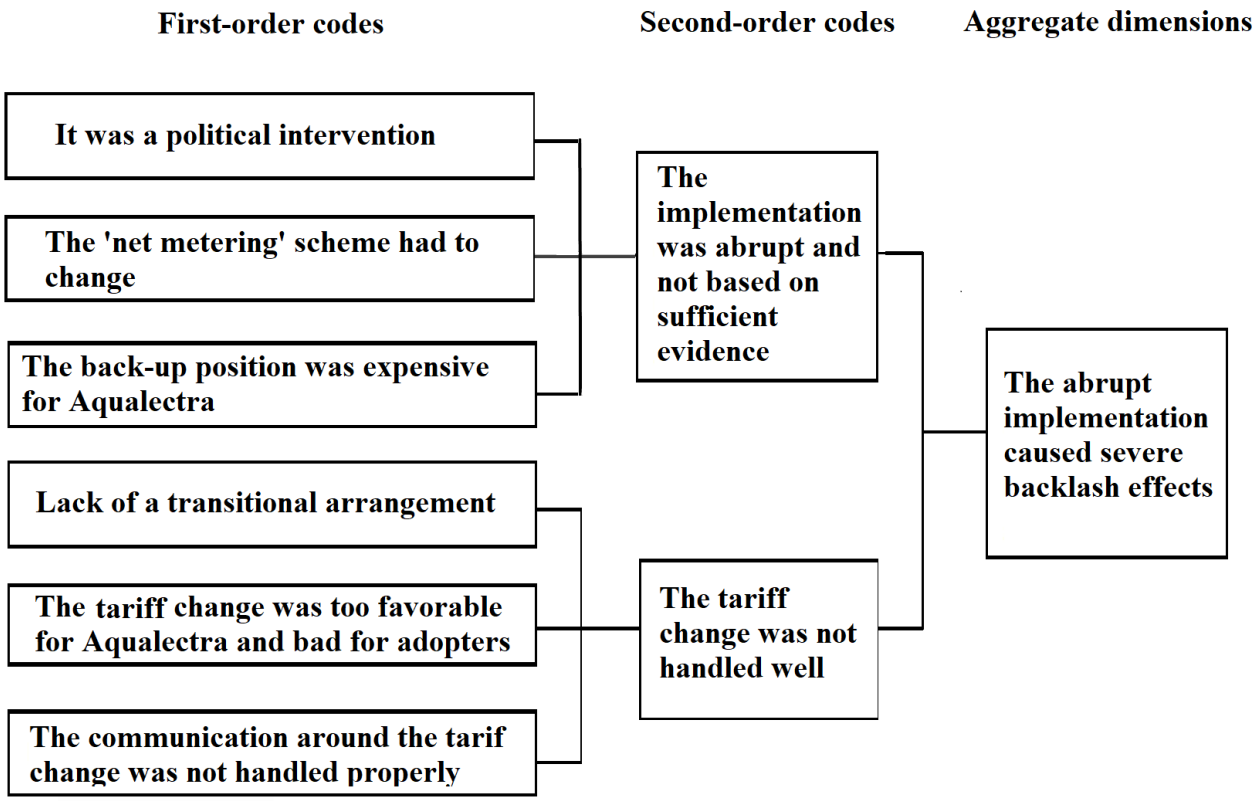


Figure B.1: Code tree

Appendix C

Sample Codes

Sample Codes		
Aggregate dimensions	**Second Order Codes**	**Quotes**
Regime Destabalizing Pressure	Concern About Oil Dependence	Het punt is namelijk, als sustainable sources aantrekkelijker worden, word de vraag naar fossiele brandstof minder
		Om te beginnen, worden we onafhankelijk van fossiele brandstoffen.
		We zijn hier helemaal afhankelijk van fossiele brandstoffen, dus het kan niet anders. Het zijn allemaal conversies dat je dan hebt. Om de ruwe olie op te pompen heb je kosten. Dan moet je het transporteren, dat zijn weer kosten, je moet het verwerken, dat zijn weer kosten. Bij het verkopen komen ook allerlei markups erbij. Daar betalen we voor.
		We zouden eigenlijk onafhankelijk moeten zijn van fossiele brandstoffen. Iedereen bijt de nagels van de handen af, ze zeggen: er is geen bradnstof, er is geen dit. Gewoon afstappen zeg ik.
		Wij kunnen heel groen zijn en ook helemaal onafhankelijk worden van de ISLA.
		Feitelijk moeten wij niet afhankelijk zijn van fossiele brandstoffen. In een heel enkele geval, bijvoorbeeld in regenseizoenen, in zulke tijden, maar over het hele jaar hebben we zon.
	Monopolistic Utility barriers	Het is een efficiency-slag die ze dan nootgedwongen zullen moeten gaan maken. Aqualectra pretendeert dat ze op het gebied van duurzame energie een soort voorloper zijn. Er zijn zelfs uitspraken gedaan dat ze het bedrijf zijn in het hele caribische gebied met het hoogste percentage groene energie. Ik heb zoiets van, waar halen ze dat vandaan?! Maar dat is pretentie. Maar goed, er zijn windmolenparken.
		Ik denk dat dat de enige manier is om die kentering te weeg te brengen is dat er een andere partij op de markt is, die precies hetzelfde doet, maar een tikje goedkoper is. Het leven op Curaao is heel duur en ik vind wat Aqualectra doet gewoon belachelijk. Het is gewoon echt belachelijk en de hele beviolking is ermee geholpen als daar traks een verandering in komt. De tijd zal leren hoe het eruit komt te zien. Ik denk dat de prijsverlaging niet bij 5% zal blijven, ik denk dat het nog veel lager kan.

		Maar wat gaat er dan gebeuren, dat is de partij die nu zegt: ik kan niet verlagen, die moet dan verlagen. Ze hebben ook heel veel ruimte om te verlagen, alleen is de overhead nu zo ontzettend hoog en de commitment en de verplichtingen en financieringen en al dat soort dingen. Maar, dan kan de ware Aqualectra wel eens naar buiten komen. Dan moet er wel iets veranderen.
		Ik denk wel dat het belangrijk is voor het eiland. De tarieven zijn gewoon belachelijk hoog. Als je kijkt wat je hier aan elektriciteit en ook water, trouwens, betaald.
		Die trigger, die moet er komen in de markt. Uit zichzelf gaan ze het nooit doen.
		Ik wil dat de markt op Curaçao voor energie opengebroken wordt.
		Een ander ding is natuurlijk dat de Utilities in het Caribisch gebied vaak nog monopolistisch zijn en die zitten niet echt te springen om allerlei groene en nieuwe dingen te implementeren, snap je. In nederland word het juist gepropageerd. Als ik in Nederland geen dak heb, kan ik betalen dat het op jouw dak komt. Je kunt daar zonnecorporaties doen. Terwijl we hier toch nog iets hebben van de utility zegt van 'its my water' het gaat nu al goed 'why rock the boat'.
		Er is geen plek ter wereld waar het zo gunstig is om te doen en dat het zo tegengewerkt wordt, dat is wel een nadeel van zo een monopoly systeem hier, wat Aqualectra heeft?
	Positive perception of upcoming Niches	Mijn zonnepanelen hebben minder last van corrosie en heeft geen bewegende delen. Dus je komt relatief goedkoper uit in dat opzicht. Je hebt er bijna geen onderhoud aan. Alleen schoonmaken zo nu en dan.
		Je helpt mee aan een schoner milieu. Dat zijn zaken die heel belangrijk zijn. Er worden overal bossen weggekapt, ik weet niet hoeveel honderden hectares die worden weggekapt. Dit zijn longen van de natuur. Wij breken af, maarr we zorgen nooit dat we terug helpen met de natuur. Dit is een manier om te helpen.
		Ik denk dat gewoon heel veel mensen niet beseffen dat je hier gewoon op een uniek eiland op dit moment leeft, waarin dit als een soort van voorbeeld naar de rest van het Caribisch gebied kan gaan uitrollen.

		Hier in onze regio is het bij uitstek ideaal om toe te passen. We hebben geen sneeuw en alleen sporadische regenbuien en alleen eind van het jaar eventjes. Daarbovenop regent het niet eens de hele dag, het regent maar een uurtje of paar minuten en dan klaart het weer op.
		Als je dat op een goede manier wilt doen, dan is zon, in dit klimaat natuurlijk wel DE manier.
		Het blijft gewoon een feit dat we hier de meeste zonuren hebben en als jij al 1 paneel op je huis hebt zitten, dat je al kosten kan besparen.
		Ik vind dat het zeker met dit onderwerp het gewoon mega interessant is om juist in dit gebied (Caribisch gebied) te zitten.
		Ik denk dat gewoon heel veel mensen niet beseffen dat je hier gewoon op een uniek eiland op dit moment leeft, waarin dit als een soort van voorbeeld naar de rest van het Caribisch gebied kan gaan uitrollen.
		Zeker op de antillen en het caribisch gebied zijn bij uitstek ideaal voor de toepassing van zonne energie
Landscape Stabalizing Pressure	Education mindset barriers	Maarja, als iemand helemaal van Fuik naar Mal-pais moet rijden, dan is hij alleen op de heenweg al een uur onderweg. Dat kost ook nog brandstof en dan moet hij daarna nog terug komen. En dat is niet in rekening nemende van de tijd die nodig is om te laden en uit te laden. De mondi is dichtbij en niemand ziet het, dus waarom niet gewoon daar dumpen? Makkelijk.
		Ik denk dat je ten eerste je moet de mensen opvoeden leren wat de voordelen ervan zijn. Want het is een nieuwe technologie het is disruptive dus het kan je denk en leef patroon veranderen. En je kan niet verwachten dat de mensen dat van de een op de andere keer zomaar gaan aannemen. Je moet er vanuit de overheid een stukje educatie bij doen. Dus je zegt van luister: Als dit de manier is dat je het wilt gaan doen, dan moet je daar toch wel een beetje over nadenken en je moet de mensen toch wel een beetje voorlichten van: 'Ja, het kost nu meer, MAAR .. snap je?' Anders weet men het niet. En de mensen die het nu al weten kennen het al in Nederland, dus voor hun is het verder een no-brainer.
		Ik denk dat daar een heel groot taak is weggelegd voor de overheid, misschien niet eens alleen de overheid, maar ik denk ook zelf de hele sector, dat je de mensen moet uitleggen van: 'Dit is het.'

		Dat moet nog komen en ik denk dat educatie daar een heel belangrijk onderdeel van is.
		In nederland, colombia doen mensen aan recycling, maak de gemeenschap BEWUST van recycling. Doe alles apart, flessen, papier apart. En alles moet je incentivisen, want anders heeft het geen zin.
		Niemand is bewust van het milieu, daarmee bedoel ik de gemiddelde man.
		Ik denk dat op de eerste plaats niet voldoende bewustzijn is binnen de ik mag niet zeggen gemeenschap maar de overheid, over belangrijkheid van dit soort zaken.
		volgens mij weten de mensen gewoon niet anders
		Ik vraag me soms af waar we mee bezig zijn. We moeten juist de gemeenschap bewust maken van natuurbehoud. Zo een gedachtegang of zo een policy druist er gewoon tegenin.
	Economic financial barriers	We hebben een Nederlands paspoort en je ziet onwijs veel armoede hier.
		wegens de financile situatie hebben we het niet meer kunnen doen
		De koopkracht gaat achteruit. Er zijn nu minder mensen die echt werken. Bij ISLA zitten nu praktisch alleen mensen op de pay-roll en er zijn vrijwel geen contracters meer omdat er geen werk is. ISLA zelf kan deze mensen ook niet betalen, want er is geen productie, omdat er geen productie is, is er geen cash-flow, wat betekent dat je geen geld hebt om die contracters te betalen.
		De Amerikanen hebben vandaag bijna de oorlog verklaard aan Venezuela, want de sancties die zijn weer toegenomen. Niet alleen Venezuela, maar alle landen die relaties hebben met Venezuela, die krijgen nu ook sancties tegen zich. Curaao heeft moeten bedelen bij de Amerikanen dat ze niet uitgezonderd mogen worden, want guess what, PDVSA zit hier op het eiland. Dus, wat ga je doen als je sancties gaat nemen tegen alle landen die nog relaties onderhouden tegen Venezuela.
		Maarja, Curaao is een double edged sword, want wij zijn ook de hub om de hulpgoederen te brengen en wij maken ook onderdeel uit van het koninkrijk der Nederlanden en we liggen hier een paar km afstand van Venezuela, dus ze moeten wel voorzichtig te werk gaan.

		Maar we hebben een raffinaderij, waar niet meer wordt geproduceerd, vanwege de situatie in Venezuela. Venezuela is een van de rijkste landen ter wereld voor wat betreft Oliebronnen en ze hebben ook nog goud en uraan en weet ik nog meer wat. Alleen ISLA draagt voor zeker 10% bij aan het nationaal product.
		Verontrustend. Het is nu nog open, maar het draait niet. Heel verontrustend. Niet alleen voor de collegas die daar zitten. Meer voor het hele eiland de hele gemeenschap. We zullen het allemaal gaan voelen als hij niet meer gaat draaien.
		Het levensondehoud op het eiland zal veel duurder worden.
		De mensen zullen niet veel meer gaan verdienen, werkloosheid zal natuurlijk hoger worden, criminaliteit zal omhoog gaan (dat is sowieso).
		Er is minder geld en mensen moeten blijven leven, dit gaat allemaal meetellen.
		Ja, die krijgen betaald, maar we weten niet tot wanner.
	Political legislative barriers	Ook toen ze een keer bij mij zijn komen kijken hebben ze me uitgelegd hoeveel dingen je moet doen voordat Aqualectra een goedkeuring geeft. De goedkeuring van Aqualectra is ongelooflijk; vele voorwaarden. Ik denk dat dat al een moeilijk punt is.
		EN je moet voldoen aan alle voorwaarden van Aqualectra. Ze moeten het goedkeuren en dan krijg je ook nog een keurmeester die vervelend is dat zijn ze allemaal, haha. Al die voorwaarden zijn een grote barriere geworden.
		Er kwam dus een wetgeving dat het altijd mocht, maar dan moest het systeem wel gekeurd worden en aangelegd worden door een installateur die ook gecertificeerd is dat zijn wel een aantal fors beperkende factoren.
		Ik had een keer een buitenlander hier op bezoek en we hadden het over projecten enzo en ik vertelde hem dat een project dat was allemaal in kannen en kruiken, maar er moesten nog bepaalde beslissingen genomen worden, dat zo een project gestart kon worden en dat duurt zo lang. Hij zei tegen mij 'It went into the Curaçao mode'.

		Ja, dat is variabel. Volgens mij gaat het hier wel sneller dan op Aruba daar heb je soms wachtlijsten van 3 maanden. Maar het heeft ook weer met aanleveren van bepaalde documentatie te maken maak je ergens een foutje in, dan is het weer wachten. Dus, daar kan ook weer verbetering in komen. Maar dat zijn dus ook partijen waar je afhankelijk van bent bij het implementeren.
		Het duurt op dit moment bij ons veel te lang voordat we gewoon een klant kunnen bedienen met een quotation, dat kan gewoon niet, vind ik. We moeten die klanten in de voorfase beter en sneller kunnen adviseren en bij wijze van, ook sneller de panelen op het dak kunnen leggen. Op dit moment hebben we zeg maar een soort van waglijst. Het duurt gewoon veel te lang voordat we klanten kunnen helpen
		Want ik zie dan ongeveer, 3 maanden dat ik ze hier op het eiland kreeg, want dan komen ze rond 15 februari installeren, maar dan heb je n.a. 3 maanden, dat was ook een heel onnodig langdradig proces (gelul), dan komen ze pas keuren. Ik moest toen elke week mijn emails checken om af te wachten wanneer ze nou eindelijk kwamen keuren.
		Het is een mooie paper, maar het naleven is feitelijk belangrijk papier is geduldig.
		Het is zo geweest, Aqualectra heeft in die tijd een project geinitialiseerd. Aqualectra had zelf geen geld en heeft van buitenaf iemand gekregen die mee wilde investeren. Uiteindelijk was het niet meer mee investeren maar die zou investeren. Het project is helemaal ontworpen en aanbesteed en tijdens het vergunningsproces is het bedrijf dat zou financieren Econcern failliet gegaan. Nou is er weer een initiatief om in dat project leven te blazen. Ik hoop dat dat lukt. Dat is een bedrijf .., heb je daarvan gehoord?
		Nee, het hoeft in principe geen probleem te zijn. Kijk, je kunt iemand hebben die LTS heeft gedaan, bijvoorbeeld, maar in principe niet de mogelijkheid heeft gehad om hoger op te beginnen, maar kan toch heel intelligent zijn. Van deze man bijvoorbeeld kan ik zeker niet zeggen dat hij dom was hoor, hij was niet dom, het was een hele intelligente man, maar hij had gewoon geen chemische achtergrond

		Ik denk ook dat bij onze overheid, dat er veel te weinig praktisch georinteerde, ik bedoel anders dan ik mag niet zeggen economisch, ik mag ook niet zeggen handelswijze maar het is niet technisch, men is minder technisch georinteerd. Wat wij hier nodig hebben op een gegeven moment is dat iets technisch opgelost wordt.
		Wat ook is; kijk, als universiteit kunnen we heel veel dingen doen, maar het bedrijfsleven die moet investeren in de universiteit. Niet alleen met geld natuurlijk ook geld maar ook mankrachten. We zijn hier gewoon overbelast wat betreft werk, dus heel veel dingen die van ons worden verwacht, kunnen we gewoon niet doen omdat we er gewoon niet aantoe komen om dat te doen.

Table C.1: Sample Codes

Appendix D

Summary of Internal Niche Processes

In Table D.1 I have combined the previous analyses. I conclude that overall, the quality of niche processes in Curaçao was limited.

Period	Main Characteristics of Niche Processes	Quality of Internal Niche Dynamics
1980 - 2011	Private adopters have marginal expectations about Solar PV installations, in line with the Utility. The network is small, but there is high alignment due to a small group of first movers with the same, almost altruistic, reason for adoption. All adopters were first movers that adopted purely out of technological or environmental interests, but expectations were low, since economically the technology was far more expensive than utility-based electricity and all adopters knew this beforehand. These actors (private adopters) designed experiments to learn about basic parameters, Solar PV yields and economic performance, which was shared with the Utility at first and then also done by the Utility, including the first grid-connected experiments in 1995 and 1998. The main lesson was that plants were economically unfeasible without any type of financial incentives (or subsidies) and technological performance itself was good (first-order learning).	**Voicing of Expectations** Not Robust Semi Focused **Network Building** Not Functioning **Learning Process** High Quaility, but insufficient
	After the merger in 2001, expectations within the Utility were still mixed and research continued at a relatively slow pace due to these internal tensions, resulting in abundant technical knowledge about feasibility of grid connectivity.The main lesson was that the grid was not yet technically suited for large scale implementation (first order learning). Yet, technical and economic performance has drastically improved in the meantime (Solar Tech become much less novel, R&D improved and they started to be sold on a larger scale, making them drop in price quickly). Despite this, expectations were not aligned, and experimentation was kept separated from the market.	

2011 - 2015	The 'net metering' scheme is introduced, and the Solar PV market takes off. A total of 10MW is installed, mainly on rooftops of Private adopters (home owners). Yet, this was detrimental to the finances of the Utility, due to them having to buy overproduction from these private installations back for the same price as it is sold, which doesn't take into account the Utility's fixed grid costs. The learning process is of high quality. Due to high rates of adoption, the use of Rooftop Solar PV over time increases the understanding of every aspect of it. This results in accumulated facts and data (first-order learning). Additionally, the accumulated facts and data about the Solar PV in the first- order learning changes the actors' expectations towards the technology. This results in changes in cognitive frames and assumptions. This can be seen by prior adopters expressing extra benefits of Solar PV.	**Voicing of Expectations** Not Robust Not Focused Low Quality **Network Building** Semi-Functioning **Learning Process** Insufficient
	They learned that the adoption of panels makes it easier to track electricity use on a moment to moment basis, "Just like one would with an internet bank account". Additionally, the Utility learned about the technical (grid) implementation of large-scale adoption in the form of the 'duck curve'. Users had extremely high expectations for the technology in this period, mainly attributed to its profitability. This caused them (mainly the wealthy inhabitants) to install oversized systems and communicating this to their neighbors, telling them to do the same. The Utility, on the other hand, had far different expectations. Their expectation for the technology was for adopters to invest from more of an environmentally friendly ('altruistic') perspective, than a profit-making perspective. They expected people to invest in solar panels, even if it would cost more, but the extra costs should be outweighed by 'saving the environment'. Still, the Utility had higher expectations for Wind energy for the majority of large-scale renewable energy production, professing that solar energy was still too expensive. Even through the large-scale implementation, the utility's expectations about technical and economic feasibility increase, but only on Utility-scale, highly regulated implementations. This led to them thinking about a tender for a 15MW PPA agreement. For retailers, network forming proved particularly difficult due to a lack of experienced actors on the Island itself and a lack of trustworthy high-quality actors in the region. This made it difficult to establish great relationships, while maintaining and guaranteeing quality to potential adopters. Additionally, the fact that partnerships are formed with parties abroad, communication is made more difficult and products become more expensive due to the transport.	

2015 - 2019	When the tariffs changed, the backlash effects from prior adopters were severe. The tariff changes immediately got a negative connotation and were infamously called 'Solar Tax' by the general public. This is attributed to the misalignment of expectations of the utility and adopters. This was further enhanced due to the bad communication when the 'net metering' scheme was introduced. At the introduction there was no official alignment of expectations for the scheme from the government towards the public, thus there was no communication that the tariff scheme would be temporary to boost the technology. Additionally, the lack of a transitional arrangement caused adopters' ROI to look completely different. Because of this, expectations immediately became very negative when it came to economic performance and the current tariffs were seen as too much in favor of the Utility and detrimental for adopters (with a payback period of 7-8 years). This, even though internationally, a payback period of 7-8 years is relatively beneficial. For the Utility, this change in tariffs, granted the possibility of implementing experiments which produced broad learning processes. This broadened the scope of benefits that the utility saw for the technology, particularly externalities to do with isolation and thus energy savings (cost savings) and a 'green' image especially for international companies.	**Voicing of Expectations** Not Robust Not Focused **Network Building** Highly-Functioning **Learning Process** Sufficient

Table D.1: Summary of SNM