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Increasing the efficiency of renewable energy; drawing lessons from niches regarding Demand Side Management in countries across the world

Master's Thesis

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Abstract:

The Dutch government wishes to reduce the Greenhouse gas emissions in 2050 by 80 to 95% compared to the emissions in 1990, and to have an almost completely sustainable energy system, based on renewable energy. The problem is that in an electricity system based on renewable energy, renewable energy cannot always be used efficiently. When the supply of renewable energy cannot be balanced with the needed demand, the renewable energy suppliers, such as wind turbines, will be turned off, decreasing the efficiency of the electricity system. This inefficiency is what Demand Side Management (DSM) wants to decrease. DSM is a portfolio of measures which helps adjusting the demand to match the fluctuating supply of renewable energy. However, DSM is still in the experimental phase, where niches that are going on in DSM need to be upscaled in order to affect the regime level. The purpose of this study is to acquire lessons regarding the upscaling performance of niches in DSM. Therefore, the following main research question is formulated: *"Which lessons can be drawn from niches regarding demand side management in countries across the world, for the implementation into the regime level in a Dutch context?".* A comparative case study is conducted to answer this research question, using a document analysis as the main research method. The cases that are selected, based on the availability of data are DSM in the countries of; The United Kingdom, India, Australia and China. The conclusion for this study is that the most valuable lesson for the implementation of Demand Side Management in the Netherlands, and the upscaling of niches in DSM into the regime level, is the need of a regulatory framework and active policy support from the government. This insight is valuable for policy makers and will contribute to increasing the efficiency of renewable energy in a sustainable energy system.

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Chapter 1: Introduction

Reason for this study:

The need for a new energy system

In 1959, a huge gas field was discovered in the Netherlands. This moment of the discovery has been of a great importance to the state and the society. The Dutch gas bubble yields enormous economic benefits, roughly 280 billion euros have been earned in total since the discovery in 1959 (Historiek, 2018). However, the discovery was not only of importance to the state, society adapted to the new energy source as well. The energy infrastructure experienced a significant transition. In 1963, already 75% of the households in the Netherlands was connected to the gas field (Historiek, 2018). The Netherlands in general became very dependent on the exploitation of natural gas.

A concept that is being used to explain this dependency is path dependency. Path dependency means that something becomes harder to change the longer that that same thing exists (Sorensen, 2015). Small changes at the beginning, can lead to significant outcomes in the long run. If one step provides positive feedback, then it is more likely that a next step is taken as well. But going a step back might then become more difficult, because you grew dependent on it. This concept is applicable to the gas field for the Netherlands. At the discovery, inhabitants would connect to natural gas, since it was a source of energy that was cleaner than coal. This was the positive feedback and made sure that even more people connected to it. Furnaces or heating systems began to adapt to the new source as well. More and more were being invested in the extraction or products of gas. Slowly, the Netherlands became dependent on this new source of energy. Once this dependency occurs, it is very hard to change back to an alternative. Sometimes, it is not necessary to change back to an alternative, but in the case of the exploitation of natural gas in the Netherlands, they eventually arrived at a moment where they needed to do exactly that.

The winning of gas was not flawless and had its negative impact. During the 1990's, the first earthquakes emerged in the province of Groningen. Since 2012, a total of 80.000 damage claims have been notified (Historiek, 2018). Even worse, the people in the province began to lose a feeling of safety. The state didn't want to stop with the extraction of gas at the discontent of the inhabitants of the province of Groningen. Participants in a study by the university of Groningen about the acceptance of the Gas exploitation of Groningen felt that they were powerless (Rijksuniversiteit Groningen, 2018), and the negative emotions about the earthquakes increased over time. There are, besides the earthquakes in Groningen, other reasons why the consumption and exploitation of gas needed to stop. One of the more important reasons is with the exploitation of gas, a lot of CO2 is released in the atmosphere, which has a negative impact on the climate. The Netherlands wants to achieve almost zero CO2 emissions by 2050 (Rijksoverheid, 2019). Eventually, Eric Wiebes, the Minister of Economic Affairs and Climate Policy

in the Netherlands announced that they will stop with the exploitation of the natural gas in 2022 (NOS, 2019).

The dependency of Groningen on the gas field has led to a crisis. The period during a crisis can be seen as a critical juncture (Sorenson, 2015). “Critical junctures are moments when existing political and institutional structures fail to provide either adequate solutions to pressing problems, or explanations of challenging events, and thus lose governance legitimacy and their ability to determine action and interpretation, creating opportunities for actors of all sorts to play greater roles in developing new institutions” (Sorenson, 2015). This quote is applicable on the situation of the gas exploitation crisis in the Netherlands. It shows that the political and institutional structures failed to solve the problem of the earthquakes and the decline in the feeling of safety of the inhabitants of the province of Groningen. It also suggests a need for a more sustainable energy system to meet the CO2 emission goals of the Dutch government. More importantly, in line with Sorenson (2015), this is the moment of opportunities for actors to play a great roll in the transition towards a new energy system.

Renewable energy: Opportunities

As mentioned, the Dutch government wish to reduce the Greenhouse gas emissions in 2050 by 80 to 95% compared to the emissions in 1990 (Planbureau voor de Leefomgeving, 2020) and to have an almost completely sustainable energy system. But next to this goal, there are a lot more incentives to change towards a sustainable energy system with renewable energy. The Union of Concerned Scientists (2017) has produced a report with the benefits of renewable energy. The first benefit addressed in the report of renewable energy is less global warming. Due to greenhouse emissions, the global temperature is rising. A way to reduce the emission of CO2 is renewable energy as it produces little to no global warming emissions (Union of Concerned Scientists, 2017). This will make a huge impact as 80% of the total greenhouse gas emissions in the EU-27 in 2013 were the result of the energy system, including energy production, consumption and transport (European Environment Agency, 2013).

The second benefit is improved public health. According to the European Environment Agency (2019), air pollution is the largest environmental health risk in Europe. The energy sector is one of the main causes of air pollution (European Environment Agency, 2019). The pollution due to the coal and natural gas plants is linked with multiple health problems such as breathing problems, cancer or heart attacks (Union of Concerned Scientists, 2017). Renewable energy production in wind and solar energy does not produce direct water or air pollution and is therefore a more suitable option.

The third benefit is that most forms of renewable energy is inexhaustible. Wind and solar energy, compared to coal or gas, does not use any depletable resources. This also results in the fourth benefit of renewable energy mentioned in the report of the Union of Concerned Scientists (2017), namely stable

energy prices. Besides the upfront investment costs, the sources of renewable energy can produce energy at low costs, since it does not require any valuable source of fuel. This leads to stable energy prices. Next to that, the upfront investments costs of especially solar energy are dropping significantly (The Solar Nerd, 2020), which is the main component as there are only limited running costs. The prices of Solar PV have already dropped by 89% since 2010 in the United States, and it is expected that the Solar PV will drop by another 34% by 2030 (The Solar Nerd, 2020).

The fifth benefit of renewable energy is that it creates more jobs and other economic benefits. On average in the United States, for each unit of electricity, more jobs have been created from renewable sources than from fossil fuels (Union of Concerned Scientists, 2017). These jobs can be in the form of manufacturing, installment or financial, legal and consultation services.

The last-mentioned benefit is reliability and resilience of renewable energy sources. According to the report, wind and solar energy sources are less in risk of failure because they are distributed and modular (Union of Concerned Scientists, 2017). The sources are more spread out over a large geographical area, as opposed to coal and gas plants. In case of a natural disaster for example, the disaster will most likely not have a devastating impact on all the sources, but the renewable energy sources are also modular. Even if some parts of the system are damaged, the rest can still operate and produce energy. This makes the renewable energy system more robust and resilient.

Renewable energy: Challenges

However, while the benefits of a sustainable energy system are clear, achieving such a system brings challenges that needs to be addressed. The first visible challenge is the construction of wind and solar parks. Wind and solar parks take up a lot of space and are visible even from a large distance. This creates a problem, especially for countries with a high density like the Netherlands. Countries with a high population density have less space available for wind or solar parks, but also have a high energy consumption per square kilometer. This creates a negative spiral so to say. Because of the available land scarcity, offshore wind farms see an increasing popularity. In 2017 alone, offshore wind electricity generation grew with 32% (IEA, 2019). But in the case of the Netherlands, there is also not that much space available offshore as well, as the North sea has already have a lot of space covered up by dedicated activities such as fisheries or military purposes (Maritiemnederland, 2018). In addition to the availability of offshore space, the transport of energy leads to a loss in exergy, which is amount of energy that is available to use, and large cables are required to transport the energy produced by the wind turbines to the electricity converter stations. Next to this, there are also ecological risks associated with wind farms, especially during the construction period (Nunneri et al, 2008).

A second important challenge of a renewable energy system is that society is dependent on a guaranteed flow of electricity. The production of renewable energy has a fluctuating nature and cannot be forecasted precisely (Robert et al, 2018). The demand and supply of electricity needs to be matched in order to function well. This is why a guaranteed flow of energy is required to close the difference between supply and demand. Renewable energy cannot fulfill this task yet, because it does not have a guaranteed flow of energy making the system unstable when integrating into the power system on a large scale (Robert et al, 2018)

Besides the fluctuating nature of renewable energy, there is another characteristic that makes it harder to effectively implement the renewable energy sources to the electricity grid. This characteristic is that most of the production of renewable energy comes at the time of the day when the consumption of energy is the lowest. Solar panels produce energy only during the day when the sun is shining, but the consumption of energy is usually lower at this point. This leads to an overload of production, which cannot be used effectively. This results in solar parks that are not operating during the day, simply because the energy that the park would produce could not be used. Demand Side Management (DSM) is a portfolio of measures that want to tackle this problem and is introduced by Palensky & Dietrich (2011). The measures of DSM range from improving the energy effectiveness by better materials, to changes in electric usage by users in response to changes in the price of electricity over time or across different energy sources (Maharjan, 2013). DSM is way to stretch the capacity of the electricity grid and increases the stability of the demand for electricity, making the whole system more efficient. This becomes increasingly important because of the rising share of renewable energy in the grid (Wahlén, 2019), and the growing electricity consumption (Pérez-Lombard & Pout, 2008). DSM will be the focus of this study.

How to manage the transition towards the desired energy system based on renewable energy

Despite the challenges, a sustainable new energy system with renewable energy sources is still desired. The Dutch government proposed the following steps to achieve their emission reduction goals (Rijksoverheid, 2019), and by doing so, receiving the benefits of renewable energy as explained in the section above:

- Be more effective with energy
- From electricity out of coal, to electricity from the sun and the wind.
- From heat of natural gas, to sustainable heat
- Citizen participation by offering them the opportunity to think along and shared ownership of local energy projects.
- Smart implementation of energy projects in the environment and the landscape.

These steps will not change the current energy system, but the current energy system needs to be replaced by a new one, which requires a transition. A transition is a long-term process of co-evolution in various dimensions such as markets, institutions, technologies or policies that goes from a relatively stable system to another (Van der Brugge, 2005). It's a process of structural change that is influenced by both endogenous and exogenous forces (Loorbach, 2010). Energy systems can be seen as socio-technical systems. Which means that there needs to be a linkage between elements, such as technology, economy and physical elements, to fulfill societal functions (Geels, 2004). Within this energy system, it is hard to implement radical innovation within the system, due to path dependency and stability (Geels, 2004). But how then, can a transition occur?

According to Geels (2002), transitions are placed into a multi-level perspective, which consists of three different layers (see figure 1). The highest level (macro) is called the landscape. The landscape level consists of macro economy, politics, cultural values and worldviews. Changes in the landscape level will lead to changes in the physical environment and our belief system. The second level (meso) is called the regime level by Geels (2002). This level is about institutions and the rules of the game and shapes the governance of certain phenomena. However, according to Geels (2002), this is also the level where change is inhibited the hardest. The lowest level (micro) is called the niche level (Geels, 2002). Individual actors and technologies are placed within this level. This is the place where innovations are occurring. In order for a transition to take place, the landscape and the niche level need to work together, to shape the regime level (Geels, 2002). A successful development in the niche level, such as a new technology, can then be upscaled to the regime level and be repeated in different contexts (Loorbach, 2010). When all three levels are interacting and working together, the transition is accelerating.

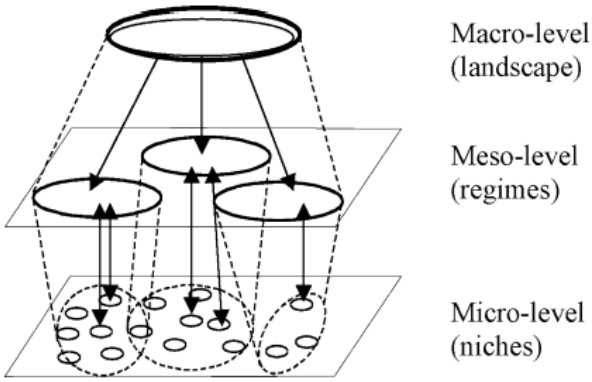

Figure 1: Multi-level perspective (van der Brugge et al, 2005)

The upscaling of niches is not as easy as it may seem. Dijk et al. (2018) suggest that interconnected socio-technical networks and institutions in which the development takes place, are often the constraining factors which makes the upscaling of niches more difficult. In other words, the upscaling of new innovations into new institutions or guidelines are often constraint by the institutions or guidelines in which the innovation takes place.

Purpose of this study:

In this study, the focus will be on the Dutch government its first step in achieving a sustainable energy system and one of the challenges of an energy system based on renewable energy, namely being more effective with renewable energy. As discussed, renewable energy sources are sometimes not operating because there is no demand for the energy that they produce at that moment, resulting in an inefficient system. This inefficiency can be decreased by adjusting the demand for electricity to the supply of energy accordingly. The measures that that are aimed at adjusting the demand for electricity is called Demand Side Management (DSM). Within DSM, there are innovations or experiments occurring, but it remains hard to upscale these innovations into new institutions or ways of governing. The aim of this study will therefore be to acquire new insights in the upscaling of developments from the niche level to the regime level regarding DSM. This will be done by conducting a comparative case study, examining niches that are occurring in countries across the world and to see what barriers or challenges they run into with regard to upscaling to the regime level.

The expected results of this study for planning practice are new insights in the form of lessons and conditions under which the developments in the niche level could be upscaled towards the regime level within a Dutch context. This will be helpful to create a policy or institutional framework under which local innovation projects regarding DSM could be implemented more easily within the Netherlands. This will accelerate the transition to a sustainable energy system which in turn will contribute to the goal of the Dutch government to reduce CO2 emission and to have an almost completely sustainable energy system in 2050.

Research questions:

For this research, the following main research question is formulated:
"Which lessons can be drawn from niches regarding demand side management in countries across the world, for the implementation into the regime level in a Dutch context?"

To help answer the main research question, the following sub questions are formulated and will be researched:

1. Which factors have an influence in the upscaling performance of niches in Demand Side Management into the regime level?
2. What is the context of each case, in which the niches in demand side management take place?
3. How do the niches in Demand Side Management, in each case, perform with regard to the theoretical factors on the upscaling performance of niches into the regime level?
4. What are the constraining factors of the niches in Demand Side Management, in the cases, on the upscaling performance of the niches into the regime level?

The outline for this study is as follows. Chapter 2, the theoretical framework, creates a deeper understanding of DSM, transition management and the upscaling of niches. This chapter will result in factors that are important in the upscaling of niches into the regime level which in turn will create valuable insights for the case studies. The comparative case study, and the research methods that are used to answer the research question will be explained in Chapter 3, the methodology. Chapter 4, the empirical data, will then present the collected data and will end with a comparison of the results between the cases. After the empirical data, Chapter 5 will conclude main research question and will discuss the relevance of the findings. Finally, the study will be reflected on, which can be found in Chapter 6.

Chapter 2: Theoretical Framework:

The aim of chapter 2, the theoretical framework, is to create a theoretical background, and a deeper understanding of the various components of this study. This chapter will start with an explanation of the subject for this study, namely Demand Side Management (DSM), and will also provide the benefits and challenges of DSM. Then, a theoretical overview of transition management literature will be provided. The third section of this chapter will go more in-depth into the upscaling performance of niches into the regime level. This chapter will end with the conceptual model, where the insights and theories acquired from the literature review are applied into a theoretical representation of reality. The conceptual model also functions as the answer to the first sub question.

Demand Side Management

Balancing demand and supply:

As discussed in the introduction, a sustainable energy system with renewable energy has the benefit that it produces less global warming, increases public health, is an inexhaustible form of energy production, has stable energy prices, creates jobs and other economic opportunities and the system is robust (Union of concerned scientists, 2017). But this desired energy system is not so easily acquired and brings challenges that need to be dealt with. One of those challenges is the imbalance between demand and the supply. In this study, both the energy system and the electricity system are referred to. Electricity is a form of energy, so energy can be produced and converted to electricity. The electricity system is thus also a system that falls within the energy system. Other components of the energy system can be fuel for transport for example. This study uses energy most of the time when talking about the production or the supply side, but electricity when referring to the demand side.

Within the energy system, demand for electricity is fluctuating and the supply of energy needs to be adjusted accordingly, since demand and supply in the electricity system needs to be balanced. The balancing of demand and supply in an electricity system is important because if there is too much supply in relation to demand, the electrical frequency increases (Energuide, 2020). Since power plants have to operate within a small frequency range, they will disconnect if the situation remains imbalanced for too long. When there is too much demand in relation to supply, this frequency number drops. When this happens, the power plants will turn off and, as a result, a power blackout will happen (Energuide, 2020). According to Energuide (2020), there are multiple measurements to prevent an imbalance. The balance can be achieved by reducing demand or increasing supply, by measures such as importing/exporting , load shedding or storing electricity or using the stored electricity. The latter cannot be used effectively on a large scale yet, as the batteries are costly and cannot hold electricity for too long. Developments are happening regarding to storage, in the form of small domestic batteries or using the batteries in

electric vehicles as a buffer (Energuide, 2020), but no large scale innovations have taken place yet. This is therefore not yet a suitable measure to prevent an imbalance.

To match demand and supply in the old system, with fossil fuel plants instead of renewable energy sources, the lowest-costs options would be run first and gradually move up to other alternatives as demand increases (Schwill, 2016). The benefits of the before-used system were that the supply of energy of the used production plants was a given. The amount of energy a plant could supply is adjustable at a fixed rate. If a certain amount of energy is needed to match demand, a power plant could be turned on and the energy system was balanced again. But on a system that is based on renewable energy sources, this is significantly harder to do (Schwill, 2016). It is not possible for a solar park to deliver extra energy when asked, something that a power plant based on fossil fuels could do.

This is because solar and wind energy have a characteristic that it only supplies energy periodically, when the resources they need are present, namely when the sun is shining, or the wind is blowing. They are fluctuating in nature so the amount of energy they can deliver is hard to predict precisely (Robert et al, 2018). Besides that, it is not possible to control the resources the renewable energy production sources need in order to operate. In addition, when the renewable energy sources are operating, the demand for the energy needs to be there as well. Otherwise, the renewable energy sources will stop producing leading into a loss of energy. The result of an energy system that is based on renewable energy is a system with a fluctuating demand, that is needed to be matched by a fluctuating supply (Robert et al, 2018). This challenge is addressed by Demand Side Management.

What is Demand Side Management:

In the energy system that is based on fossil fuel power plants, there is a more one-sided relationship. An increase in demand is matched by an increase in supply, so supply is responding to demand accordingly. But with an energy system with renewable energy, the relationship must be two-sided to have an effective energy system since demand can also response when the supply of energy increases. This other direction of the relationship can be influenced by Demand Side Management (DSM). According to Palensky & Dietrich (2011), DSM includes measures that could influence the demand in response to the supply. These measures provide new opportunities to match demand and supply in a sustainable energy system.

The ideal situation for an electricity supplier in an electricity system based on fossil fuels, is when the demand and supply curve are perfectly flat (Qian et al, 2013). The demand for electricity would be evenly spread out over the day. But this is not the case as the demand for electricity fluctuates over time, in dimensions that range from seasons to seconds. Generally speaking, the time when the demand is the highest, which is called; peak-load or peak-demand, is between afternoon and the moment that people

will go to sleep (Qian et al, 2013). The problem here is that the supply of renewable energy is generally lower, due to a decreasing production of solar energy. This creates a problem as peak-demand does not match peak-supply which results in ineffectiveness of renewable energy in the electricity system. This also leads to higher generation prices for electricity suppliers with the current rules and regulations (Qian et al, 2013). As a reaction, Qian et al. (2013) propose real-time energy prices. The moment when the electricity is consumed will also affect the price, next to the amount of energy consumed. This concept is called; Demand Response Management (DRM) and can be seen as a form of DSM. Qian et al. (2013) suggest that this will provide three benefits. First of all, a flattened load demand curves lowers the costs for the power grid. This lower generation costs will produce a decrease in the wholesale price, which would lead to a higher retailer's profit. Next to this, users may reduce their electricity expenditures by responding to the real-time prices. So, both the retailer and the user receive benefits of the new electricity grid. This would attribute to a new ideal situation for electricity suppliers, where the fluctuating supply of energy can be perfectly matched by a flexible demand of electricity

Since demand and supply must be balanced, during peak-load, the generation of energy must also be at its highest in order to maintain balance in the grid. This means that the generation capacity must meet peak-load. There is even a capacity margin of 20% to meet defects on the supply side, or an unexpected increase in demand (Strbac, 2008) . The problem here is that the average utilization of the generation capacity is below 55% since the demand is highly fluctuating. This opens up opportunities for DSM to have a significant influence and can be seen as a tool to maximize the utilization of the supply. Shifting consumption from peak-load to off-peak periods could lower the generation capacity of the grid and increase the utilization of the supply which would improve the effectiveness of the grid as a whole (Strbac, 2008).

There is another benefit of DSM with relation on the challenge of implementing renewable energy into the energy system according to Strbac (2008). As mentioned before, the generation of renewable energy can fluctuate. This means that there needs to be an increasing amount of reserve capacity of electricity when the generation would decrease. Most of the times, this role would be served by power plants which would be part-loaded. But according to Strbac (2008), these plants would run less efficient when part loaded. Instead of these part-loaded power plants, DSM could improve the effectiveness of the system serving as a form of reserve. Shifting demand in reaction to the supply using DSM would decrease the demand when the supply of renewable energy is low, instead of burning fuels of the power plants with a lower efficiently rate due to operating part loaded (Strbac, 2008).

Strbac (2008) also provides techniques of DSM that can be used to manage the demand. The first technique mentioned in the article is night-time storage heating. These heaters would operate at night when the marginal electricity costs are lower, due to a lower demand, and would store heat that would

then be used during the day. This will shift the electricity consumption from the day with higher total energy consumption to the night when there is a lower total energy consumption. The second technique mentioned is direct load control. A DSM tool could turn off certain electricity consuming facilities for a short time when demand is high. These facilities could be air conditioning or swimming pool pumps for example. Another technique related to the previous one is load limiters where the limit of the energy consumption of individual consumers can be set to meet the system conditions accordingly. Strbac (2008) also mentions special programmes for industrial and commercial consumers. These programmes would not have an effect on a daily basis but could serve as a reserve or can provide support during outages of generations plants. The industrial and commercial consumers help to control the load. The last important techniques mentioned are time-of-use pricing or Demand Side Response (DSR), which are already discussed in chapter 1, and smart metering.

Challenges of Demand Side Management:

In addition to mentioning benefits and techniques of DSM, Strbac (2008) also suggest reasons for a slow implementation of DSM. The first one is the lack of ICT infrastructure. Advanced real time measurement and control devices are required to facilitate the control of the generators, loads and various network devices (2008). The key ingredients of the technology exist, but more experience with the context of DSM is needed. Strbac (2008) suggest that commitment in the implementation would increase the strength of DSM significantly. The loss of commitment could be explained by another challenge of DSM, namely the lack of awareness or understanding of the benefits of DSM. While it is clear what the costs and benefit of the concept could be, it remains hard to quantify this. The quantified benefits are context dependent and fluctuate, which leads to unclarity with making a business case for DSM (2008).

DSM also increases the complexity of the system operation when compared to traditional solutions. However, Strbac (2008) argues that this challenge will change in the future, as the flexibility of DSM is an important tool to deal with the uncertainty in future developments. Together with costs reductions in DSM technologies and the development of targeted trial schemes, the confidence in the concept will increase and will make DSM more competitive.

The last challenge of DSM that is addressed in the article (Strbac, 2008) is inappropriate market structure and lack of incentives. In case of the benefits of DSM, it is split among different participants. The system as a whole would see the most increase in value, but this could not be of interest of the individual actors that make up for the system. These individual actors are mostly interested in the benefits that they would see themselves. This results in a lack of incentives of individual consumers to take part in the process. Strbac (2008) concludes that a regulatory framework is necessary to optimize the benefits of DSM. There is a serious barrier to the implementation of DSM without a proper framework.

The study by Strbac (2008), provides a solid overview of the benefits and challenges of DSM and can be considered as an influential study with regard to DSM (article is cited 1677 times as of July 2020). Next to this, the article by Strbac (2008) is cited many times in publications in recent years. Therefore, the benefits and challenges mentioned by Strbac (2008) can be considered as still being relevant.

Lack of institutional harmonization in energy planning in the Netherlands:

Providing a regulatory framework is a difficult thing to do since there is a fragmentation of responsibilities and institutions with regard to energy planning. In a study of Spijkerboer et al. (2019), the institutional harmonization for spatial integration of renewable energy was researched. The spatial integration of renewable energy and other land uses required institutional harmonization between various policy domains. But Spijkerboer et al. (2019) suggested that there was limited guidance on how this institutional harmonization does or could occur. Spijkerboer et al. (2019) researched the case of spatial integration of solar panels with transport infrastructure networks in the Netherlands. Three findings are: (1) insight in interrelations between institutional barriers is crucial for addressing institutional harmonization; (2) institutional harmonization within policy domains is a precondition for harmonization between policy domains; and (3) the agency component (play of the game) is key to successful harmonization. In conclusion, the analytical approach provides insight into the co-evolution between the rules of the game and the play of the game, which is pivotal to institutional harmonization (Spijkerboer et al, 2019). The findings of Spijkerboer et al. (2019) are increasingly worrisome when examined together with the challenge of DSM as suggested by Strbac (2008). The lack of institutional harmonization with regard to energy planning in the Netherlands could make it much harder to develop a regulatory framework that is necessary in order to optimize the benefits of DSM.

Spijkerboer et al. (2019) also provide some suggestions to solve the issue of a lack of institutional harmonization. An important role in successful harmonization is with the actors. Institutional harmonization is dependent on the organizational cultures and individual characteristics. These components are shaped by the actors that are embedded in the organizational cultures and practices. So, harmonization of institutions does not only imply harmonization of the rules of the game, but also harmonization of the players of the game (Spijkerboer et al, 2019). When this is successful, the institutional harmonization can lead to policy harmonization, which in turn could result in a regulatory framework for DSM.

A special role in the development of a regulatory framework for DSM can be assigned to planners. DSM can be considered as a complex planning issue. Complex issues are interwoven in a dynamic context and the predictability of the outcome is low (de Roo, 2000). Instead of a more top-down approach, focusing on predefined goals, a more open, process-oriented approach is required (de Roo, 2000). Planners can take the role of the strategy maker (Mintzberg, 1994), and can manage the process towards

a regulatory framework. Collaboration between various dimensions, such as technical or financial dimensions, are required, with the planner linking the dimensions together. The role of the planner is therefore crucial in the development of a regulatory framework, which could be significantly important in the transition towards a sustainable energy system and can stimulate the upscaling performance of niches in DSM. This required transition will be explained in the next section.

Transition management:

System transition:

"Transitions refer to large-scale transformations within society or important subsystems, during which the structure of the societal system fundamentally changes" (Loorbach et al, 2008). It is the shift from a stable equilibrium, towards another stable equilibrium through a period of rapid change relatively speaking. According to Rotmans et al. (2001) transitions share the following characteristics: Transitions concern large-scale technological, economical, ecological, socio-cultural and institutional developments that influence and reinforce each other. The transition towards an energy system based on renewable energy with DSM requires or benefit from development of these domains. Technological developments, such as the Smart Metering, can have a significant impact on the transition. Economic developments can be the financial benefits of implementing DSM measures. For institutional developments, the needed regulatory framework for DSM, mentioned by Strbac (2008) and Spijkerboer et al. (2019) can stimulate this transition as well. As can be seen in figure 2, developments in a certain domain, such as the ones mentioned above, can set the gears in motion and lead to developments in other domains which could reinforce each other and accelerate the process. This is a crucial aspect of the transition towards an energy system based on renewable energy. Transitions are long-term processes that take at least one generation and transition have multi-level interactions (Rotmans et al, 2001). Kemp adds to this that process of change is generally non-linear where slow change is accelerating into rapid change when development is interacting with each other. This acceleration then slows down and stabilizes (Kemp, 2010). This multi-phase characteristic will be elaborated on later in this chapter but is important for this transition as each phase has different impacts on the transition at hand.

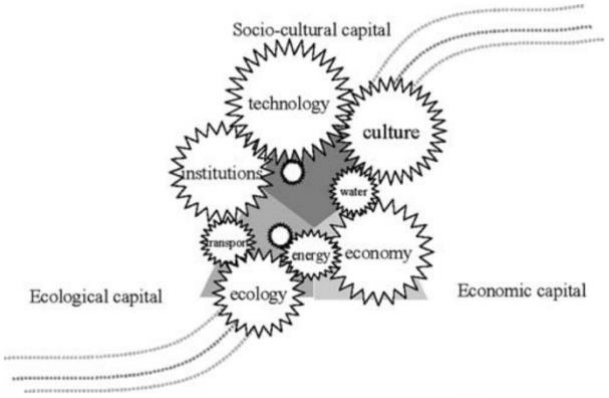

Figure 2: Transition needs change in several divisions (Martens & Rotmans, 2005)

An interesting example for this study is given in the article of Kemp (2010) about the Dutch energy transition. In the article, the example is given of the transition of coal, to natural gas in the space heating in the Netherlands. The discovery of the gas field at the end of the 1950's led to a new energy system. The transition from coal to natural gas is government steered according to Kemp (2010). The Dutch government had clear objectives which made sure that the transition would occur relatively smooth and quick. But this situation is not the typical transition (Kemp, 2010). Most of the time, a transition is the outcome of decisions made by many actors that do not share a long-term vision or goal.

The problems regarding the current energy transition can described as 'persistent problems' following the definition of van der Brugge et al. (2005). They describe persistent problems as societal problems with a high level of complexity, high uncertainty, high level of diversity of stakeholders with different interests and governance problems. These problems are embedded in our societal structures and institutions (van de Brugge et al, 2005). Van der Brugge et al. (2005) use this definition of persistent problems for water management, but this can also be used with regard to the energy transition. There are a large number of stakeholders with different interests. Environmental protection agencies want to reduce the CO2 emissions of the energy system, while it could be the case that energy suppliers want to generate and supply energy in the cheapest way, to maximize their profit. In addition, as is illustrated in the previous sections, the energy system is rooted in our societal institutions, infrastructure and economy (Loorbach et al, 2008), as is illustrated by the gas exploitation in the Netherlands of the first chapter. According to Loorbach et al. (2008) dealing which these persistent problems require long term and coordinated efforts that take economic, socio-cultural, ecological and institutional factors into account. The proposed approach is called transition management. Transition management is a multi-level and multi-phased approach that addresses change in complex systems.

A special interest of the transition theory is about the behavior and dynamics of complex adaptive systems (Loorbach et al, 2008). Complex adaptive systems, defined by Loorbach et al. (2008), are systems where agents interact with each other, and through this interaction among different actors, patterns emerge on a system level which changes conditions in which the interaction takes place. This two-sided relationship between actors and the system is important for transition theory. This interaction is explained by using the multi-level perspective where transitions are placed in.

Multi-level and multi-stage perspective:

The multi-level perspective explained the functional scalar levels at which a transition takes place (van der Brugge et al, 2005). Van der Brugge et al. (2005) theorizes a world consisting of three different layers (as can be seen in figure 1, on page 9); the macro level, the meso level and the micro level. The macro level, which can also be called; the landscape level (Geels, 2002), is the highest level and consists of macro economy, politics, cultural values and worldviews (van der Brugge, 2005). The macro level

would hardly see drastic changes and keeps a certain level of stability. It reacts slowly to trends and developments but is an important factor for the speed in which a transition takes places. The middle level is often called; the regime level (Geels, 2002). The regime level is a combination of institutions and norms that influence societal and economic activities. It is the level where the rules of the game are set and the way how we interpret certain things. The regime level is the hardest level to change (Geels, 2002). Most of the time, there is a dominant regime that already shapes the rules of the game. This dominant regime wants to maintain the status-quo and is more focused on optimization and protecting investments rather than radical changes (van der Brugge et al, 2005). While this level is the most difficult to change, the impact of such change is the most visible. The micro level is the lowest level and is often called; the niche level (Geels, 2002). According to van der Brugge et al. (2005), the niche level consists of individual actors, technologies and local practices. This is the first level that is subject to change most of the time. New ideas or technologies can affect the status quo and try to set a foothold in the regime level. These happen in the form of local experiments or innovations. To understand how these levels, interact with each other, the multi-stage perspective needs to be elaborated on first.

A transition, in theory, occurs in four stages which represents the speed in which the transition currently takes place (van der Brugge et al, 2005). As can be seen in figure 3, the transition takes place in a s-curve. The four stages or phases, are:

1. The pre-development phase: in this phase, the changes on the status quo are taking shape but are barely noticeable.
2. The take-off phase: in this phase, the first small changes are visible, and the equilibrium begins to shift towards a new one.
3. The acceleration phase: In this phase, developments in multiple dimensions occur which reinforce each other and increase the speed of the transition. The gears as can be seen in figure 2, are set in motion
4. The stabilization phase: in this phase, the speed of the transition is decreased, and a new equilibrium has taken form.

The multi-level perspective and the multi-stage perspective have a connection with each other. In the pre-development phase, the regime level is a barrier to new developments that occur. The old regime level wants to maintain the social norms and belief systems and want to improve the existing parts of the regime. The way a transition can go into the next phase, the

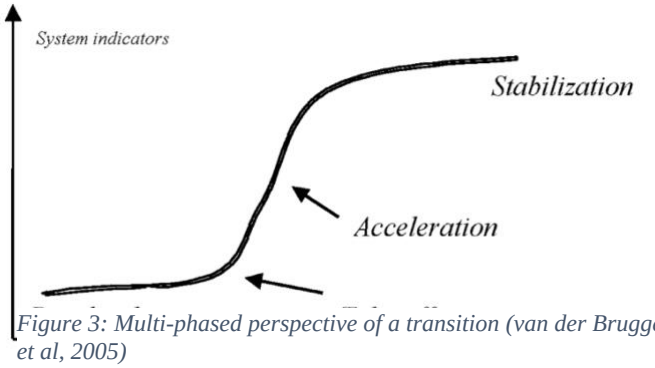

Figure 3: Multi-phased perspective of a transition (van der Brugge et al, 2005)

take-off phase, is if developments in either the landscape or the niche level are connected with each other. New policies or innovations in the niche level can be reinforced by changes in culture or macro politics, but it can also go the other way around. Changes at the landscape level can be backed up by initiatives in the niche level. An important aspect according to van der Brugge et al. (2005) for the transition to go to the take-off phase from the pre-development phase is if developments from different type of fields (e.g. socio-cultural, economic) interact with each other and merge into a single, more or less consistent paradigm.

The period between the pre-development phase and the take-off phase is often described as a highly uncertain period. In this period, innovations and experiments that are happening in the niche level tries to find its place in the regime level. The regime level on the other hand, begins to slowly open up to these new developments in the niche level. The developments in the niche level could either push the regime level over the edge or could fail to get a grip on the regime level which would result in a lockdown of the transition. This period is particularly interesting for this study, because it is likely that this is the phase where DSM currently is positioned in. There are developments or experiments going on regarding DSM, but the developments in the niche level need to be adopted in the regime level to make a significant impact and remain valuable. Another interesting aspect is to see which factors influence this push and pull game between the niche and regime level. This part will be further elaborated on, later in this chapter, in the upscaling of niches.

Instead of acting as a barrier to transitions in the pre-development phase and the take-off phase, the regime level acts as an enabler and accelerator of the transition. Due to top-down pressure of the landscape level and bottom-up pressures from the micro-level, the regime level begins to adopt these developments and will be re-shaped. This process will be accelerated by the capital, investments and knowledge that is being applied into the transition and by the three levels interacting and reinforcing each other. In the last phase, the new regime level has taken shape and a new equilibrium is established. The speed of changes is decreasing because the new established regime level is, once again, resisting new developments that occur in either the landscape or the niche level. The transition process has ended until another transition would take-off.

Transition management framework:

Rotmans & Loorbach (2009) suggest a framework, which gives more insights on how to manage a transition. But before that, Rotmans & Loorbach (2009) proposes theoretical principles of transition management that are inspired from complexity theory. These principles are important for this study as they provide a better understanding on the process of a transition and on niches more specifically. The 7 principles of Rotmans & Loorbach (2009) are:

1. Creating space for niches.
2. Focus on frontrunners.
3. Guided variation and selection.
4. Radical change in incremental steps.
5. Empowering niches.
6. Anticipation.
7. Cross multiple domains and scales.

The first principle is 'creating space for niches' in transition arenas. Small initial change in the system can have a significant impact in the long run. This principle is about creating space or an environment that gives a level of protection for the innovation or experiment to take place. This stimulates the development of that niche and stimulate the upscaling of that niche into the regime level (Rotmans & Loorbach, 2009). The second principle is the 'focus on frontrunners'. This principle shares some characteristic with the first one. Frontrunners, which can be described as creative minds, strategists and visionaries, need to be able to operate without much hindrance of the regime. Then they can create new configurations which helps the development of the niche. The third principle is 'guided variation and selection'. Diversity increases flexibility within the system (Rotmans & Loorbach, 2009). When a regime is in an equilibrium, the diversity of the system is decreased. But a certain level of diversity is needed to keep the system innovative. This principle suggests that niches should experiment with an open vision, and learn from the alternatives, rather than focusing on a single innovation and improve on that. This means that for DSM, not all the experimentation should be on Demand Response for example, but that an open mind to the different measures should be kept. The fourth principle is called 'radical change in incremental steps'. While radical change is needed to ensure structural change to the regime, this must go in incremental steps. If a radical change is proposed and implemented in one go, the regime resist that change because it would disrupt the system. This radical change must go in steps to maintain a level of flexibility and gives the possibility for structures to adapt to the changes. The next principle in transition management is 'empowering niches'. This principle entails that niches should be provided with knowledge, financial investments. An important aspect in this is that empowered niches could connect with empowered niches in other domains in order to create a new regime. Anticipation of future trends and developments is another principle. The niches should be able to adapt while the structure of the system is changing. Rotmans & Loorbach (2009) suggest that even with the unpredictable and

uncertain complex system dynamics, there are moment where the system behaves with order and is predictable, although limited. The last principle is called 'multiple domains and scales'. Developments in a transition need to touch multiple domains, like economic, cultural or technical domains. This will reinforce each other, accelerating the process and make the transition more robust. Besides multiple domains, the developments need to have an impact on the multiple levels theorized by van der Brugge et al. (2005). As discussed, interaction between the landscape level and the niche level is necessary in order to shape the regime level. It can also be argued that interaction on the geographical scalar levels, like the local, national and global, is important for the development of the niches. National initiatives and programs could provide benefits for local innovations.

Upscaling of Niches

While the transition management gives us a deeper understanding of the necessary process, a special focus of this study is on the upscaling of niches. This section, the upscaling of niches, will focus on which factors are relevant in the upscaling process of niches into the regime level. It must be noted that in the literature review, more articles than the ones that will be discussed were being found and examined. The factors provided in the articles, such as the articles by Coenen et al. (2010) and Jolly et al. (2012), were impossible to apply to the case of DSM, due to being immeasurable or just not relevant for niches in DSM. This is why these factors are left out of the literature review.

Three processes of successful niche development

The first article that will be discussed is Schot & Geels (2008), which is still being cited by many other studies with regard to sustainability transitions and can therefore be considered as still being relevant. Schot & Geels (2008) suggest three dimensions of successful niche development. Successful in their point of view, meant that a technological niche transforms, first, into a market niche and then shifts a regime (Schot & Geels, 2008). The transformation of a technological niche to a market niche is an interesting step. Technological niches operate mostly in experimentation arenas. There are multiple, not connected, local experimentation going on, and the cognitive rules (such as expectations) of the projects are initially diffused, broad and unstable (Schot & Geels, 2008). They operate in a local, protected area with instable rules, standards and networks. Through aggregated learning processes, the cognitive rules, in this case the expectations for the niches of the technological niche can become more stable and specific. This results into a market niche, where

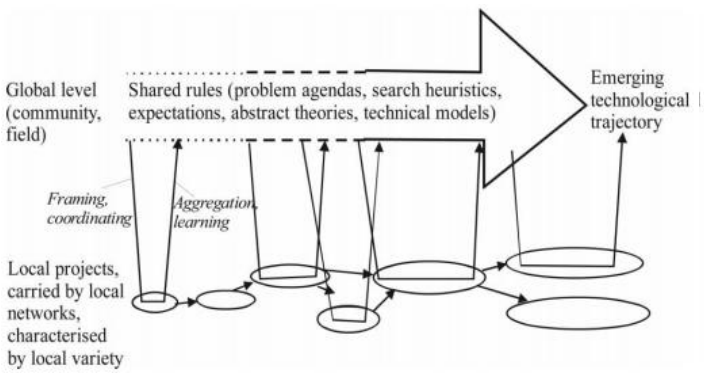

Figure 4: Technological niches to Market Niches (Geels & Raven, 2006)

the niche is not only prone to outside factors, but also operates with cognitive rules that are more stable and specific then in the experimentation arena. The niches can now work together and try to challenge the regime level (figure 4). Failures of certain projects can now function as valuable lessons for other, contribute to learning processes, provided that the findings of the projects are communicated.

In the article of Schot & Geels (2008), the three processes for successful niche development are:

1. The articulation of expectations and visions
2. The building of networks
3. Learning processes at multiple dimensions

For the first process, the articulation of expectations and visions, are important because they serve as a direction to learning processes, attract attention and legitimate protection and nurturing (Schot & Geels, 2008). The expectations can be seen in the form of goals, specifications or requirements (Geels & Raven, 2006). The expectations are about what the project, or the niche should contribute to. According to Schot & Geels (2008) expectations should be robust and specific, in order to contribute to the development of the niche.

The second process is the building of social networks. The building of social networks is important for successful niche development because it create coherence and stability behind the new niche, but it also creates interaction between relevant stakeholders, and it contributes to the availability of resources. Two factors are important according to Schot & Geels (2008) in the building of networks, namely that the network is broad, and that the network is deep. A broad network contributes to the development of the niche because stakeholders with different viewpoints could each contribute to the learning processes and development of the niche with regard to their own expertise. A broad understanding of the niche can therefore be the result. In addition, a deep network is desired. Schot & Geels (2008) explain deep networks as that the actors involved, that represents the organizations, can provide commitment and resources from their organizations or network for the niches. In other words, the actors that are involved must be able to contribute to the development of the niche.

The third process as proposed by Schot & Geels (2008) is learning processes at multiple dimensions. Dimensions can be for example; technical aspects and design, or regulations and government policies (Schot & Geels, 2008). Schot & Geels (2008) makes the distinction between two types of learning processes. The first learning process is first-order learning, which entails resources which are created or redesigned towards a specific learning objective (Allert et al, 2004). These processes are usually in a form that presents information, such as facts and data (Allert et al, 2004; Schot & Geels, 2008). There are, besides first-order learning processes, also second-order learning processes, which are resources that provide and reflect a strategy (Allert et al, 2004). They are a means to assist knowledge creation

(Allert et al, 2004). Second-order learning processes can be frameworks or assumptions for example (Schot & Geels, 2008)

These three processes are relevant for this study, as they can serve as factors contributing to the success of certain niches. The processes can be seen as categories under which the upscaling of certain niches can be examined. The factors are Integrate in a framework under which the upscaling of niches can be researched, which can be seen in figure 5, the conceptual model.

Sustainable transitions.

Insights regarding the upscaling of niches is also provided by Wieczorek (2018). Before going into the upscaling process, Wieczorek (2018) makes an interesting annotation that innovation is shifting from countries in the western world, to the countries in other parts of the world. Niche experiments are more conducted in developing, or late coming, countries. According to Wieczorek (2018), this shift is occurring due to transnational connectivity and innovative funding schemes. This shift in innovation to other places in the world beside the western world could be relevant for the context under which these experiments take place, and for the selection of case studies for this research.

Besides this notion, Wieczorek (2018) also suggest that, while technology remains important, the main barriers regarding the upscaling of niches are institutional and political aspects. Not only is state support and state engagement important, mostly in urban Asia, vertical linkages also have a significant influence on the upscaling performance of niches, complying with the study of Schot & Geels (2008). Bai et al. (2010) also supports this claim. Their research showed that many projects that have upscaled, experience strong vertical linkages with governmental entities. The opposite is also true, according to Bai et al. (2010). Projects that don't have strong vertical linkage, will not lead to drastic change most of the time. Next to vertical linkages, Bai et al. (2010) also state that horizontal linkages are an important factor in the upscaling of niches. Horizontal linkages can be public-private partnerships, or a network between different regimes, in this case different policy domains

Bai et al. (2010) also suggest other aspects that influence the upscaling performance of niches. These are, next to Linkages, Triggers, Actors, Barriers and Pathways. Triggers, according to Bai et al. (2018), are events or factors that have led to the need for action, or the proposed niche. Actors refer to both the type, and number of actors involved around the niche project. Large number of actors with different types could for example, increase the difficulty of managing the niche. This statement is an extension to the findings of Schot & Geels (2008) on the building of networks. While Schot & Geels (2008) state that the network should be deep and broad, they do not mention the fact that too many actors could actually limit the upscaling performance of niches. The suggestion made by Bai et al. (2010) needs to be kept in mind. The barriers that are mentioned in the article of Bai et al. (2010) for the upscaling of

niches are; Political, institutional, economic and/or financial, technological, natural/physical limits, historical limits, cultural factors, and level of social acceptance. The listed barriers by Bai et al. (2010) cover almost every dimension. This is in line with the definition of a transition by Loorbach et al. (2008), where multiple different dimensions have an influence on the development of a transition. The last one, pathways, are defined by Bai et al. (2018) as the trajectory and outcome of the experiment. This can be for changes on a regime level, for further experimentation or for multiplying projects for example.

Coming back to Wieczorek (2018), the suggestion is made that the way projects are set up, and if the project actually meets the needs of the people that are affect, need to be considered in order to contribute to the self-reliance and self-sufficiency of the project.

Conceptual model:

The insights and theories of the literature review are conceptualized into the model as can be seen in figure 5. For a qualitative research, the process of operationalization will lead to a set of topics, which are not necessarily measurable but recordable (Mills et al, 2010). At the top of the conceptual model, the blue shapes represent the process of the upscaling of niches into the regime level, and the interaction of the regime level and the landscape level. The arrows are illustrating a two-sided relationship. The landscape level affects the regime level and vice versa. The interaction between the niche, regime and landscape level is researched with the sub question: "What is the context of each case, in which the niches in demand side management take place?". The green shapes represent the processes of successful niche development as proposed in the article of Schot and Geels (2008). These processes, if present, will have a positive effect on the upscaling process, hence the color green. The red shapes, however, are the constraining factors to DSM as proposed in the article by Strbac (2008). While they do not originate from niche development literature, they can be seen as barriers which would have a negative effect on the success of a niche, and thus the upscaling process of that niche into the regime level. The conceptual model (figure 5) also represents the answer to the first sub-question: "Which factors have an influence in the upscaling performance of niches in Demand Side Management into the regime level?". Next to this, it provides a theoretical hypothesis for the fourth sub-question: "What are the constraining factors of the niches in Demand Side Management, in the cases, on the upscaling performance of the niches into the regime level?" The conceptual model (figure 5) will function as a theoretical framework for the empirical research of this study.

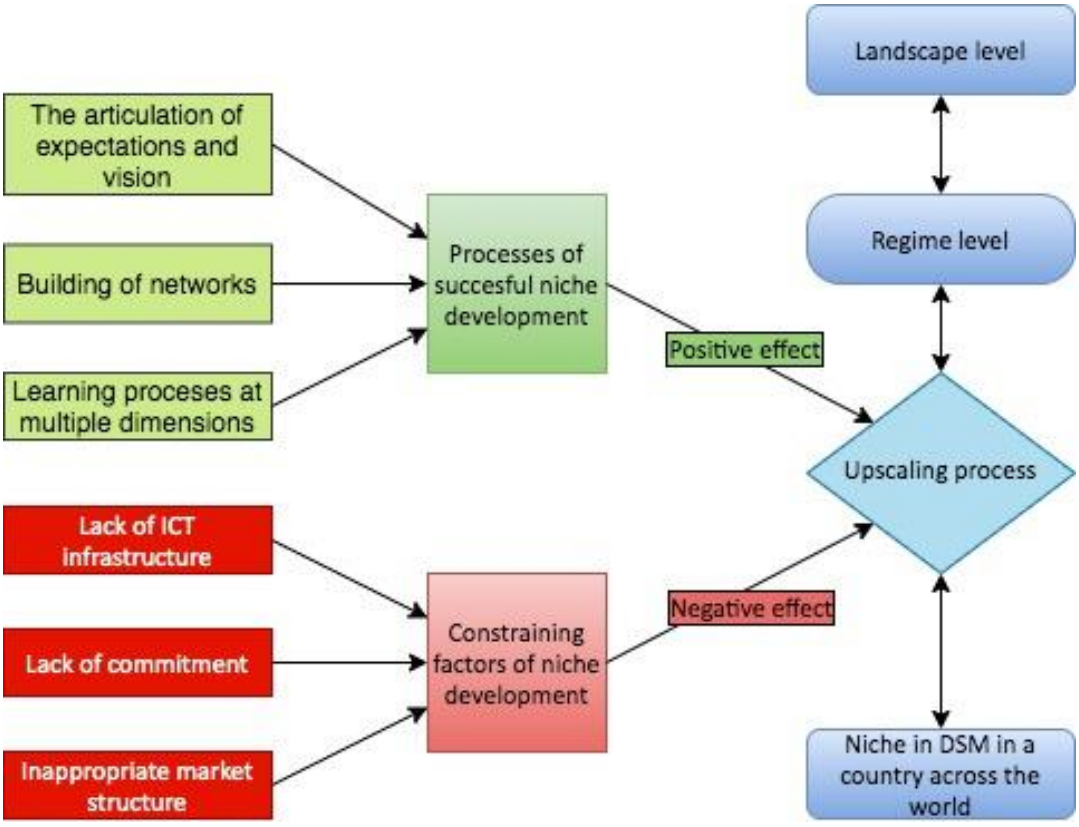

Figure 5: Conceptual model (Source: Author)

Chapter 3: Methodology

The methodology chapter explains the research strategy, the data collection and analysis process, and the ethical considerations for this study. The chapter starts with a general explanation of the research type for this study. Following that, the different research methods that have been used to collect the data, which served as the basis for the answers to the sub-questions, will be elaborated on. Then the next section, the data analysis, will give a description of how the collected data has been analyzed and interpret. The last section for this chapter presents the ethical considerations for this study.

Research Strategy

Research design

Sub-question	**Chapter**	**Research method**
Which factors have an influence in the upscaling performance of niches in Demand Side Management into the regime level?	Chapter 2: Theoretical Framework	Literature research
What is the context of each case, in which the niches in demand side management take place?	Chapter 4: Introduction to the cases	Desk research and Document analysis
How do the niches in Demand Side Management, in each the cases, perform with regard to the theoretical factors on the upscaling performance of niches into the regime level?	Chapter 5: Empirical data	Document analysis
What are the constraining factors of the niches in Demand Side Management in the cases on the upscaling performance of the niches into the regime level?	Chapter 5: Empirical data	Document analysis

Table 1: Research design

Comparative research:

The type of research for this study is a comparative research. In the scientific methods, comparative research falls under the non-experimental methods (Lijphart, 1975), as can be seen in figure 6. In experimental methods, the research is done in isolated areas so that the subject or phenomena that is being research is not prone to exogenous factors. The research of this study cannot be done in isolation, as external factors are a crucial aspect to consider. The loss of control as compared to the experimental methods is substituted by comparison, which is exercised by careful selection of the cases (Flyvbjerg, 2006). A comparative research consists of at least 2 or more cases, but it is not an easy research method, as it is difficult to identify comparable cases. Finding comparable cases is important in order to make generalizations of the findings. Another important aspect is the context of a case. Because with regard to lesson drawing, which is the main aim of this study, it is not only relevant to know how something works in the case, but also if it could in another place (Rose, 2005). It includes a concern of context (Rose, 2005). The sub-question: "What is the context of each case, in which the niches in demand side management take place?" is therefore important to convert the information of each case to lessons for the implementation in a Dutch context.

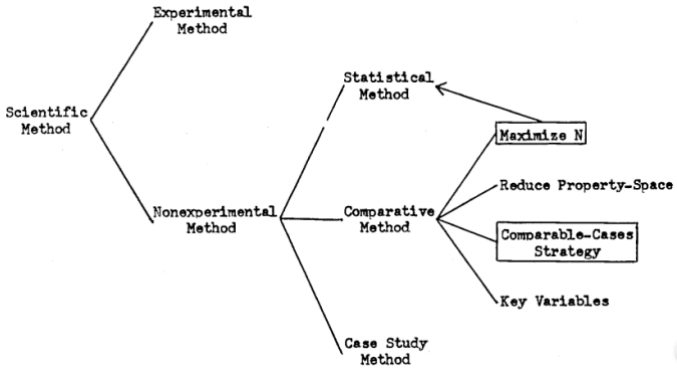

Figure 6: Typology of scientific methods (Lijphart, 1975)

Case selection:

"Case selection is the rational selection of one or more instances of a phenomenon as the particular subject of research and is an essential part of the case study research design" (Mills et al, 2010). Case selection is a crucial step as it gives a form of control and generalizes the findings. For this study, an embedded multiple case study has been conducted using a total of four different cases. As can be seen in figure 7, an embedded multiple case study contains multiple units of analysis for each case. The

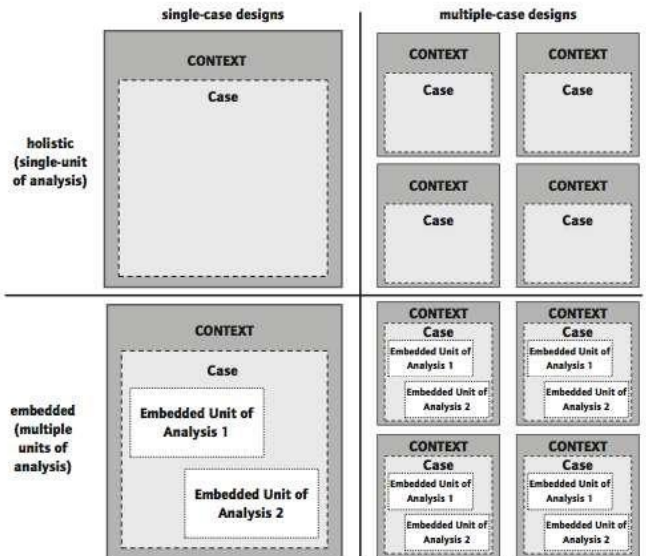

Figure 7: Case study designs (Mills et al, 2010)

units of analysis are documents regarding a niche in DSM. In contrast to surveys, these cases are purposefully selected instead of randomly (Mills et al, 2010). This study consists of descriptive sub-questions, which tries to answer what is happening out there. Descriptive case studies try to discover patterns and connections, based on theoretical findings. Therefore, the selected cases should give maximal information about a certain phenomenon. The typology for the selected cases for this study is called; Maximum variation case. This means that the four cases for this research that are very different from each other in one dimension (Flyvbjerg, 2006).

For this study, a case is DSM in a country across the world. Following Wieczorek (2018), niche experiments are conducted in countries. Besides Wieczorek's (2018) notion, interaction between the niche level and the landscape level is important for shaping the regime level (Geels, 2002). It is observed, during the data selection process, that most of the evaluations and reports on DSM are happening on a national scale. Countries, representing the landscape level, are therefore a relevant and suitable geographical scale to use as a case. An important selection criterion for the countries was that the data should be available in the English language and that the countries should have plentiful available data to collect and analyze. Many countries, especially relatively small countries such as Denmark, were not possible to analyse due to having only a few documents available with regard to DSM. So, before being selected, the countries were first checked on the availability of data, and whether or not the data was documented in English.

The first case that was being selected was DSM in the United Kingdom. This case is chosen because it is relatively comparable to the context of the Netherlands. It is a more typical case, providing a good start for the comparative case study. The second case was DSM in India and was selected because the electricity system in India is under significant pressure and could therefore be seen as a critical case. The third case, DSM in Australia, was selected since Australia has extensive experience with DSM and could be seen as a frontrunner with regard to DSM. Australia can also be seen as a success case for the upscaling performance of niches in DSM. The fourth and last case, DSM in China, was selected because the country experiences very rapid economic growth and urbanization rate. The context of DSM in China was expected to be significantly different than that of the other cases.

Research Methods

Literature research

A literature research has been conducted to answer the first sub-question: "Which factors have an influence in the upscaling performance of niches in Demand Side Management into the regime level?". A literature research does not serve as a mere summary of the existing literature of the subject, but functions as a means to create a deeper understanding of the different parts of the research. The literature review for this study is roughly divided into three parts; 'Demand-Side Management', 'Transition Management' and the 'Upscaling of Niches'. The last part, regarding the upscaling of niches', was the part that helped answer the sub-question that was formulated for the theoretical framework.

The literature review has been conducted by using the' backward snowballing' method. The first step in using this technique is by setting-up a start set (Wohlin, 2014). The starts set are articles of different authors that are used as a beginning of the snowballing process. Diversity is important issue here (Wohlin, 2014). These articles were found by using key words for each specific part and searching for these key words on Google Scholar. After that, the papers would be read, and new information would be acquired. Special attention in these papers was on which references they used in their research. Mainly the introduction and theoretical chapters of the paper were used to find new sources of literature. The relevant papers that were referenced to would then be scanned if they were useful or not. If so, the article would be read the same way as the other articles, providing possible new articles. If no new relevant articles were found, the snowballing process was finished. Another method that has been used for the literature review is 'forward snowballing'. With the 'forward snowballing' technique, new papers are found by identifying in which papers the paper that is being examined are cited in (Wohlin, 2014). 'Forward snowballing' is also a technique that has been used in this study to check whether the paper is still relevant. This is checked by looking at how many times, and in which kind of papers, the study is cited in in recent years.

Both the 'backward snowballing method' and the 'forward snowballing method' proved to be an effective method in how to search for articles that were relevant for this study. The literature review has resulted in factors that have, in theory, an influence on the upscaling process of niches. The results of the literature review are conceptualized into a model, which can be seen in figure 5.

Desk Research

A desk research had been conducted for the second sub-question: "What is the context of each case, in which the niches in demand side management take place?". Whereas a literature research is foremostly limited to scientific literature, a desk research examines non-scientific sources as well. This provided to be useful when the context of a certain case needed to be researched. The result of the desk research

was to give an understanding as to why a certain niche could work in a specific place. The desk research served as a starting point for the document analysis. So, each case was first examined using websites, documents or other types of available material. After an understanding of the context of the specific case was acquired, the document analysis using an interview technique by O'Leary (2014) was conducted. However, understanding the context was an ongoing process. With conducting the document analysis, new insights regarding the context were acquired as well. Still, creating a general overview of the context of the case before going into the document analysis was helpful. A desk research has also been conducted to gather more information about certain projects or data from the document analysis. It has functioned as a check on the validity of the documents as well.

Document analysis:

For this study, the primary research method was a document analysis. In this research method, documents were seen as the main source of information. According to Yin (1994), a document analysis is particularly applicable to qualitive case studies. Non-technical literature is a potential source of information for empirical data for case studies and can be a valuable addition to the knowledge base (Bowen, 2009). The advantage of a document analysis is that it is an efficient method, it relies more on data selection than on data collection. Another major advantage of a document analysis is the availability of documents (Bowen, 2009). There are lots of documents available which can provide a broad coverage. According to Bowen (200), a wide range of document is better, but the quality of the documents selected is more important than the quantity. For this study, many public domains have documents or reports available on their website with regard to energy policies which can be accessed freely. Besides that, there are many 'cases' to choose from. But a document analysis also experiences some potential flaws. The main risk is that the documents contain insufficient detail to answer the research question. The documents act independently to the study, so you do not have an influence on the information they provide. This independence can be seen as an advantage as well, as the documents are unaffected by the research process (Bowen, 2009). Another potential flaw is a biased selection of the documents (Bowen, 2009). It can be the case that the documents that are available on a certain governmental website are a selection of documents that they are willing to provide. Only 'success stories' can be accessible on the website for example. To limit bias, a wide variety of sources are needed to increase the reliability of the information found (Mills et al, 2010). This variety of sources has been secured in this study, by not only including governmental organizations as a source of the documents, but also research institutes, like universities, or independent organizations (see full list of the document sources on page 64). The flaws mentioned in this section do not count as major disadvantages, more as factors that must be kept into account when conducting the analysis (Bowen, 2009).

The documents that have been used in this study are mostly found by search terms in google such as: 'Demand side management report *name of the case*. This resulted in sites or documents which

contained information or reports on DSM in the specific case. The documents were then being scanned whether they would be useful or not, before they would be included in the document analysis.

The method that has been used to analyze the documents, is the interview technique. With the interview technique, documents are treated as interviews with a respondent or information (O'Leary, 2014). Before going into any documents, interview question, based on the insights of the theoretical framework, has been formulated in order to answer the research question respectively. This interview guide will be elaborated on in the next section of this chapter and can be seen in appendix 1. Eventually, the questions were 'asked' to each document and the answers in the text were highlighted and coded.

Interview guide

The interview guide, which can be seen in appendix 1, consists of the interview question that were being 'asked' to the documents. These questions are based on the conceptual model and have resulted in information to answer sub-question two, three and four. There were, besides the codes listed in the interview guide (appendix 1, table 2), other codes used as well. However, these were not directly related to a certain question, hence why they were left out of the interview guide (appendix 1, table 2). The codes are included in the full list, which can be seen in appendix 2 (table 3), and have been used in the interpretation of the data.

Data analysis:

The documents that have been examined were seen as interview transcripts. These transcripts consisted of lots of information, so a systemic data analysis was necessary. Using codes and categorizations are the most common analytic approach for interviews (Roulston, 2014). The first step in this qualitative analysis, was to 'reduce data to locate and examine phenomena of interest' (Roulston, 2014). This was done by applying codes to transcripts. This process was theoretical driven, where the codes focus on the phenomena that was being researched (Roulston, 2014). The codes contained data or text about a certain subject. The second step was 'reorganizing, classifying, and categorizing data' (Roulston, 2014). This step was about reassembling and reorganizing the data, codes and categories (Roulston, 2014). Linkages between codes were made and combined into larger ideas called categories. An example of a category for this study is the category; Building of networks. This category consists of codes that represent parts of every document of a certain case, that is about the building of networks. This helped with the third step of the analysis, which was the 'interpreting and writing up of the findings' (Roulston, 2014). In this step, the data from the documents were interpret, and stories were developed that were based on this interpretation and the theory.

In Chapter 4, the empirical data, the data analysis is written down. The way this is done, was by using the documents from the document analysis as ‘respondents’. The source of every document, or ‘respondent’, for each case can be found in the chapter: ‘Sources of the Documents Analysis’, starting on page 64 . For a certain group of codes, all the information was acquired and then written down as a story, using the documents as references. It can be compared to the writing style of the theoretical framework, but then with using statements and claims that are made in the documents. All the findings of the documents for each case were combined for each factor or barrier and analyzed to make an overarching interpretation. After analyzing and documenting the results for each case, a comparison for every sub question was made between the cases.

The programme that has been used for the data analyzation was ‘Atlas.ti. Atlas.ti is a coding programme, where transcripts or documents can be imported. Within these documents, parts of the text can be highlighted and coded. This programme has contributed to the organization of the data analysis by providing an overview of the codes and documents. A screenshot (figure 9) is provided in appendix 3, to illustrate the interpretation of the collected data using ‘Atlas.ti’.

Ethics

For this study, the data that has been used is collected by other organizations or parties. This makes the ethical considerations during the data collection process different, since the choices regarding ethics were already made by another party. The difficult part was however, that there was less information available on how this data is collected and how the collector has dealt with ethical considerations themselves, making it harder to check the quality and validity of the collected data. With regard to the data for this study, namely documents regarding DSM in countries across the world, a few problems have been kept into account when interpreting the data. It could have been the case that the documents or reports were misleading, that the phenomena that is being described is written down as a better version than how it actually went down (Mathison, 2005). The documents available might be unrepresentative, or the recorded data was inaccurate. A critical view on the selected documents for this study was necessary, in order to make sure that this research is valid, trustworthy and ethical. The validity of the documents is also checked by conducting a desk research on certain aspects of the documents, such as some projects mentioned in the documents

Chapter 4: Empirical Data

Chapter 4 will consist of the empirical data that is acquired with conducting the desk research and the document analysis. The chapter is first of all divided into the four cases, and a finalizing section where the cases are compared to each other. Each case starts with an explanation of the context of DSM in the specific country. This part can be seen as the introduction to the case, and provides the information required to answer the second sub question. After the context, the results of the data analysis with regard to sub question 3 and 4 will be given for each case separately. After the upscaling performance of niches in DSM of each case, the cases are analyzed, and the results of each case are compared to each other. This chapter will be the foundation, together with the theoretical findings, for the answer to the main research question. A full list of all of the documents that are being used and referred to can be seen in the chapter 'Sources of the Document Analysis' starting on page 64.

The United Kingdom

The context of the United Kingdom

The United Kingdom (UK) is an island country located off the northwestern coast of mainland Europe. The UK is a combination of countries including; England, Scotland, Wales and Northern Ireland. It is a highly urbanized country, as 83.4% of the citizens live in urban areas (Britannica, 2020). As of 2016, the UK's main source of energy production was natural gas, namely 42% (Energy UK, 2020). However, the UK is investing heavily in offshore windfarms and in the third quarter of 2019, renewable energy provided more electricity to UK homes than natural gas and coal (Ambrose, 2019). The UK increased share in renewable energy makes it an interesting case to research with regard to DSM.

What is special about the geographical context of the UK, is its climate. The demand for electricity is heavily influenced by the seasons (Document U1). Human behavior is different in the winter than in the summer, and the demand for electricity varies between them. Not only the demand is affected by this, also the amount of sunlight varies between the seasons. This will, in turn, affect the supply of solar energy. The UK also experience a harsh environment on the coast. Document U2 explains that these harsh conditions increase the wear and tear of the electricity network. A network with a flatter demand curve would run more efficiently, and in turn, would require less upkeep. This was an important incentive for one of the niches to invest in DSM and is an interesting contextual factor.

The electricity system in the UK is undergoing a significant change since it wants to achieve a low level of carbonization (Document U4). To achieve this, the electricity system is increasing the amount of renewable energy and inflexible nuclear generation. At the same time, the more traditional energy sources such as coal and gas, will reduce in capacity (Document U4). This makes the system less able

to deal with fluctuation in demand, which is why new flexibility approaches, such as DSM, is needed (Document U4).

In the 1990's, the regulatory framework for the privatized energy utilities in the UK had a strong supply-led orientation of the industry (Document U2). There were disincentives for the energy companies to consider DSM options. The energy companies wanted to maximize their revenue, so they wanted to increase their electricity sales. Measures that would try to decrease the demand would mean a loss in revenue (Document U2). Programmes, such as DSM, were not invested in at that time. But this has changed, as the government has, as of now, adopted a target of net-zero greenhouse gas emissions by 2050 (document U5). Demand Side flexibility in the UK has been encouraged since 2015, by the National Grid's Power Responsive Initiative (document U3). The Power Responsive initiative wants to increase awareness of DSM and wants to equal the opportunities for demand and supply to balance the electricity system (document U3). There is also a great focus on removing barrier to flexibility in the UK, and the target of net zero greenhouse gas emissions could strengthen the requirement for DSM (document U5). On the other hand, in the generation market, the excess generation capacity that has existed over the last years has decreased, resulting in a rise of the market price of power.

The provision of DSM in the UK is expected to attend to industrial and commercial consumers (Document U3). A reason for this is that it becomes more difficult to provide DSM to the residential sector, as this sector consists of a large number of clients with a relatively low energy consumption (Document U3). It is also worth mentioning that around 71% of the participants asked in surveys do not participate in DSM (Document U3, U5).

The upscaling performance of niches in DSM in the United Kingdom

The articulation of expectations and visions:

DSM in the UK is needed to reduce the peak loads in the increasing demand for electricity. DSM reduces the capacity of the low carbon generation needed by improving the utilization of the generators, and in turn contributes to the goal of achieving net-zero greenhouse gas emissions by 2050 (document U4). Going more in-depth into the niches, most of the time, the purpose or goal of the niche was to create a better understanding of the practicalities of DSM. Most niches that are mentioned in the documents served as a trial or pilot project. For example, for the Low Carbon London project mentioned in document U1, the niches had the purpose to contribute to a model, which could increase the confidence to both parties (supplier and client) about the effects on the client's day-to-day business. The Low Carbon London project has identified different consumption patterns and has enabled analysis to correlate consumption patterns with household's income levels and occupancy class, achieving the purpose of the niches to contribute to a model (UK power Network, 2015). Especially among the client's side, as it is a niche subject, most people have never heard of DSM (Document U6). So, there is little

known about the effects and benefits of DSM. The lack of understanding is also, although to a lesser extent, present at the supplier's side. The potential of DSM needs to be better understood (Document U1). The niches were mostly set up to function as a trial, gathering new information on DSM.

The building of Networks:

The niches in DSM in the UK comes from a broad network of actors. Different energy companies are currently focusing, to a greater or lesser extent, on DSM products (Document U3). The suppliers of DSM see the potential of DSM and are encouraging to participate in the niche (Document U3).

However, the network of the niche is lacking on the consumer side of the niche. There are limited vertical linkages within the niche with regard to the client's side. As mentioned, most people have not heard of DSM, and document U1 suggest that it proved difficult to acquire support of senior management for implementing the niche into their operations. Most energy managers had other facility management duties and did not see it as their part of their role to introduce DSM programme (Document U1). Since DSM is for most people an unfamiliar and complex subject, it was hard to communicate and gather support among internal stakeholders (Document U6). For now, knowledge about the niche is largely restricted to the energy staff, rather than the commercial side or the board of businesses. They do not see the value of DSM, which results in a low participation rate (Document U1). Another downside of the knowledge about DSM is mostly present only by the energy staff, is that this makes the formulation of a regulatory framework more difficult. It might be the case that governmental organizations, who are responsible for the implementation of regulatory frameworks most of the time, do not have the knowledge available to create such a framework, hindering the development of niches in DSM.

The learning processes at multiple dimensions:

The document analysis showed many results of learning processes. The documents that are being examined consisted mostly of reports or evaluations of projects. It is thus unsurprising that these documents contained many inputs on first-order learning processes, in the form of data and facts. The purpose of most of the niches was to acquire some form of lessons. This included graphs and data (Document U1), lessons on the market perspective (Document U3) and statistics and stories of participants (Document U6).

Not only first-order learning processes were present in the niches, also second-order learning processes were observed in the documents. Second-order learning processes focused foremost on creating a better understanding of DSM. For example, a niche that is described in document U1 had the purpose to provide the information to create a model. This model or framework could then in turn be used to create a more accurate business case for future implementations of DSM. Other forms of second-order learning

processes were assumptions or the identification of barriers of DSM (Document U1, U2, U3, U5 and U6).

The barriers that limit the upscaling performance of niches in DSM:

There were many different types of barriers present that had an influence on the success of the niche, so only the most noted ones will be elaborated on in this section. The barrier that is mentioned the most times, is the lack of financial incentives (Document U1, U2, U3, U5, U6). People do not see the value of DSM (Document U1). In their view, the DSM schemes are very costly, and they do not know if the returns are worth their effort (Document U1 and U6). The cost-benefit of implementing DSM does not stack up, and it even looks less promising in the near future (Document U6). Financial barriers are not only present and the consumer side of the niche, also on the supply side of the niche, financial barriers are mentioned many times. The market for energy supply is highly competitive (Document U4) and there is a lot of uncertainty about the prices and business cases (Document U6). This is also in line with another barrier that has a severe influence, namely regulatory barriers. The legislative landscape with regard to DSM is changing rapidly (Document U6). According to document U6, this brings unpredictability in the benefits of DSM. There is also not a lot of upfront guidance (Document U6). Overall, there is a lack of vision and long-term planning. This is illustrated by the fact that you can only bid for a one-year contract with a DSM supplier (Document U6). The suppliers mentioned in document U6 say that providing a 15-year contract would provide long term certainty to build a business case. Another barrier to the niches is the increase in risk when DSM is implemented in their operation (Document U1, U3, U5 and U6). Participants of the niche fear that DSM would have a potential impact on their services, comfort levels or quality of end products (Document U1). The revenue that they would receive would not outweigh the increased perception of risks .

India

The context of India

India is home to more than 17% of the world's population (Document I2), with a rapid growing economy. It is expected that India will be the third largest economy by 2030 (Document I2). One of the key factors in economic development is energy, as it is an important building block. However, energy can be a sporadic commodity in some cases. India is one of those cases where electricity is not a given. Only 55% of the households in rural areas in India is connected to the electricity grid (Document I2). This not only restricts the development in these rural areas, but also have a significant impact on India as a whole, as India experience a heavy dependence on the rural economy (Document I2). In cities however, energy intensity is extremely high compared to same-sized cities in other advanced countries. Rapid economic growth has intensified the need for a strong energy system even more. India has achieved a steady increase in its electricity capacity, but the increase in demand as outweighed this growth in supply (Document I7). India faces very difficult challenges in meeting the demand in a reliable, economic and sustainable manner (Document I3). DSM is therefore considered as an approach with huge potential, but it also needs to deal with significant pressure, due to the growing need for a solid energy system.

This explains why DSM in India has not seen many experiments or programs in the past. In the 1990's, there were three major DSM programs attempts, but only one of them was fully operational (Document I3). While these attempts have led to lessons or insights with regard to DSM, no real involvement or follow up investments have been observed (Document I3). From the beginning of the 21st century until now, policies and framework regarding DSM are being research and implemented. An example is The Bureau of Energy Efficiency, which was set up under the Ministry of Power in 2002, with the aim to formulate an action plan for setting up DSM programs in India (Document I2). But still, there is little political visibility for energy efficiency, and there is no pressure on actors to actively pursue implementation of energy efficiency measures, such as DSM (Document I1).

DSM has not been a top priority for utilities in India. Electricity utilities are in the market to sell electricity, not to save (Document I8). Therefore, many electricity utilizes don't experience incentives to implement DSM, since they tend to look for current benefits, rather than having long term benefits through investments in DSM technologies (Document I7). Indian Electricity Utilities are in declining financial health and are not able to finance any capital-intensive programs like DSM.

Another challenge for DSM specifically for India is that the DSM programmes needs to be designed to address all the types of end users of different sectors (Document I7). During daytime, the peak is due to industrial, institutional and business sectors whereas the evening peak is largely due to the residential

sector. A programme which would address multiple sectors is comparatively costlier (Document I7). The energy regulations in the agricultural sector in India is also worth noting. The energy costs for farmers in India is entirely subsidized by tariffs, disregard of energy efficiency (Document I8). Farmers are therefore not inclined to make any efforts in improving their energy efficiency, since they do not bear the burden of the costs. They do not gain or lose anything.

The upscaling performance of niches in DSM in India

The articulation of expectations and visions:

India's demand for electricity has been growing by about 8% every year in the year 2009-2014 (Document I1), but the generation of power is lagging behind. The demand for electricity is increasing significantly, as 1/3 of the Indian households which are currently not have access, will be connected to the grid. The country is installing new power generations, by the supply side is still plagued by many issues (Document I4), such as rising electricity prices. Besides that, the utilization of electricity has been inefficient (Document I7). Therefore, there is a huge potential for DSM. According to document I8, DSM has been recognized as a least cost energy resource and is proven to be cheaper than building new energy supply infrastructure. Besides the financial argument, DSM is regarded as an important strategy for India to achieve its climate goals of the UN Paris agreement (Document I8).

The current status of DSM in India is that most observed programs remain largely in form of pilot projects (Document I3, I7, I8). DSM is still in the development phase, despite the recognition of the benefits of the program. The focus of these DSM pilots is mostly on raising awareness of the subject (Document I1), establishing a market and to reduce the uncertainty in energy savings (Document I2). The majority of these pilot projects did not have the aim of increasing the scale of the pilots (Document I1), due to the lack of appropriate regulatory framework and the insufficient (financial) resources to undertake marketing, outreach, and program monitoring activities (Document I8). There is also not much information to be found about the outcomes of these pilots (Document I1). The transparency and communication the results of the niches that are going on has been lacking (Document I1). The niches in DSM in India are remaining on a small, pilot scale and the willingness to take these niches to a larger scale has not been visible yet.

The building of Networks:

The niches in DSM experience a broad network of actors. There has been increasing activities in DSM by utilities and other actors in the recent years (Document I1). However, Indian's power market structure is dominated by unbundled or vertically disintegrated state-owned utilities (Document I8). The same utilities are mostly responsible for the planning and implementation of DSM programmes (Document I2, I7). These utilities are bounded in India to provide reliable supply of electricity to the consumers at minimal costs (Document I7). However, the utilities that are responsible for the implementation are in

financial difficult times. They are expected to keep the electricity prices low for politically influenced sectors but have a very low revenue (Document I7). Some service sectors like municipalities do not pay the consumption charges due to financial reasons but receive reliable supply of electricity. Due to their declining financial health, the utilities are not able to invest in approaches like DSM. So, while DSM experience a broad network of actors that are enthusiastic about implementing DSM measures, they lack the skill and resources to implement these (Document I1, I7).

The learning processes at multiple dimensions:

Currently, there is a lack of learning processes for the niches in DSM, both first- and second order processes. First of all, there is limited information on the monitoring and evaluation of ongoing programmes, and there is almost no communication between different actors to share their experiences (Document I1). The reviews of the programmes mentioned in Document I3 share this statement, as the post evaluation of programmes is largely missing. The goal of the niches was foremost to serve as a pilot project and gather new information with regard to DSM. The scale of these pilots is small (Document I1), and together with limited documentation of the findings (Document I6), it remains hard to learn from the niches. Still, efforts are being made. Documents I3, I4, I5, I6 are evaluations and reports on Utility DSM Forums. This is a platform where knowledge and insights are shared and discussed between relevant representatives from utilities in India. While this has produced new insights or focus points for DSM, the learning processes for the niches have been limited. Making data available of evaluations of pilot projects could significantly help the learning process (Document I1)

The barriers that limit the upscaling performance of niches in DSM:

The success of the niches in DSM in India are affected by many barriers. The barrier that is mentioned the most times is regarding regulations. As mentioned, the actors that are responsible for implementing DSM in India do not have the skills or resources to do that. The lack of guidelines or implementation frameworks discourages utilities from implementing large scale programmes (Document I1). The absence of clear guidelines for the evaluation, measurement and verification of saving acquired from DSM is an important bottleneck (Document I8). The reason that the niches in DSM has not been implemented on a large scale is because this requires large technical and financial investments, as well as high level of monitoring and governance system (Document I7). While there are some regulations and policies regarding DSM, there is a lack of enforcement of those same regulations. The enforcement of DSM regulations has been limited (Document I8), and actors are not induced to implement DSM measures since they are not mandated under the legal framework (Document I7).

Another major barrier to the success of DSM in India is the lack of financial incentives and the way the energy market is organized. The utilities in India are mainly focusing on only improving the supply system and are inhibited to experiment with DSM due to a poor financial condition and resources

(Document I3). Implement DSM measures on a large scale may come with a greater risk (Document I3), especially due to the lacking regulatory framework which could have decreased the uncertainties that are present with implementing DSM measures. Utilities tend to be risk averse, and often reluctant to propose and design DSM programs on their own that could fail and force the utility to shoulder the financial consequences (Document I3). Besides, utilities earn significant revenue by supplying power to the industries during the peak hours as tariffs are higher during these periods (Document I7). This gives a disincentive for the utilities to implement measures that try to shift the demand to off-peak hours.

Australia

The context of Australia

The power system the NEM, which is the National Electricity Market of Australia, is one of the world's longest interconnected system (Document A2). The system stretched along the eastern coast of Australia. The two states; Western Australia and Northern Territory are not connected to the grid of the NEM, because of the lack of electrical interconnections, and the vast distances between their load centers and the interconnected electricity network in the southern and eastern States (Document A2). This is important to keep in mind, since these states will be excluded for most of the DSM reports.

DSM is a relatively unknown subject in Australia as 80% of the respondents in a survey across all states and territories did not know about DSM (Document A3). However, the potential of DSM to support reliable electricity supply while reducing total costs has been widely recognized for many decades. The first form of DSM already appeared in the 1930's in Victoria, which is a state in Australia, but the potential has not been fully embraced by policy makers during the years after. Until the mid-1990's, the electricity businesses were owned by State governments (Document A2). The electricity industry operated as a public service, rather than as profit-making commercial ventures (Document A2). The industry did not have an incentive to implement projects that cost-effectively reduce load on the system. DSM was thus not something that the electricity businesses were particularly interested in. This changed during the 1990's as the vertically integrated electricity utilities in Australia were unbundled into separate generation, transmission, distribution, and electricity retaining businesses (Document A2). Competition was introduced to the electricity industry and a more formal system of economic regulation was required (Document A2). This resulted in new agencies, established by State and Territory governments, with the aim to regulate the electricity industry (Document A2).

The NEM is one of the few purely cash-settled electricity markets in the world (Document A2). The Australian electricity businesses are increasingly recognizing the importance of supporting DSM, as a means of providing higher value, lower costs and more reliable network services for consumers (Document A1). Since the NEM was established in 1998, there have been several major missed opportunities to apply DSM, in order to decrease the expenditure on supply infrastructure and energy bills (Document A1). DSM is now seen as more important than ever (Document A1), and this is reflected in the increase in policies and regulations with regard to energy efficiency or DSM in the NEM. DSM has already taken form in Australia and has certainly surpassed the experimental phase.

What was notable during the analysis, is that Australia mainly focus on Demand Response, as a form of DSM. Demand Response is a change in the electricity consumption to match the demand and supply. As a result, the importance of costumers and the engagement towards them by the utilities is of more

importance. This can be seen in the analysis, where relatively more documents, compared to the other cases, focused on researching the customers side of the story. Another reason why this is the case, can be that DSM is more developed in Australia. The understanding of the suppliers is present with regard to DSM, so the research can therefore focus on the experience by the users instead.

The upscaling performance of niches in DSM in Australia

The articulation of expectations and visions:

As mentioned, the NEM has missed several opportunities to implement DSM, to reduce the expenditures on infrastructure and to decrease the energy bills of consumers (Document A2). Besides, the increased penetration of renewable energy into the energy system in Australia, has put pressure on the existing system ability to meet demand (Document A5). DSM could play a significant role in ensuring the security and reliability of the grid (Document A6). The experimentation of DSM started happening in the 2000's. in 2008, the Australian Energy Regulators released a DSM Incentive Scheme, which would provide energy businesses incentives to investigate and conduct DSM projects throughout a regulatory control period (Document A2). The aim was to increase the current stock of knowledge and experience of the energy businesses, so that in the future, DSM projects could be seen as viable alternatives to network expansion (Document A2). The tools provided by regulations or framework such as the DSM Incentive Scheme rewarded businesses to implement DSM measures (Document A4). This helped in increasing the willingness and the participation to implement the niches. Besides the increased willingness to participate, the expectations of the niches were specific. This has stimulated the development of niches in DSM in Australia.

The building of networks:

Initiatives and the implementation of niches in DSM comes from a broad network of actors. The main group of actors that develop and implement DSM initiatives are State governments, electricity businesses and institutions responsible for operation and governance of the NEM (Document A2). Before the 1990's, the electricity suppliers were state owned, meaning that the electricity industry operated as a public service (Document A2). The electricity suppliers did not have impactful incentives to implement DSM measures. This changed with the decoupling of the electricity industry and the public sector. Competition was introduced into the sector (Document A2) This had increased the number of businesses capable of providing DSM, with presence across all major jurisdictions in the NEM (Document A4). But still, State governments were supporting the development of DSM. An example is the Victorian government, who proposed the Victorian energy demand management framework (Document A1). This framework was developed to complement the DSM Incentive Scheme proposed by the National government suggesting coordination between the various governmental levels (Document A1). The privatization of the energy sector has decreased the vertical integration of the

sector, relying more on competition and communication between the various level. This does not seem to have a significant negative effect on the upscaling performance of the niches in DSM.

An interesting characteristic of the network on the consumer side of DSM in Australia, is the collectiveness of the people. People valued their effort of their action within the context of contributing to a higher goal and the broader community (Document A3). Many people were motivated to continue with participating in the DSM program because of the potentially larger impact across the total group of participants (Document A5). The network both on the supplier as on the consumers side of DSM is broad and deep. Both the public and the private sector is keen in participating and implementing DSM measures. There is a willingness to act, but also the ability to implement DSM measures onto a larger scale.

The learning processes at multiple dimensions:

In the document analysis, many forms of learning processes were observed with regard to DSM. Starting roughly from the year 2000, pilots or experiments in DSM were set up and funded (Document A2). As mentioned, the aim of most of the pilots was to increase the existing knowledge base and the understanding of DSM (Document A2). From these pilots, regulations and models, came forth, further increasing the development and implementation of DSM in Australia. The learning processes had special attention for the policies and frameworks regarding DSM . Regulations were tested and reviewed (Document A2). However, the more recent researches that were found in the analysis, such as document A3, were focused on gathering new insights with regard to the experiences of the consumers of DSM . The learning processes has shifted attention to the practicalities of the niche, instead of creating a better understanding of the subject based on pilots and experimentation in DSM.

The barriers that limit the upscaling performance of niches in DSM:

DSM in Australia has relatively limited number of barriers that have a constraining effect on the success of the niches that are occurring. The reason for this might be that DSM is not in the experimental phase anymore. Through experimenting and pilot projects, the number of barriers constraining the development of the niches could be reduced or limited in its impact. Still, there were some barriers that came forth out of the document analysis. The type of barrier that is mentioned the most time are regulatory barriers. However, it must be noted that the results on the regulatory barriers were difficult to interpret. While it is mentioned the most time, the regulations were not a barrier to the success of niches in DSM. On the contrary, the regulatory framework or policies regarding DSM were seen as a success factor for the development of the niche. Certain parts of a regulation or policy could be seen as a constraining factor, but these parts were addressed and solved in a later framework. The restructuring of the electricity industry in Australia, which has been proceeding since the 1990's (Document A2) can be an explanation for this. The whole market for electricity needed to be reorganized (Document A2),

which has resulted in a bit of trial and error. The result of the document analysis suggests that regulations and policies regarding DSM experienced a lot of reviews and changes over time.

The second type of barrier that is mentioned the most time has to do with social and behavioral factors of the consumer of DSM. However, this barrier is not seen as having a constraining effect on the upscaling process of the niches in DSM but can rather be seen as effecting the experiences of the consumers. According to document A6, the consumers preferred a better feedback mechanism and reward system with regard to Demand Response. People were rarely called upon when moments were Demand Response was needed occurred (Document A4), lowering the engagement of the consumers (Document A3). In addition, there was a lack of knowledge on the actual reason why a sudden response in demand was needed (Document A3).

China

The context of China

China is located in eastern Asia and is one of the largest countries in total land surface, and the largest in terms of population. Since the reforms in 1978, transforming the country from a planned system to a market economy, China has achieved huge economic development. The growth has lifted hundred millions of people out of poverty and raised the average standard of living dramatically (Document C1). The electricity rate of China has also raised to 100% in 2014 (World Bank, 2020).

Chinese power supply is dominated by coal, accounting for 69.8% of the primary energy production (Document C7). Compared to other countries, the coal mining industry is relatively bigger, resulting in low level coal power generation efficiency and serious environmental pollution (Document C6). There is an enormous pressure on the energy supply of China, due to the rapidly increasing economy. Demand for electricity increases rapidly due to the industrialization, urbanizations and the rapid development of the energy industry (Document C6). According to Document C1, a major challenge to the Chinese policymakers is how to power this extraordinary economic growth. Currently, there is a low reliability of the electricity network, due to the aforementioned rapid load growth (Document C3). This is not a local phenomenon, but a common problem that is nationwide, especially in highly populated and industrialized areas. Managing the increased demand for electricity has become one of the top policy priorities in economic development in China (Document C5). DSM is therefore a suitable approach of where the energy system of China can benefit a lot from.

DSM is not a new concept in China, as in was already introduced in the early 1990's. Since then, a lot of effort have been put by the government agencies, power companies, research institutes and other organizations to promote the use of DSM in China (Document C1). The activities in the early periods ranged from international exchange and cooperation, pilot studies and educational activities, with the aim of providing experience regarding implementing DSM in China (Document C1). China has begun to incorporate the concepts of DSM into national plans, policies, regulations and standards, but these have not been widely implemented as of 2003 (Document C1). But since then, China has issued guidance and methods with regard to DSM. One of the methods that has been passed is giving the responsibilities of initiating DSM to all levels of governments, the grid management enterprises are given the task to implement the DSM measures, and the power users are the participants (Document C6). The electricity sector was also experiencing a reform during the early 21st century, with the aim at creating a more competitive, market driven, and efficient power sector (Document C3). But, according to Document C3, the reforms only have positive outcomes for DSM when explicit policy attention was given towards the approach.

An interesting characteristic of China with regard to the energy sector is the differences between the regions in China. China's energy resources are located mainly in the less-developed and less-populated regions. Coal reserves are mostly found in the North and the West of the countries for example (Document C3). So, while the demand for electricity is mostly centralized in the urbanized regions in the East, the production of energy comes from the other regions. This requires extensive collaboration between the various regions, with regard to transmission and transportation systems (Document C3). The electricity prices in China also vary from province to province, and from sector to sector. Generally speaking, the price for electricity is lower from large industries in urbanized areas, compared to the price for electricity for the agricultural sector in rural areas.

The upscaling performance of niches in DSM in China

The articulation of expectations and visions:

As mentioned in the context section, China experiences a rapid economic growth, with an increasing demand for electricity. China has a hard time to keep up with the pace of the growth in demand, resulting in electricity shortages, especially in highly populated and industrialized areas (Document C5). The traditional power planning methods can no longer meet the long-term economic development, which also leads to waste of resource and pollution (Document C6). DSM is therefore an important approach that can have a significant impact on the energy system in China. The development of DSM has started from the 1990's, when China has started to conduct activities in order to provide experience regarding the challenges and opportunities of implementing DSM in China (Document C1). However, the pilot projects remained at a small scale, aiming on gathering knowledge. This aim continued to be present at the pilot projects that have been conducted afterwards. For example, pilot projects that are being mentioned in Document C2, focusing on the industrial sector, were conducted to provide experience with a more dynamic integration of industrial load flexibilities based on market mechanisms. Also, the pilot projects in Beijing, Tangshan, Suzhou and Fo-shan had the aim of developing measures of electricity demand response, research, propaganda, training and assessment, testing and to provide practical basis for the policy making (Document C6). Therefore, the expectations of the niches in DSM in China has been to gather experience, knowledge and information to further develop the approach.

The building of networks:

The electricity sector in China was dominated by two major power grid companies, the State Grid Corporation and the China Southern Power grid, and by five major power generation corporations, which are all state-owned enterprises (Document C7). Government authorities are involved in the regulatory oversight of the electricity sector, and the three departments of Electricity, Nuclear Power and New Energy, who fall under the NEA, are responsible for managing the sector's development and reform, formulating development plans and policies and ensuring their implementation (Document C7). However, China's power sector has reformed and as of 2018, competition was released in the energy

sector to break up the monopolies. The power grid enterprises were separated from the government and were no longer entitled to exercise governmental functions (Document C3). The implementation and development of DSM measures requires coordination and cooperation of all these different government agencies or utility companies (Document C5). The network of actors responsible for implementing niches in DSM is broad, with the responsibilities being split over multiple parties. This can, however, create some difficulties for the development of DSM. Document C3 for example, suggest that it is not clear which entity or entities have responsibility for DSM implementation. The Document (C3) suggest that there is a lack of institutional home and that DSM planning and policies has fallen off. Power grid companies would most likely be the main entity responsible for implementing DSM, but the companies would not do that without support from the Chinese government. An example of the difficulty in the coordination between the government and the power grid companies, is that the electricity price is regulated by the government. This makes it more difficult for the power grid companies to implement Demand response project, hindering the development of DSM (Document C6).

The learning processes at multiple dimensions:

A lot of time and effort has been put in the learning processes of niches in DSM in China. As mentioned, the concept of DSM was first introduced in the early 1990's (Document C1). The activities during that period included international exchange and cooperation, training courses, pilot studies, demonstration projects and educational activities (Document C1. In 1995, the electricity utility groups from the G-7 countries send experts to China for cooperation to a demonstration project of DSM (Document C1). However, the pilot projects were actually never implemented, besides a niche project in Beijing focusing in load management (Document C1). Still, according to Document C3, China has substantial experience and achievements in DSM, mostly on load management, due to the pilot project in Beijing. The experience with load management provides a solid foundation, that can stimulate niches with regard to load management in areas other than Beijing. More recently, pilot schemes in 4 cities explored the role of fiscal funds and support measures that can enable DSM (Documents C7). China is also committed in strengthening the cooperation with other countries with the Belt and Road Initiative. This initiative will boost the energy resources development and energy infrastructure, but also illustrate the focus of China on international cooperation. This, together with the experience of DSM from the pilot projects, stimulates the learning processes of niches in DSM, and will help with the development of DSM in China, but also on a more global scale.

The barriers that limit the upscaling performance of niches in DSM:

The barriers that limit the developments of the niches in DSM in China are pre-dominantly divided into three types. These three types are; Regulatory, Market organization and Lack of financial incentives. To start with the regulatory barrier, according to Document C3, China lacks the legal basis to adopt effective DSM policies. Besides the legal basis, it lacks an adequate and stable DSM funding mechanism, which

is critical for the success of DSM (Document C3). In addition, the electricity price is regulated by the government, making Demand Response project harder to implement for power companies (Document C6). The lack of funding seems to be the most dominant barrier that has a constraining effect on the development of niches in DSM. This barrier is also mentioned in the other types of barriers. Document C1 argues that there is a lack of a sustainable mechanism to generate the necessary funding for DSM program. Another factor that disincentives power grid companies to implement DSM measures is that the utilities make money by selling electricity, not by saving electricity (Document C1). DSM, which increases the energy efficiency, will reduce the utilities revenue and profits (Document C3). The lack of financial incentives is also an important barrier for DSM in China. Even for pilot projects, the lack of financing and incentives were the reasons that they were never conducted (Document C1). An example of a consequence of this is mentioned in Document C6, where the suggestion is made that due to Demand Side Response not been widely adopted in the market, the average capital costs of projects implementation increases, which, in turn, limits the implementation of pilot projects and thus the breakthrough of niches.

The comparison between the cases

The articulation of expectations and visions

The expectations and visons of niches in DSM across all the cases, had an aim to create a better understanding of the subject. However, there are some differences between the cases in the urgency of the niches and what is actually being done with the new information and knowledge. In India, the niches in DSM are under serious pressure. The actors responsible for the implementation need short-term benefits and cannot upscale the niches, since the investments that are needed cannot be made. The niches in China also remain at a relatively small scale, focusing on gathering new knowledge. This is surprising since DSM was already introduced in the early 1990's. It seems that not that much have been done to upscale the niches in DSM in China. In the United Kingdom, DSM is in the experimentation phase, and it is a relatively unknown subject. The expectations of the niches are to create a better understanding, and to decrease the uncertainty for the ones that are responsible for the implementation of the measures. This follows roughly the same pattern as Australia, only the concept of DSM in Australia is more mature. Here, the purpose of the niches was to gather new insights that could stimulate further development. What makes Australia a success case, is that the knowledge and experiences from the niches were converted into new guidelines or regulations. Now, the purpose of the niches in DSM in Australia is more focused on doing research on the practicalities of DSM. An overarching finding with regard to the expectations and visions of the niches, is that there is a clear purpose of acquiring new insights and knowledge. Creating a better understanding of DSM is the first step in the development of the approach.

The building of networks

For the building of networks of the niches, the cases show a similar pattern across the cases. What is interesting is that all of the cases experience a reform in the energy sector, although some cases later than others. Most of the time, the energy sector is unbundled from a public sector, to a more market driven sector with competition. This, however, does not necessarily mean a positive factor on the development of DSM. Because the energy sector is split into multiple actors, each with their own responsibilities, heavy coordination is required. The government plays a key role in this, as it is the initiator of the implementation of DSM measures. The government is also important in the development of a regulatory framework for DSM. However, the case of the UK suggest that the knowledge is not present at the right people yet. The knowledge is largely restricted to the energy staff, but those people are not the ones responsible for the development of a regulatory framework. Bringing the knowledge to the governmental side of the network of DSM can be a crucial first step to take. In the case of Australia, it can be seen that the development of niches in DSM has benefited significantly from the active policy support of the government. This on the other hand, is lacking in the case of India. Here, the utility companies are responsible for implementing DSM measures, but they do not experience support from the government. They are therefore not willing to make the risk of experimenting and conducting pilot

project, hindering the development of DSM. It can be seen throughout the cases, that more actors, does not mean a better upscaling performance of niches. Responsibilities are split into more parties, requiring an active coordinating role of the government.

The learning processes at multiple dimensions

An overarching result that is analyzed from the document analysis with regard to the learning processes, is that there is a significant focus on the learning aspect of niches in DSM. However, it must be noted that this is unsurprising, since the documents that were analyzed were foremost reports and evaluations of DSM. The purpose of these documents is to provide information that can stimulate further development. But still, the learning processes were present across the cases. As mentioned, the aim of the niches was to create a better understanding of DSM. This has resulted in new information which could be valuable for policymakers or further trials. But acquiring this information is not enough. The most important part is what is being done with the information. In the case of India, pilot projects were set up, but the results were not available. This blocks the learning processes of the niches. With Australia, the insights were put into new regulations or guidelines. These were then tested with other pilot projects, providing valuable lessons that could improve the same regulations or guidelines. Therefore, while the learning processes were present in niches in all of the four cases, the upscaling performance of niches is dependent on what is being done with the lessons.

The barriers to the upscaling performance of niches in Demand Side Management

As for the barriers or the constraining factors on the success of niches in DSM, barriers with regard to regulations is the most dominant one across the cases. As mentioned, the government need to take an active role in the development of DSM. The only issue here is that it can be questioned whether the government has the required knowledge and skill to take up this active role. Still, policy support, in the form of regulations or funding is a key factor that significantly helps with the success of DSM. For example, in the case of India, there is a lack of regulations and support from the government. The utility companies are in bad financial health and are not able to make the risk of experimenting with DSM. Regulations or funding could decrease this risk, given the responsible actors an incentive to implement niches in DSM. DSM, without support, does not provide enough financial incentives to implement it. The lack of financial incentives is the second most dominant barrier that is mentioned across the cases. In the case of the United Kingdom, the increased risk of implementing DSM measures does not outweigh the reward. On both the consumer and the supplier's side of DSM, the reward is unknown, decreasing the participation in the development of the approach. Another barrier that is mentioned throughout the cases, is the fact that electricity companies are in the market to sell electricity, not to save it. The more electricity they sell, the higher their revenue. Even load shifting is not desirable, as in the case of India, utilities earn significant more revenue when they sell electricity to industries in period of high demand.

In a market driven energy sector, active policy support by the government is thus crucial to provide incentives to the utility companies to implement DSM measures, or a reform in the revenue model might be needed. If the active policy support by the government remains limited, the upscaling performance of niches is hindered, as the actors responsible for the implementation do not have incentives to participate.

The conceptual model (figure 5) of Chapter 2, the theoretical framework, can be renewed into an improved version. The improved version of the conceptual model, which can be seen in figure 8 includes the findings of the empirical data of this study. The difference between the models are the first two constraining factor, namely the lack of regulations and policy support, and the lack of financial incentives. These two factors replace the technical aspect, and the lack of commitment.

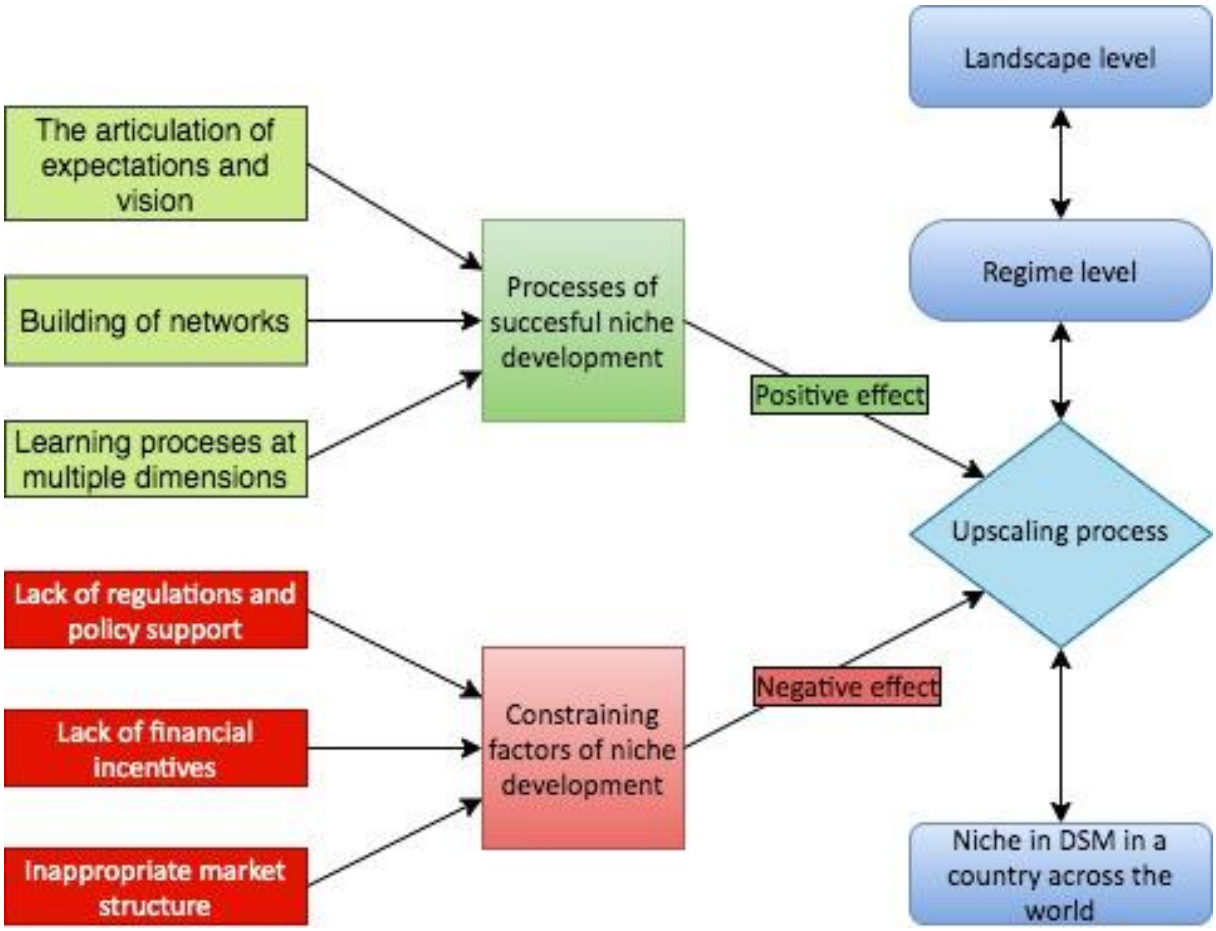

Figure 8: The renewed conceptual model (Source: author)

Chapter 5: Conclusion and Discussion

Demand Side Management (DSM) is the central subject that has been examined in this study. DSM is a portfolio of measures with the aim of decreasing the inefficiency of the electricity system, by adjusting the demand for electricity to match the supply of (renewable) energy. DSM is currently in a beginning phase, where experiments and projects (niches) need to be upscaled to affect the way we operate our electricity system (regime level). The aim of this study is to acquire new insights regarding the upscaling performance of niches in DSM into the regime level. Therefore, the following main research question is formulated: "Which lessons can be drawn from niches regarding Demand Side Management in countries across the world, for the implementation into the regime level in a Dutch context?". DSM is occurring in other countries across the world as well. It is therefore relevant and interesting to research which lessons can be drawn from niches in DSM in these other countries. Therefore, a comparative case study is conducted to answer the research question, using a literature review, desk research and a document analysis as the main research methods. To provide a conclusion to the main research question, sub questions are formulated which serves as the foundation on which the conclusion is based. The last two sub questions will be answered first, before the conclusion to the main research question will be provided and elaborated on. Lastly, the relevance of the findings will be discussed.

How do the niches in Demand Side Management, in each the cases, perform with regard to the theoretical factors on the upscaling performance of niches into the regime level?

The answer to this sub question is based on the empirical data from the comparative case study and the factors coming from the theoretical framework. Based on Schot & Geels (2008), three theoretical factors have an influence on the upscaling performance of niches into the regime level. These factors are: The articulation of expectations and visions, the building of networks, and the learning processes at multiple dimensions. The presence of these theoretical factors is seen in practice. For the first factor, the articulation of expectations and visions, it can be concluded that the goals of the niches that have been analyzed in the comparative case study, is to create a better understanding of DSM. The expectations of the niches are specific, with a clear aim in mind. For the second factor, the building of networks, it can be concluded that the niches that have been analyzed in the comparative case study experience a broad network of actors. However, more actors do not necessarily mean a better upscaling performance of the niches. A broader network of actors leads to distributed responsibilities and makes the coordination of the upscaling of niches more difficult. This conclusion is in line with the findings of the study of Bai et al. (2010), where the suggestion is made that more actors will increase the difficulty of managing a niche. Besides, while DSM experience a broad network, it can be argued that the knowledge around DSM is not present at all the people involved. The governmental organizations who are responsible for the implementation of a regulatory framework do not have the required knowledge on DSM. This

hinders the development of a regulatory framework, and thus the upscaling process of niches in DSM. As for the third factor, the learning processes, it can be concluded that the niches, in the cases, have a strong focus on gathering new information and knowledge, with the aim of creating a better understanding of the subject. The learning processes are therefore present in the niches. However, the most important aspect in practice, is what is being done with the acquired lessons. The presence of the learning processes is not enough, in order to contribute to the upscaling performance of niches into the regime level.

To conclude, the theoretical factors were certainly present in the niches in the cases and did have an influence. But, the presence of these factors is certainly not enough to upscale the niches in DSM into the regime level. The context into which the niches takes place are crucial, and there are constraining factors present that can have a severe impact on the development of the niches. The constraining factors, or barriers, will be discussed in the next section.

What are the constraining factors of the niches in Demand Side Management in the cases on the upscaling performance of the niches into the regime level?

The answer to this sub question is built upon the interpretation of the results from the document analysis. It can be concluded that there are mainly three types of constraining factors that limit the upscaling performance of niches in DSM. The first and most pronounced constraining factor is the lack of regulations or the lack of policy support. There is a risk for utilities to experiment and implement niches with regard to DSM. This risk can be decreased, when there are proper regulations or implementation guidelines available. The results from the document analysis suggest that these regulations or guidelines are often not available. There is uncertainty or a lack of understanding of DSM, and without policy support from the government, the utilities, the ones responsible for the implementation of the niches, are not willing to take the risk. The second dominant constraining factor adds to this, as there is a lack of financial incentives to implement or experiment with niches in DSM. The risk of implementing DSM measures is not worth the reward. In addition, the utilities make profit by selling electricity, not saving it, leading to the third type of barrier, namely the market organization. The current organization of the market gives them another disincentive to implement niches in DSM. Based on the empirical data from the cases, these constraining factors mentioned have a significant impact on the success of DSM. Without regulations or active policy support, there are little incentives for actors to implement or experiment with niches in DSM. The constraining factors that are found in the document analysis are in line with the research of Strbac (2008). Strbac (2008) suggest that there is a lack of incentives for consumers to participate in DSM and that there is a need for a regulatory framework.

Conclusion to the main research question

The conclusion for the following main research question: "*"Which lessons can be drawn from niches regarding demand side management in countries across the world, for the implementation into the regime level in a Dutch context?"* is as follows: the most important lessons that can be drawn from this comparative case study, is the need for regulations and active policy support by the government. Active policy support in the form of regulations, funding and frameworks, have a significant positive impact on the upscaling performance of the niches in DSM. It is the kick starter of a vicious circle. Policy support reduce the uncertainty and the risk of experimentation for the responsible actors, who are mostly utility companies in the context of DSM. The experimentations of the utility companies, in turn, provide new insights and increase the knowledge base. The increased knowledge base helps with providing more accurate policies, reducing the uncertainty and the risk even more. But it all starts with active policy support, which activates this vicious circle.

Strong regulations and active policy support are present with the development of DSM in Australia. This case can be seen as successful, where DSM is having an impact on a larger scale. For the other cases, the lack of regulations and policy support can be seen as the dominant constraining factor. Without support from the government, the niches in DSM cannot change the current regime level, resulting in a lockdown which is seen in the case of India for example. With regard to the theoretical findings, the research of Strbac (2008) and Spijkerboer et al. (2019) also suggest the need for a regulatory framework for DSM. The empirical data comply with the theoretical findings of Strbac (2008), Spijkerboer et al. (2019), but also with the findings of Bai et al. (2010) and Wieczorek (2018). Bai et al. (2010) and Wieczorek (2018) suggest that state support and state engagement is important for the upscaling performance of niches, a suggestion that is supported by the result of the document analysis.

Based on the findings of this comparative case study, it can be concluded that the most valuable lesson for the implementation of DSM in the Netherlands, is the need of a regulatory framework and active policy support from the government.

The relevance of the findings

This study provides new insights for both planning theory, as planning practice. To start with planning theory, the conclusion of this study, that there is a need for a strong regulatory framework or policy support, complies with the scientific literature on DSM, but also for renewable energy. Strbac (2008) suggest that a challenge for DSM is the lack of regulations, something which can be seen in the empirical data as well. While the study of Strbac (2008) dates from the year 2008, it is still a relevant paper as it is cited many times in recent publications. Next to Strbac (2008), Spijkerboer et al. (2019) suggest that

a regulatory framework with regard to renewable energy is a difficult thing to do, due to fragmentation of responsibilities and institutions in energy planning. However, both theory and the empirical data show that this is the most important step towards the development of DSM. With regard to the upscaling performance of niches into the regime level, it can be argued that the theoretical factors from Schot & Geels (2008), while being useful for this study, did not proved to be the decisive factors for the success of the upscaling process of niches in DSM. The theoretical factors hardly cover the context, and there are many other factors that can have a severe impact on the success of the niche development as well. The upscaling performance of niches into the regime level remains hard to quantify or to theorize. A relevant new insight for transition theory is that subject related factors, such as the lack of a regulatory framework or the lack of financial incentives for DSM, have a more influential impact on the upscaling performance of niches, than the factors that are proposed in the theoretical literature, such as learning processes at multiple dimensions.

For planning practice, this study is relevant for policy makers and planners with regard to renewable energy, but especially for policy makers and planners in DSM. The new insight of this study is that there is a need for active policy support in DSM. Niches need to be set up to gather knowledge and new information, and these findings of the niches need to be converted into new regulations or guidelines. This is a reinforcing process where the niches are implemented under more grounded regulations or guidelines, which gets even better with the new findings of further niches. In this process, planners can play an important role. It is questioned whether the government has the required knowledge to develop a regulatory framework as the knowledge and experience of DSM is largely restricted to the energy staff. This study showed that the upscaling performance of niches in DSM are constrained by factors such as the lack of regulations, the lack of financial incentives and an inappropriate market structure. These constraining factors cannot be solved by people in the technical domain alone but require for knowledge in other domains as well. For instance, knowledge and skills from economists is required to help reorganize the current inappropriate market structure of the electricity system. This links back to a characteristic of a transition according to Rotmans et al. (2001), where developments in multiple dimensions are required in order for a transition to take place. The role of the planner in this transition, can be to function as a sort of mediator, bringing the various people together and guiding the process of the development of a regulatory framework with regard to DSM. This can be considered as a crucial first step in increasing the upscaling performance of niches in DSM.

The planner can not only fulfill this role with regard to DSM, but also in a broader sense. Planners can contribute to society, by serving as the mediator between all the various dimensions and therefore steer and manage a transition in the desired direction. The role of the planner within a transition can therefore be an interesting and relevant topic for further research. For instance, new insights on how to share the knowledge and experiences between the various dimensions can be an extremely valuable.

This study also showed the relevance of cross-border learning. For example, the Netherlands, they do not have to reinvent the wheel by themselves. Looking at how people, in this case countries, are implementing DSM measures can be valuable for their own implementation.

Chapter 6: Reflection

This chapter, the Reflection, will go more in depth into the challenges that the researcher had with conducting this study. Overall, the process of conducting this study went well. There were hardly any serious obstacles during the research process, which would have made a significant impact on conducting the study, or the study's outcome. As a result, the researcher will, most likely, not make any radical changes with regard to the process of conducting this study, if the same study must be done again. Something which could have been added to this study, however, was an interview with an someone experienced in DSM in the Netherlands. This could have increased the validity of the results, by adding another layer of data triangulation, and could have led to interesting new insight regarding DSM in the Netherlands. The choice is made to not conduct interviews, due to the time limitation of this study, and that the research question can be answered without the need of an interview.

The first challenge of conducting this study, was to quantify or to measure the factors that influence the upscaling performance of niches into the regime level. There was plentiful relevant scientific literature available on transition management and on the upscaling process, but it remained at giving a general overview of factors that might have an influence. There are some articles that do provide quantitative measures on the upscaling performances of niches, but these were impossible to translate to another subject, such as DSM. A new insight for the theory on the upscaling performance of niches into the regime level is that the subject and the context of the subject is crucial to determine the factors that have an influence on this process. The theoretical factors were useful to serve as a scope on where to look for, but these factors were not the most influential ones on the upscaling performance of niches in DSM.

The second challenge was the selection of the cases for this comparative study. At first, the aim was to use large urban areas, like the city of New York, as cases for this study. This proved to be extremely difficult as there was very limited data available on DSM on a city scale. The provision of reports and evaluation took place almost exclusively on a national scale. This could have been expected as the electricity system of a city is always part of a bigger electricity system. Regulations and guidelines are proposed and formulated on the higher, national scale, so it makes sense that this is also the geographical scale where the evaluation and reporting of DSM happens. But even on a national level, it was hard to find cases with enough data available. This is the reason that the selected cases for this research are large countries. Smaller countries do not have many documents available with regard to DSM. While this was certainly a limitation of this research, it did not have an effect on the outcome of this study and its validity.

A challenge with regard to the document analysis was to keep the context of the document in mind when interpreting the information. For example, with the case of China, three documents (Document C1, C3, C5) were from the early 2000's. Not only the timeframe needed to be kept in mind, also the target of the document was important for the interpretation. Document A3, for example, was about the customers insights with regard to DSM. The customers can have very different barriers or experiences with DSM than industries. The context of each document could have had an impact on the interpretation of the results, but nevertheless, roughly the same pattern in the data could be seen across the four cases, and across many different documents within those cases. The asnwer to the sub questions is based on multiple different documents, and this might have filtered out some of the possible interpretation errors.

Despite the challenges, the outcome of this study appears to be convincing. The main reason for this, is that the results from the theoretical framework, and the analysis of the empirical data are in line with one another. They suggest the same constraining factor, namely the lack of a regulatory framework, that limits the upscaling performance of niches in DSM. This result is found across all of the four cases, making it possible to generalize the findings to other possible countries as well, such as the Netherlands. A crucial next step is the development of a regulatory framework, which can be difficult to develop as there might be limited knowledge available by the actors responsible for it. Planners can play an important role in this step, and their role can be an interesting topic for further research.

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Appendices

Appendix 1: The Interview Guide

Factors	Interview questions	Corresponding Codes	Documents:
Geographical context	What is the geographical context in which the niches take place?	Geographical context	U1, U2, U4 I2, I3, I4, I7, I8 A1, A2, A3, A5 C1, C2, C3, C5, C6, C7
Historical context	What is the historical context in which the niches take place?	Historical context	I3 A1, A2 C1, C2, C3, C6, C7
Political context	What is the political context in which the niches take place	Political context	U2, U3, U5, U6 I1, I2, I7, I8 A1, A2, A4 C1, C2, C3, C5, C6, C7
Market context	What is the market context in which the niches take place	Market context	U3 I1, I7, I8 A1, A2, A4 C1, C5, C7
Expectations and visions	Why are the niches needed	Triggers	U2, U3, U4, U6 I1, I2, I4, I7, I8 A1, A2, A3, A5, A6 C1, C2, C4, C5, C6
	What are the goals of the niches?	Goals of the niche	U1, U2, U6 I1, I2, I3, I4, I5, I7, I8 A1, A2, A6 C1, C2, C6, C7
	What is the outcome of the niche?	Outcome of the niches Evaluation: Lessons for increased success	U1, U2, U6 I1, I2, I8 A1, A3, A4, A5, A6 C1, C2, C3, C4, C5
Building of networks	Is the network of the niche broad?	Network: horizontal linkages	U3, I1, I2, I7 A1, A2, A3, A4, A6 C1, C2, C3, C5, C6, C7
	Is the network of the niche deep?	Network: vertical linkages	U1, U3 I3, I4, I7, I8 A2 C3, C5, C6,
Learning processes	To what extent does the niche contain forms of first-order learning processes?	Learning: first order	U2, U5, U6 I3, I4, I8 A1
	To what extent does the niche contain forms of second-order learning processes?	Learning: second order	U1, U6 I1, I2, I3, I8 A1, A2, C1, C2, C3, C5, C6, C7

Barriers	Which type of barrier has the niche run into?	Barrier: Cultural Barrier: Customer Barrier: Institutional Barrier: Increase complexity Barrier: lack of awareness Barrier: lack of demonstration Barrier: Lack of experience Barrier: Lack of financial incentives Barrier: lack of incentive Barrier: lack of ownership/enforcement Barrier: lack of support/participation Barrier: lack of transparency Barrier: lack of understanding Barrier: Market organization Barrier: Regulatory Barrier: Risks Barrier: Short term Barrier: Small scale and selection Barrier: Social and behavioral factors Barrier: Split incentives Barrier: Technical Barrier: Time and Resources Barrier: uncertainty	U1, U2, U3, U5, U6 I1, I3, I4, I5, I6, I7, I8 A1, A2, A3, A4, A5, A6 C1, C2, C3, C4, C5, C6

Table 2: Interview guide

Appendix 2: Full list of codes and the code groups

Code groups	Codes
Context	Geographical context
	Historical context
	Market context
	Policy context
	Sector context
Effect of barrier	Effect of barrier
Enabling factors	Enabling factors: create ownership
	Enabling factors: Customer engagement
	Enabling factors: Demonstration
	Enabling factors: Enforcement
	Enabling factors: Experience
	Enabling factors: Financial incentives
	Enabling factors: Incentives
	Enabling factors: increase awareness
	Enabling factors: increase certainty
	Enabling factors: Increase experience
	Enabling factors: Market organization
	Enabling factors: Non-energy benefits
	Enabling factors: Regulatory
	Enabling factors: Research
	Enabling factors: Resources
	Enabling factors: Social and behavioural factors
	Enabling factors: Stakeholder
	Enabling factors: Technical
Expectations	Desires of the niche
	Goals of the niche
	Outcome of the niches
	Triggers: why is it needed
Learning	Learning: first order
	Learning: Second order
Lessons	Evaluation of DSM
	Lessons acquired from the niche
Measures	Financial measures
	Policy measures

	Technical measures
Network	Network: Horizontal linkages Network: Vertical linkages
Types of barriers	Barrier: Cultural Barrier: Customer Barrier: Increase complexity Barrier: Institutional Barrier: lack of awareness Barrier: lack of demonstration Barrier: Lack of experience Barrier: Lack of financial incentives Barrier: lack of incentive Barrier: lack of ownership/enforcement Barrier: lack of support Barrier: lack of transparency Barrier: lack of understanding Barrier: Market organization Barrier: Regulatory Barrier: Risks Barrier: Short term Barrier: Small scale and selection Barrier: Social and behavioural factors Barrier: Split incentives Barrier: Technical Barrier: Time and Resources Barrier: uncertainty

Table 3: Full list of all the code groups and codes

Appendix 3: Atlas.ti – interpretation of the data

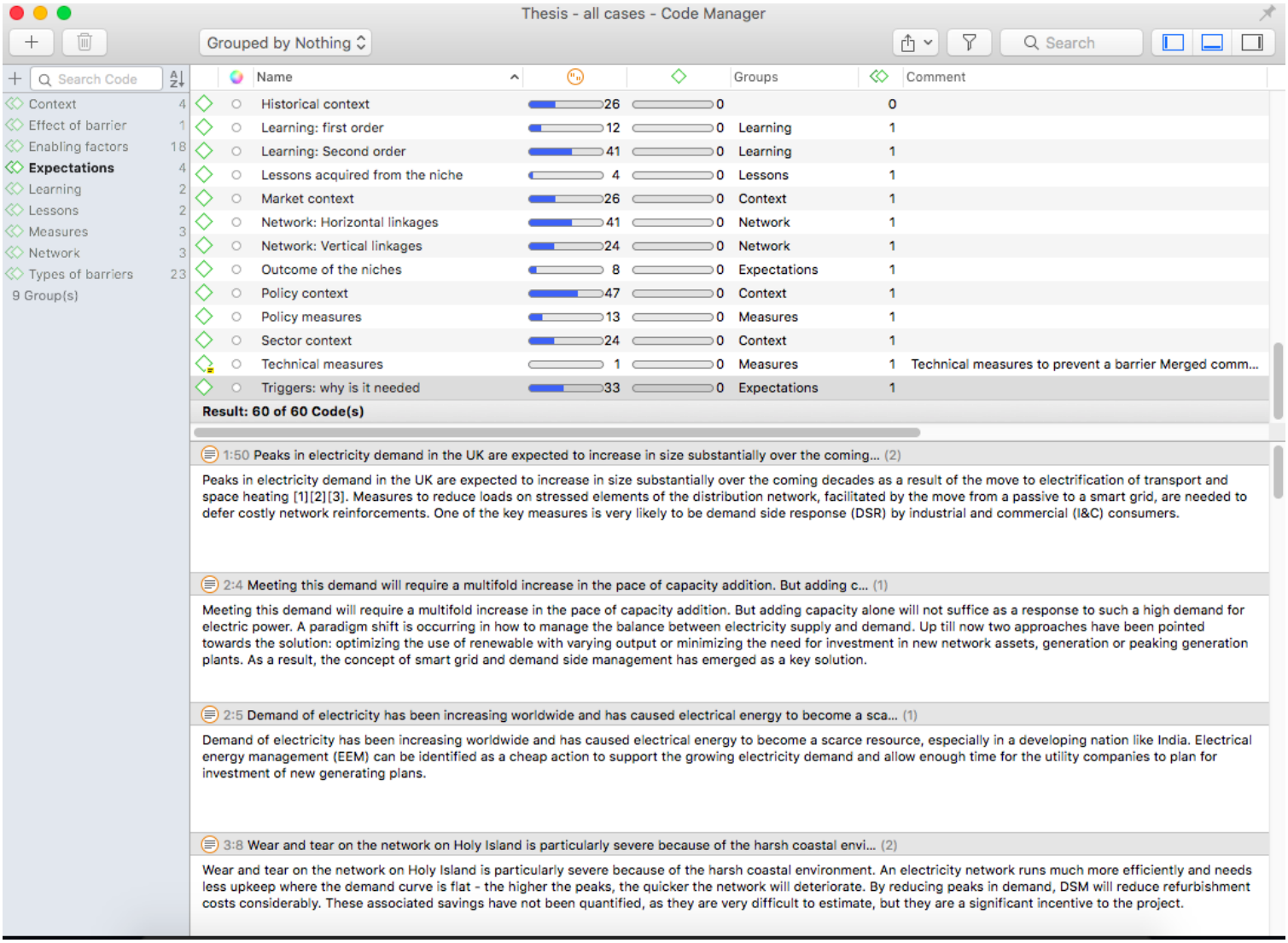

Figure 9: Screenshot of the interpretation of the data